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Mitigation of Common Mode Voltage in Induction Motor Emplyoing Multilevel Inverter

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I. INTRODUCTION

In the medium-voltage, high-power flexible speed drive (ASD) framework, AC gracefully is first changed over into DC (known as DC cradle stage) and afterward changing over back this DC into variable voltage variable recurrence AC gracefully utilizing inverter (voltage source or current source type). The front-end converter might be uncontrolled or controlled voltage source or current source rectifier while the motor side converter can be customary two-level or staggered VSI, CSI. The supply given by VSI to DC interface capacitor Cd (C1 and C2) is adequately huge and DC connect inductor Ld isn't required, whereas for CSI feederdrive, Ld is adequately enormous and Cd isn't required. The DC support stage comprises of just huge capacitor on account of voltage source inverter and just huge inductor on account of current source inverter. This procedure includes exchanging power semiconductors to control the size and recurrence of the output/yield waveforms. The exchanging activity of rectifiers and inverters brings about regular mode voltages which are basically zero-succession voltages superimposed with exchanging switching noise which will show up at rectifier, inverter, and at motor terminals. If not relieved, they show up on the neutral point of the stator twisting concerning ground, which ought to be zero when the motor is fueled by a three-phase adjusted utility supply. Further, the motor line-to-ground voltage, which ought to be equivalent to the motor line-to-neutral (stage) voltage, can be generously expanded because of the regular mode voltage ends up with premature failure of themotor winding insulation system. As an outcome, there is cutoff in lifespan of motor. This wonder is unique in relation to the high dv/dt brought about by the exchanging drifters of the rapid switches.Therefore, it is important to control/take out the basic mode voltage greatness and its pace of progress.

Regular mode voltage decrease/end methods can be named given beneath:

(A) By utilizing some additional equipment hardware, for example, disconnection transformer, zero-grouping impedance ,dynamic and detached channels, dual bridge inverter, utilizing four-leg (four-stage) inverter, or

(B) By utilizing change in control methodology utilized dependent on space vector PWM strategy (SVPWM) or sinusoidal PWM procedure (SPWM).

THE PULSE-WIDTH balance (PWM) voltage source inverters have empowered productive and simple control on the flexible regulated speed drives and they are broadly utilized in factory drives. These PWM inverters likewise cause high recurrence, elevated level regular mode voltages in the system.These exchanging basic mode voltages results in motor bearing current flow with the help of electrostatic coupling via parasitic capacitances. The inverter produce regular mode voltage that causes motor spillage current which go about as a source for Electromagnetic Interference in the drive framework. PWM inverter, which doesn't create normal mode voltage, is proposed as an answer for kill the issues related with the regular mode voltage. From the writing study we discover that adjustment plans for wiping out the basic mode voltage in the customary impartial point by utilizing two-level inverter. This plan encounters neutral point swings, which is normal for neutral point clamped topology. The swings in neutral point can be controlled, by adding extra equipment to adjust the voltage swings in neutral point.

This can be accomplished by staggered inverters, for example, three phase 2-level and 3-level inverter. These are broadly utilized in floating speed AC three phase IM drive Systems, which produce three phase AC yield voltage of wanted sufficiency and recurrence from a fixed DC voltage source. In 2-level and 3-level inverter, the yield waveform of inverter is ventured square wave. The yield waveform of an inverter ought to be sinusoidal for productive activity.

The additional equipment causes a critical increment in the framework's volume or substantially more multifaceted nature in control methods. The topology talk about here have high

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various exchanging states that can lessen or potentially dispense with the CMV: Also, for creating the gate pulses , microcontroller dsPIC33EP256MU810 is utilized. This has various focal points than typical microcontroller, for example, number of I/O ports, working recurrence, and so forth. In light of these preferences, it is use to produce the gate pulses for Cascaded H-bridge MLI topology to diminish the Common Mode Voltage.

PROBLEM STATEMENT

The most widely recognized adjustment methodology embraced for speed control in acceptance motor drives is pulse width regulation (PWM). The extreme bearer frequency is contrasted with the reference incentive so as to create the necessary PULSE. The issues identified with regular mode voltage are expanding because of expanded PWM exchanging frequencies. Henceforth advancement of new SPWM strategy with decreased multifaceted nature for the alleviation of CMV varieties and upgrade of THD is embraced. The proposed work focuses on decrease of regular mode voltage in a 3-phaseinduction motordrive application utilizing Multilevel inverter.

II. LITERATURE SURVEY

[1]B Muralidhara, ***"Test Measurement And Comparison Of Common Mode Voltage, Shaft Voltage And The Bearing Current In Two-Level And Multilevel Inverter Fed Induction Motor.***

The induction motor is known to be a consistent speed motor. It is the prime drive in industrial applications. because of the advancement in building innovation, the speed of the induction motor can be fluctuated inside certain impediments. There are numerous strategies to control and run the machine in variable speed drive applications. The fundamental strategyis 2-level inverter constrained by the microcontroller, utilizing the space vector tweak strategy. By this technique the yield of the inverter will be non-sinusoidal and subsequently at the star point of the load there exists a voltage as for ground and it is known as common mode voltage, it prompts electromagnetic obstruction which makes unsettling influence the close by correspondence and hardware gear. To diminish the regular mode voltage a more elevated level of inverter can be utilized. In this concept the creators have talked about the 2-level, 3-level with twelve gadgets and 3-level with nine gadgets. utilizingmatlabsimulink and by experiment. For 3-level inverter twelve gadgets, the common mode voltage esteems are taken from the previous distributedresults. Quick fourier change has been finished utilizing the sign investigation programming and results are plotted with recurrence versus voltage. The phase voltage, line voltage and common mode voltage are estimated utilizing agilent make blended sign oscilloscope. In the end, the common mode voltage values are contrasted and distinctive working frequencies ofinduction motor .

[2] M.M.Renge*" Multilevel Inverter to Reduce Common Mode Voltage in A.C. Motor Drives Using SPWM Technique.*

A new way to deal with decrease basic mode voltage (CMV) at the yield of staggered inverters utilizing a phase opposition disposed (POD) sinusoidal pulse width regulation (SPWM) method is proposed. The sinusoidal pulse width modulating procedure doesn't require calculations in this manner, this method is anything but difficult to actualize on-line in advanced controllers. A decent exchange off between the nature of the yield voltage and the size of thediminish Common mode voltage is accomplished. The author gives an idea to understand the execution of a PODSPWM procedure to diminish Common mode voltage utilizing a five-level diode clipped inverter for a three phase induction motor. Trial and recreation results show the achievability of the proposed method.

[3]A.Nabae,*" A new Neutral point CIamped PWM Inverter''*

A new neutral-point-clamped pulse width modulation (PWM) inverter composed of main switching devices which operate as switches for PWM and auxiliary switching devices are used to clamp the output terminal potential to the neutral point potential . This inverter output contains less harmonic content as compared with that of a conventional type. Two inverters are compared analytically and experimentally. In addition, a new PWM technique suitable for an ac drive system is applied to this inverter. The neutral-point-clamped PWM inverter adopting the new PWM technique shows an excellent drive system efficiency, including motor efficiency, and is appropriate for a wide-range variable-speed drive system.

[4] Mr.MohdEsa*"Common Mode Voltage reduction in Diode Clamped MLI using Phase Disposition SPWMTechnique.*

The point is to lessen the Common Mode Voltage (CMV) in the Diode Clamped Multilevel Inverter (DCMLI).Three phase star associated RL load is connected with DCMLI. The basic mode voltage exists between star point of load and system ground. Untimely disappointment of course of InductionMotor (IM) is brought about by CMV and is important todecrease. Phase Disposition Sinusoidal Pulse Width Regulation (PD SPWM) strategy is utilized for decrease of CMV what's more, LC channel is utilized for decrease of Harmonics.MATLAB Simulink is utilized for the recreation of circuit. Total Harmonic disturbance (THD) and CMV are explored.

[5]ChungChuanHou *,"Common-Mode Voltage Reduction Pulse width Modulation Techniques for Three-Phase Grid-Connected Converters.*

This point tentatively examines the exhibition of three-phase voltage source pulse width modulation (PWM) converter, with the grid interfaced photovoltaic vitality transformation system being the principle application. In such applications the ground spillage current [common mode current (CMC)] should be considerably less than an ampere and this is hard to get in transformer less (direct) associated system. With the objective being the decrease of the normal mode voltage (CMV) and CMC, the converter execution is researched altogether. Customary PWM techniques [space vector PWM (SVPWM) and intermittent PWM (DPWM)] and as of late created decreased normal mode voltage PWM (RCMV-PWM) strategies [active zero state PWM (AZSPWM) and close to state PWM (NSPWM)] are thought of. The exhibition of a 1-kW evaluated PWM rectifier with extra normal mode capacitor copying a PV system has been tentatively examined. It is indicated that the CMV and CMC of the tried RCMV-PWM strategies is essentially not exactly customary techniques. Specifically, NSPWM yields the best generally execution including low ground spillage current, low inverter yield (stage current) and input (dc-interface current) wave, Representing the parasitic capacitance effect, the thunderous recurrence of the regular mode circuit is recognized and it is utilized in the converter plan to stay away from resonances including huge CMV-CMC. These points helps the Design engineer to select the proper PWM technique for grid connected applications and gives some plan general guidelines.

[6]Yam P. Siwakoti*"Common-Mode Voltage Reduction Techniques of Three-Phase Quasi Z-Source Inverter for AC Drives.*

This gives the idea of the balance strategies to lessen the basic mode voltage (CMV) and basic mode current (CMC) in 3-Φ Quasi Z-Source Inverter (q-ZSI) for AC drive frameworks. An altered Space Vector Pulse Width Modulation strategy with diminished number of recompense per part was utilized to limit the CMV and CMC without including additional hardware (channels as well as spillage current segregation/sidestep circuits) in a q-ZSI while keeping up the lift ability of q-ZSI by embedding's the shoot-through vector in the middle of the dynamic state vector. Point by point investigation of the adjusted SVPWM method to diminish the CMV and CMC of q-ZSI is presented, and execution of the proposed framework has been confirmed utilizing Mat-lab Simulink.

[7]Xiang Wu,***"OptimizedCommon-Mode Voltage Reduction PWM for Three-Phase Voltage Source Inverters.***

Two new upgraded basic mode voltage decrease PWM (CMVRPWM) procedures dependent on understanding the set up obliged nonlinear programming models in the time space are proposed and investigated. The proposed current wave misfortunes advanced CMVRPWM (CRLOCMVRPWM) limits the mean-square estimations of the three-stage current waves by ascertaining the improved uncommon arrangements of the voltage-second parity conditions under the designed switching groupings. CRLO-CMVRPWM can accomplish preferable yield waveform quality over the current techniques. various burden influence factors. Contrasted with the close state PWM(NSPWM) with fixed bus clamping styles, SLO-CMVRPWM can lessen all the more switching misfortunes in more extensive scope of the balance list. Reproduction and test results check the prevalence of the proposed procedures over the customary ones.

[8] HodaGhoreishy, ***"A New Common-mode Voltage Reduction Technique for Multilevel Inverters.***

This gives thought of a novel normal mode voltage decrease method which is proposed for a three-stage staggered inverter. The procedure can be utilized to control capacitors voltages and load current with low switching misfortunes. It can be very well applied to a three-phase three-level inverter with the flying capacitor topology. One of the upsides of this strategy is that the procedure can

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be applied to more voltage levels without fundamentally changing the control algorithm. The reproduction consequences of a five-level inverter show that the proposed method can be utilized to actualize a multilevel inverter.

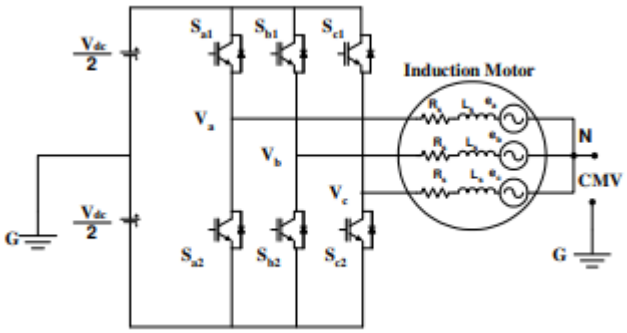
III. C0MM0N M0DE V0LTAGE

Normal Mode Voltage is characterized as the voltage between neutral point of the load and the ground of the system as shown in Equation {1}. It might likewise be characterized as the voltage between neutral point of the load & the dc midpoint. The summed up drive system can be shown as in Fig(1). Where Vag, Vbg and Vcgare the voltages between ground to phase &Vng is the voltage between neutral point of the motor and system ground.

$$\mathbf{CMV} = \mathbf{V_{NG}} = \frac{V_{ag}+V_{bg}+V_{cg}}{3}$$

Where; V_{ag}, V_{bg}, V_{cg} are the pole voltages, i.e.

$$\mathbf{CMV} = \mathbf{V_{NG}} = \frac{1}{3}\sum_{X=a}^{c} \mathbf{V_{xg}}$$



In absolutely sinusoidal three phase system aggregate of the immediate voltages at each time is zero subsequently Common Mode Voltage is zero. Voltage source inverter (VSI) yield isn't simply sinusoidal yet discretized thus total of the immediate voltage has non zero worth which creates CMV. In the event that the switching operation of the inverter is Sx and Vdc is dc voltage, at that point phase voltageVxg can be communicated as

$$V_{xg} = V_{dc}\left(S_x - \frac{1}{2}\right)$$

In ordinary three phase inverter when upper switch is on and lower switch is off Sx = 1, in leg x of the inverter and the other way around. Joining over two conditions CMV for traditional inverter is gotten as shown below:-

$$CMV = \frac{V_{dc}}{3}\sum_{x=a}^{c} S_x - \frac{V_{dc}}{2} \ldots .ForTwoLevel$$

In staggered inverter according to the dc voltage level Common Mode Voltage can be communicated as follows:-

$$CMV = \frac{1}{3}(S_a + S_b + S_c)\frac{V_{dc}}{2} \ldots .ForThreeLevel$$

$$CMV = \frac{1}{3}(S_a + S_b + S_c)\frac{V_{dc}}{4} \ldots .ForFiveLevel$$

$$CMV = \frac{1}{3}(S_a + S_b + S_c)\frac{V_{dc}}{6} \ldots .ForSevenLevel$$

Bearing voltage, shaft voltage, bearing current & parasitic capacitances in inverter driven motor.

The expected distinction among internal and external race of a bearing is called as bearing voltage [Vb]. The standard machine has two finishes - Drive End (DE) & Non Drive End (NDE). Thus two bearing voltages are characterized, voltage alluded to drive end Vb DE & voltage alluded to non-drive end [Vb] NDE. In

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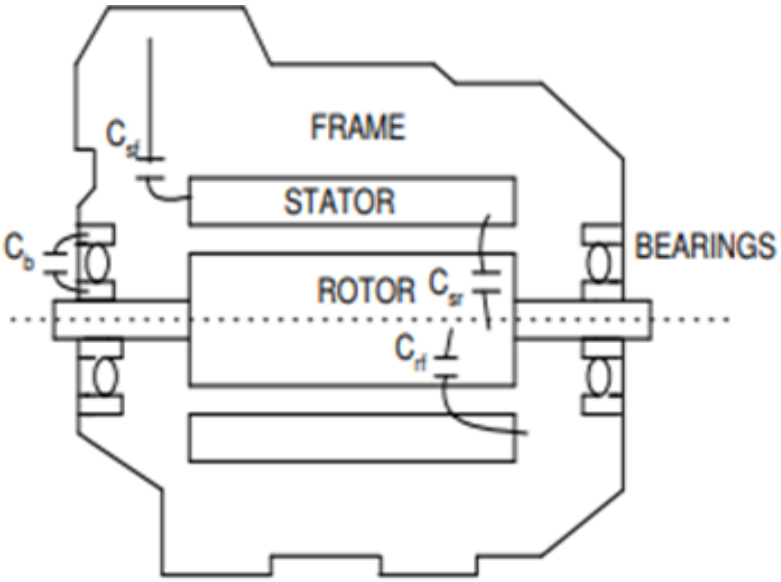
inverter-activity, when the regular Mode Voltage contains high recurrence parts and a flawless greasing up film is shaped between bearing balls and races' at that point bearing goes about as a capacitor. At right now bearing voltage reflects the regular mode voltage at the motor terminals by a capacitive voltage divider.

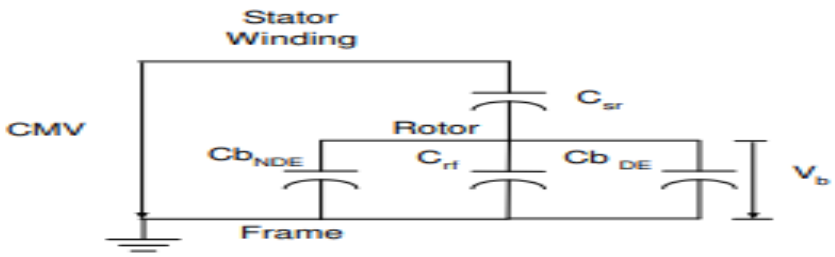
Shaft voltage [Vsh] of a machine is the likely distinction of the pole among drive &non drive end. Variable recurrence drives have various advantages, for example, they offer vitality energy savings & simultaneously they permit high powerful activity. Sadly they are likewise a wellspring of new sort of bearing current. This inverter which creates bearing currents may demolish course inside a brief time of activity. Parasitic capacitances of an electric motor give low impedance ways to high recurrence currents.

These parasitic capacitances can be ignored at typical working frequencies however at high transporter recurrence & dv/dt these capacitances become huge. The primary parasitic capacitances that have impact on bearing currents are stator twisting to outline capacitance [Csf], stator twisting to rotor capacitance [Csr], rotor to outline capacitance [Crf] & the bearing capacitance [Cb].These are appeared in Fig 2 These capacitances structure a capacitive voltage divider as appeared in Fig. 3. High recurrence regular mode voltage at the motor terminals is reflected over the bearing by this the voltage divider causes bearing voltage [Vb]. The proportion of bearing voltage to regular mode voltage at motor terminals is characterized as Bearing Voltage Ratio {BVR}. Drive end bearing capacitance Cb DE is thought to be equivalent to non-drive end bearing capacitance Cb NDE for example Cb DE = CbNDE = C b. From Fig(3) BVR can be communicated as shown in below equation:-

$$BVR = \frac{V_b}{CMV} = \frac{C_{sr}}{C_{sr} + C_{rf} + 2C_b}$$



Fig[2]: Different kinds of Parasitic Capacitances of Induction Motor.



Fig[3]: Diagram of Capacitive Voltage Divider

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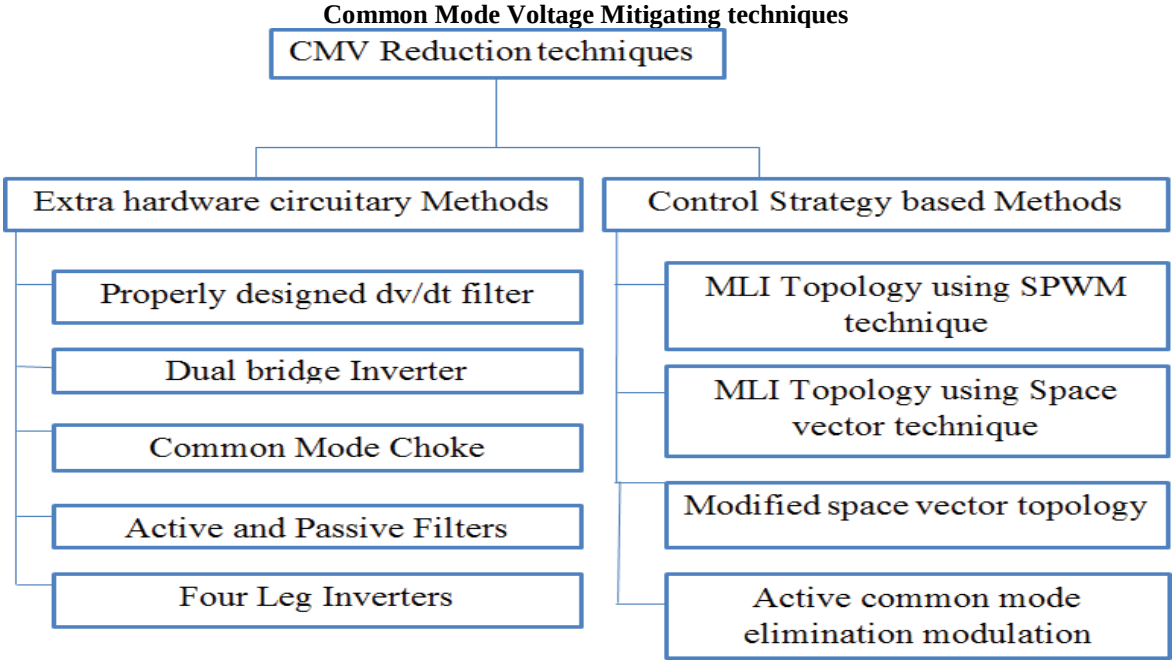
Impact of Common Mode Voltage

1) Pulse Width modulating inverters delivers high recurrence & high sufficiency normal mode voltage, which prompts 'shaft voltages' on the rotor.
2) When this incited voltage surpasses the breakdown voltage cut-off of the lubricant in the motor bearing, brings about a huge bearing current flow,
3) This causes motor bearing failure & furthermore shows Electro-magnetic Inference problems. Accordingly normal mode voltage is answerable for untimely failure of induction motor bearings, when provided from quick operation of switches along with various power parts, so it is important to wipe out Common Mode Voltage by choosing explicit mitigating techniques.

Common Mode Voltage Mitigating techniques



IV. MULTI-LEVEL INVERTERS

Introduction

Multi -level inverters are very notable in influence transformation with medium voltage and motor drives as a result of the low level distortions without change in influence yield of inverter, likewise it has little voltage weight on switches, low exchanging recurrence and even adversities in the switches are less.

A nonpartisan point clamped inverter topology mix of flying capacitor with unbiased point braced topology; which gives yield voltage Of four level. Interestingly the four level flying capacitor inverter has less capacitor. the quantity of diode utilized in settled unbiased point-braced converter is less .the voltage worry in the topology is same with respect to each switch and it is equal to 1/3 of the dc-connect voltages(Vdc/3).

A couple of control frameworks and parity procedures including capacitor voltage modifying systems have been made for staggered inverters. the current capacitor voltage adjusting method is for the most part created for diode braced inverters, flying capacitor inverters and particular staggered inverters. These techniques are answerable for the neutral point cinched inverter in light of the different topology structures. The differentiation in topology causes diverse conduct in capacitor voltages and this requires particular voltage adjusting procedure.

The staggered inverters have pulled in tremendous number of intensity industry. they show another course of action of components that are proper to for use in responsive force pay .it may be less requesting to convey the incredible, staggered inverter structure with high voltage on depiction of path which device voltage stresses occupied in structure. Rising the amount of voltage security in the inverter excluding predominant assessments on each device have the option to manufacture the force rating. One kind development of staggered voltage source inverter empowers to accomplish high voltages with low stable without usage of Transformers or, more than likely course of action related directed trading contraptions. Since amount of voltage level expands, the steady substance of the yield voltage waveform decreases basically.

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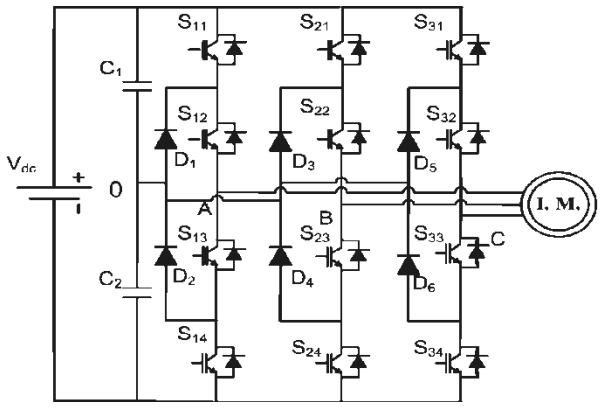
Kind of Multilevel Inverters: - The basic development of staggered converter is, to join close sinusoidal voltage from a little strength levels of DC voltages, as often as possible got from capacitor voltage sources. Since amount of security level grows, the yield waveform has extra advances, which makes a flight of stairs wave system a pined for waveform. Likewise as further walks are added to waveform ensembles twisting of the yield wave lessens, moving towards zero as extent of the level additions. The staggered inverter can be summed up into three sorts:-

[1] Diode clamped staggered inverter
[2]Flying capacitor staggered inverter
[3]Cascaded staggered inverter

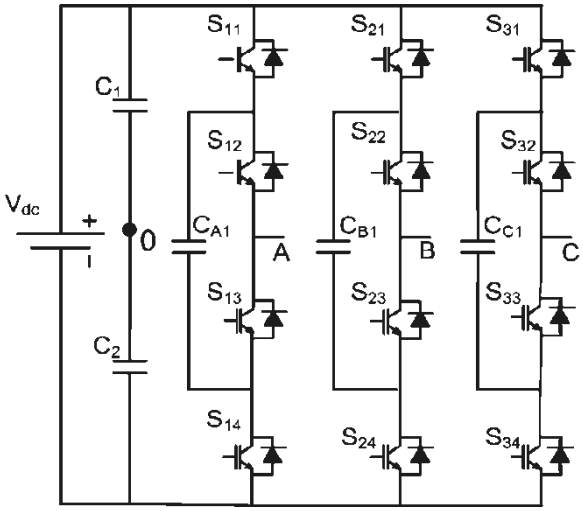
Neutral point clamped Inverter

chief idea of npc inverter is to make use of diodes and which gives limitless voltage levels specifically phases of capacitor Banks. Where capacitor in course of action. Diode associations an obliged measure of voltage, this implies reducing the weight on the electrical contraptions. Most absurd yield voltage is half of information DC voltage. It is fundamental downside of diode braced staggered inverter. Issue can be understood by expanding the directing switches, capacitors, diodes. Taking into account capacitor altering complexities, npc inverter are bound to the three levels. This kind of inverters gives high ampleness because of the central recurrent utilized for each trading devices and is a basic strategy for the consecutive power exchange frameworks.



Flying capacitor clamped inverter

The principal thought of flying capacitor inverter is to use capacitors. It is a game plan of relationship of switching cells. Capacitors move the obliged estimated voltage to electrical devices. In Flying Capacitor inverter, directing States take after the nonpartisan point cinched inverter. Bracing diodes aren't fundamental in flying capacitor staggered inverters. The yield is half of the input DC voltage. It is drawback of the flying capacitor staggered inverter. It is similarly has the continuing directing States inside a stage to change flying capacitors. It can oversee similarly the dynamic and receptive flow of power. Due to the high repeat leading States, conductive switch misfortunes adversities occur.



Cascaded Multilevel Inverter

The H-Bridge cascaded staggered inverter uses capacitors, directing switches and need less measure of segments in each level .cascaded topology grasp course of action of vitality change cells. Power can be promptly scaled. The mix of capacitors and switches consolidate is known as H-Bridge and gives the different input DC voltage for all H-interface. It is comprised of H-Bridge cells and each cell can create the three unmistakable voltages like O, positive DC and negative DC voltages. One of the advantages of this kind of staggered inverter is that it needs less number of parts developed on diode braced and flying capacitor inverter. The expense of and weight of the inverter are not actually those of the two inverters. Fragile exchanging is possible by the bit of the new switching procedures.

staggered cascaded inverter are used to clear out the monstrous transformer required if there ought to be an event of customary multistage inverters, clamping diodes required in case of diode propped inverters and flying capacitors required in case of flying capacitors inverters. In any case, these require huge number of isolated voltages to provide supply for every cell.

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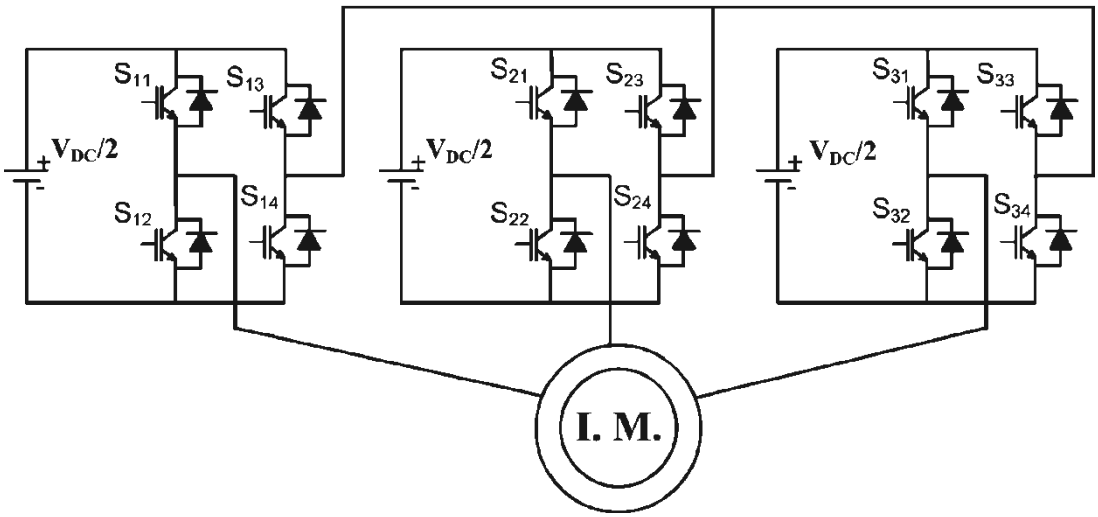

The voltage source staggered inverter topologies have the option to arrange into two get-together model staggered topologies and advanced staggered topologies. The excellent staggered topologies consolidate the impartial point clasped, flying capacitor, cascaded h-connect. the Classic staggered converters have been advocated successfully by significant makers; be that as it may, they have a couple of drawbacks which control their applications for instance, the Neutral Point Clamped design with higher number of levels is less engaging an immediate consequence of its hindrances which include:

1] Higher misfortunes and uneven apportionment of misfortunes in the outside additionally, inward gadgets,

2] DC associate capacitor voltage modify moves towards getting out of reach in bigger sum topologies with a withdrew front end while using ordinary balance procedures, and

3] The quantity of clipping diodes increases liberally with the voltage level.

The Flying Capacitor development needs changing frequencies to keep the capacitor properly balanced, whether or not a self-altering or a control helped modifying balance method is used. Moreover the amount of FC increases with the voltage level. The cascaded H-Bridge design can arrive at higher voltage level and higher power level with the separated structure; in any case ,this topology needs: innumerable DC sources, an exorbitant and gigantic stage moving transformer, and an impressive higher number of dynamic gadgets to achieve a regenerative other option.

MULTI-LEVEL INVERTERS WITH OPEN-END WINDING INDUCTION MOTOR

The three- staggered inverter topology can be acknowledged by taking care of an open-end winding acceptance motor with two- staggered inverter from the two sides of the winding ,The symphonious voltage presented by these inverters will cause consonant current in the motor phase windings, on account of the absence of confined neutral. This topology requires either consonant channel or separated dc-interface voltages to forestall symphonious flows coursing through the motor phase windings. This sort of staggered inverter topology is liberated from capacitor voltage adjusting issues.

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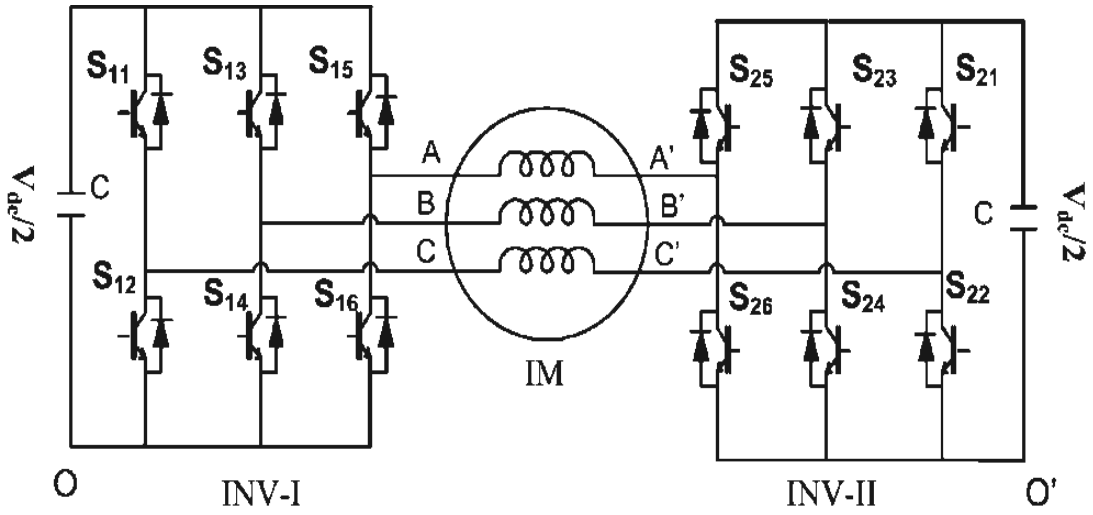

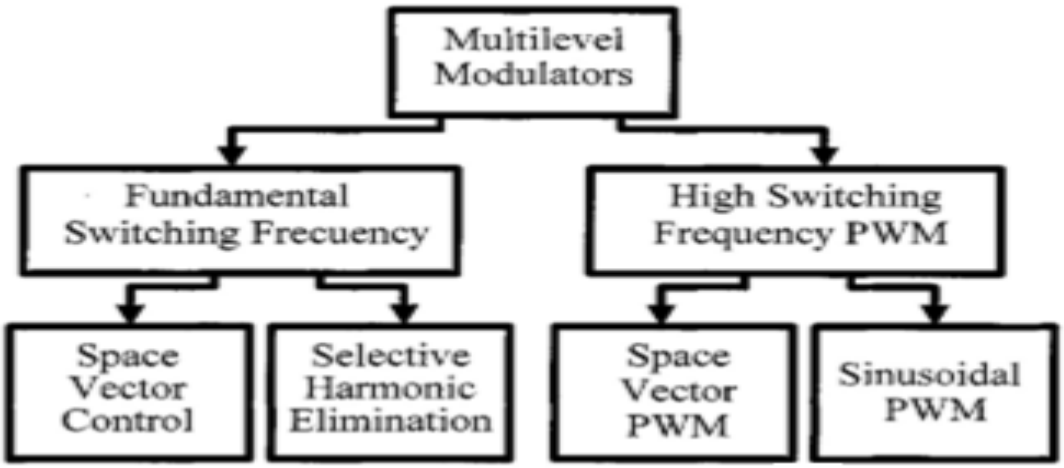

Classification of Modulation Strategies

The most appealing highlights of staggered inverters are as per the following.

- They can produce yield voltages with amazingly low twisting and lower dv/dt.
- They draw input current with exceptionally low harmonics.
- They can work with a lower switching recurrence.

A staggered inverter can be utilized to control the acceptance motor with decreased consonant disturbance. A 5/3 H-Bridge two-level inverter is proposed here as appeared in fig

Proposed 5/3 h bridge inverter

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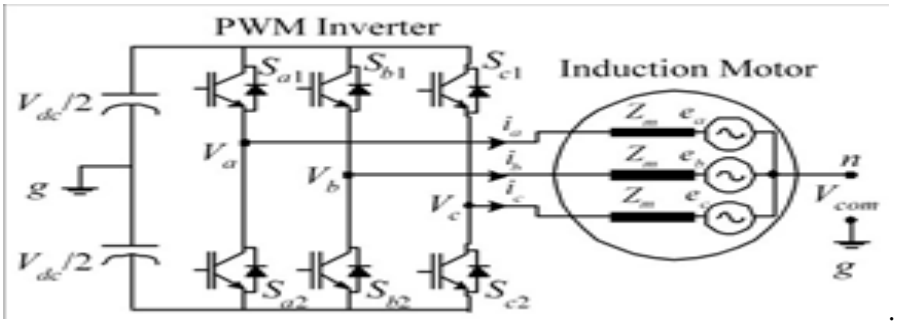
V. PROPOSED SYSTEM

PRINCIPLE

Induction motors which are used in the industries are usually fed by three phase voltage source inverters most of the time. The bearing present in the induction motor will have their lifespan for 6 to 10 years, if we provide balanced continuous AC supply for the drive. Nowadays the bearing life of the motor is reduced gradually because of the use of advanced adjustable speed drives



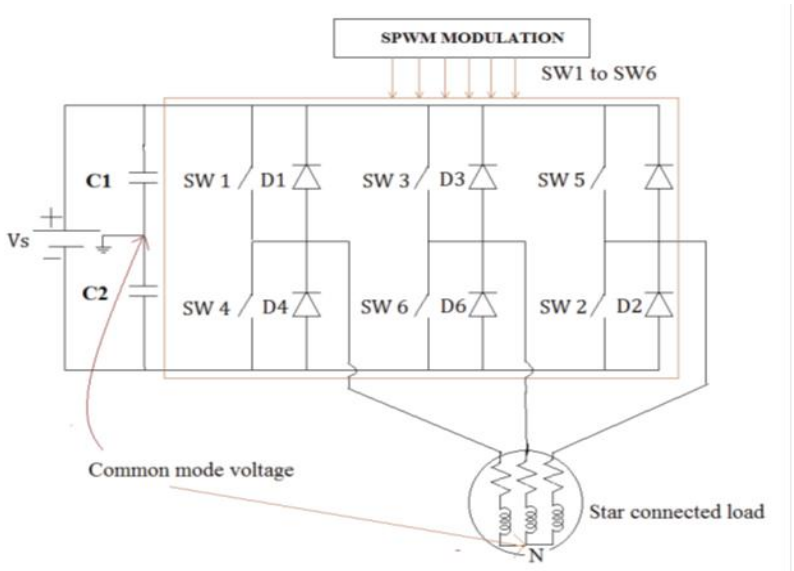
Three-phase VSI inverter and induction motor.

Due to the non sinusoidal output voltage from the inverter this adjustable speed drives are operated at high switching frequencies, as the result bearing current flows to the bearing of the motor. There are various techniques to reduce the flow of bearing current; one of the modulating techniques that we are going to implement is pulse width modulation.

When we use PWM switched 3 phase power supply which is feeded to the adjustable speed drives then the voltage which has DC magnitude is converted to AC magnitude, but the voltage at the neutral point is not zero. Therefore the voltage between system ground and neutral point of the load is called common mode voltage.

Thereby due to the common mode voltage there is a common mode current induced, which finds the return path through bearing of the motor, inverter, and motor shaft, this bearing current has high frequency which is capable of damaging the motor bearing and therefore leads to the reduced lifespan of the motor bearing.

In order to solve this problem, it is mandatory to reduce the magnitude of common mode current, this can be achieved by reducing the common mode voltage .there are various variety of techniques and methodology to reduce common mode voltage.



Schematic diagram of Inverter fed Induction Motor with Common Mode Voltage

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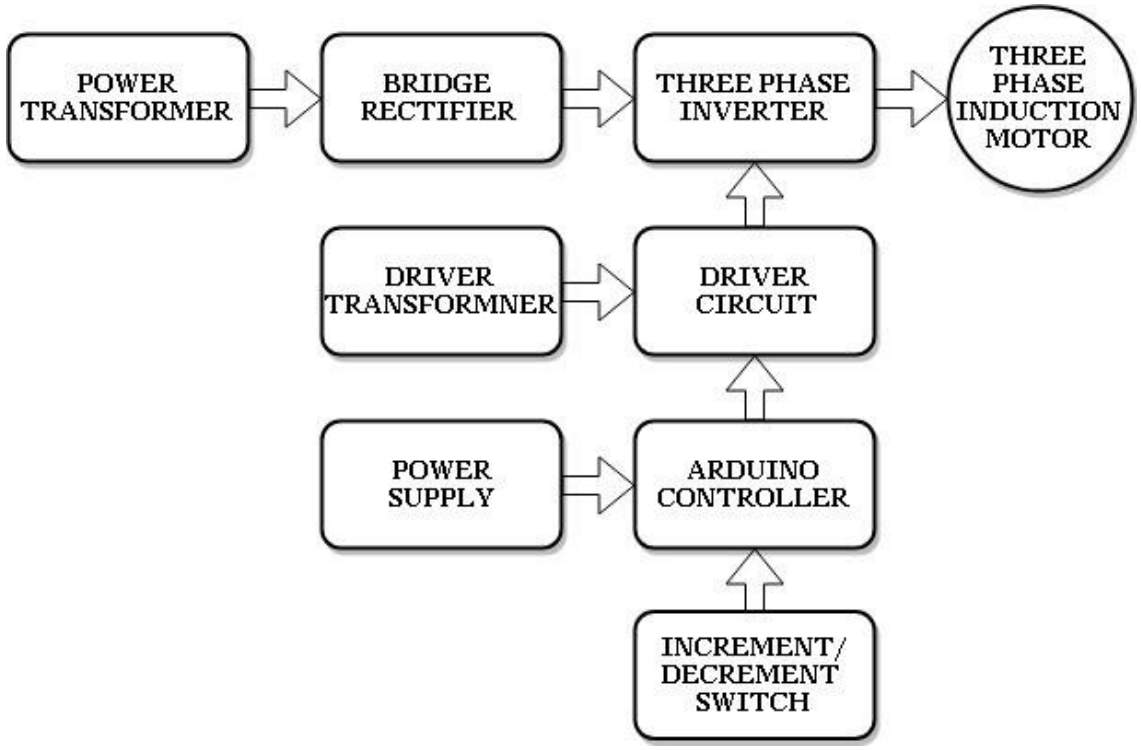
The proposed system that we are implementing has a high number of switching States, where sinusoidal pulse width modulation technique is carried out. The power Semiconductor devices such as a Power IGBT or Power MOSFET is used for switching actions. The gate signals are generated with the help of advanced microcontroller dsPIC33EP256MU810 or with the arudino Uno board.

The advantage of using advanced microcontroller is that it has got wide number of input output ports and can be operated at high frequency. Therefore it is used to provide Gate signals for a three phase Diode clamped H- Bridge multilevel inverter. This is of basically a two- level inverter and three- level inverter in construction respectively. The common mode voltage is compared with the output of two level inverter and three level inverter. In these inverters the yield waveform is stepped square wave, but the output of the inverter waveform must be sinusoidal in nature for effective operation.

The figure below shows the block diagram of hard ware setup and circuit diagram:-

HARDWARE BLOCK DIAGRAM



SPECIFICATIONS FOR 3 PHASE INVERTER BOARD

The inverter card accompanies inbuilt full extension rectifier and channel capacitor. 6 No's of IRFP250 MOSFET's are mounted with Heat sink. The yield of the inverter is ended with 3 pin PTB Connector. The client ought to get soldered on rear of the board for triggering signal interface.

1)6 No's of IRFP250 MOSFET are mounted with appropriate Heat sink
2)5A Bridge Rectifier with DC Filter Capacitor (1000uF/250V)
3) 3Pin PTB Connector gave to interface Motor.

Details

1)6 No's of IRFP250 MOSFET with Heat sink
2) Input Voltage 100V/AC/50Hz
3) Operating Frequency 25 KHz
4) Input and Outputs are ended with PTB Connectors

TLP 250 DRIVER BOARD
Determination
1)6 No's Opto-Isolated Gate Drive
2) Input Voltage 12V/AC/50Hz
3) Operating Frequency 25 KHz
4) All input and yields are ended with RMC Male Connectors

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ADDITION/DECREMENT SWITCH INPUTS

INTERFACE WITH PINS

KEYS	FUNCTION	DATA PIN	ARDUINO CONTROLLER
KEY 1	INCREMENT	DATA 1	Pin 2
KEY 2	DECREMENT	DATA 2	Pin 3

PWM OUTPUTS

PWM OUTPUTS	ARDUINO CONTROLLER	POWER SWITCH (As in inverter schematic diagram)
PWM 1	4	Q1
PWM 2	5	Q6
PWM 3	6	Q3
PWM 4	7	Q2
PWM 5	8	Q5
PWM6	9	Q4

OUTPUT OF THE MOTOR

INVERTER BOARD	OUTPUT OF THE MOTOR PHASES
PHASE 1	RED
PHASE 2	YELLOW
PHASE 3	BLUE

Figure above shows the total square outline of the created equipment for proposed framework which comprises of transformer, rectifier, channel, voltage controller LM7805 IC, proposed framework, microcontroller, resistive load and computerized storage oscilloscope. The concise clarification of each part is given as follows:

Transformer: It is static gadget which moves power from one circuit to the next circuit with steady recurrence. It takes a shot at the rule of electromagnetic enlistment. Transformer doesn't have any turning parts so the proficiency of the transformer is high contrast with the all electrical equipment's.

Rectifier: It is a gadget which changes over the ac signal into dc signal. The yield voltage of a rectifier circuit contains undesirable ac components (segments of flexibly recurrence f and its music) alongside dc part. So as to lessen ac segments from the rectifier yield voltage a filter circuit is required.

Filter: It is a gadget which passes dc segment to the load and stops ac parts of the rectifier yield. Filter is regularly built from

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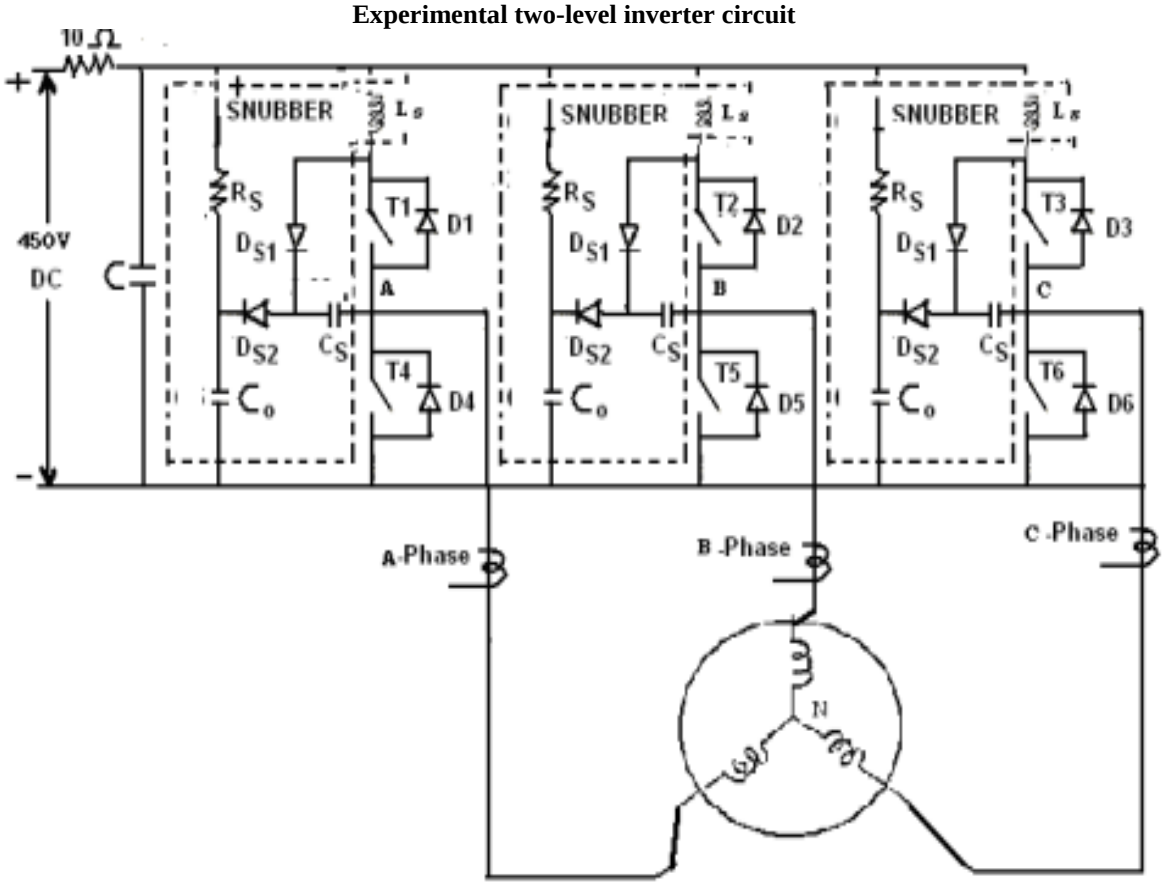
receptive circuit components, for example, capacitors and additionally inductors and resistors.

Driver circuit: The principle capacity of driver circuit is to intensify the signs which are created from microcontroller unit. TLP driver circuit additionally gives confinement between the power circuits just as the control circuit.TLP250 is increasingly reasonable for MOSFET and IGBT. The principle contrast among TLP250 and other MOSFET drivers is that TLP250 driver is optically disengaged. It implies that input and yield of TLP250 driver is disconnected from one another.

Voltage regulator: Voltage source in a circuit may have vacillations which may not give fixed yield voltage. A voltage controller keeps up steady estimation of yield voltage. 7805IC is an individual from 78xx arrangement of fixed direct voltage controllers used to keep up such variances which are a well-known voltage controller coordinated circuit (IC). The xx in 78xx shows the yield voltage it gives.

Experimental two-level inverter circuit



BLOCK DIAGRAM OF PROPOSED INVERTER

Square chart of proposed converter is as appeared in figure underneath the converters are expected to expand the voltage gain. The proposed inverter is the one which is utilized to accomplish a high voltage gain and furthermore, the high productivity

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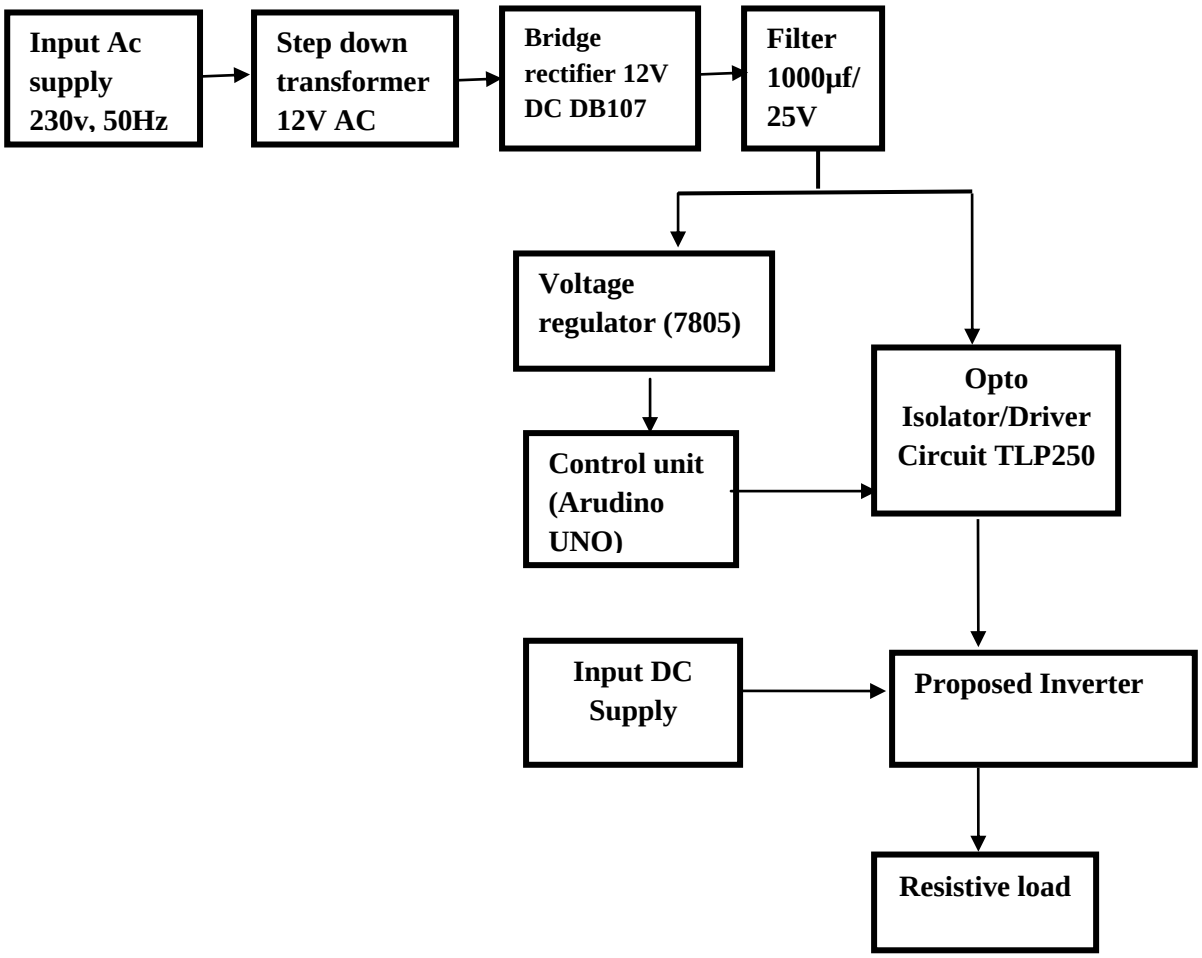

POWER SUPPLY: A 230V AC power flexibly is taken from the primary supply to run the circuit. The 230V is step down to the necessary voltage by utilizing the progression down transformer.

STEP DOWN TRANSFORMER: A 230V is step down to 12V by utilizing the progression down transformer.

EXTENSION RECTIFIER: AC flexibly of 12 V is given to the scaffold rectifier which changes over the AC supply into DC supply. DB107 is utilized as an extension rectifier.

FILTER CAPACITOR: An undesirable dc part is sifted through and unadulterated DC is given to the voltage controller.

VOLTAGE CONTROLLER: A voltage controller is intended to naturally keep up a steady voltage level. TheLM7805 voltage controller is utilized which will keep up a 5V voltage which is given to the microcontroller.

ARDUINO UNO MICROCONTROLLER: - ARDUINO is an open-source gadgets prototyping stage dependent on adaptable, simple to-utilize equipment and programming. Arudino UNO is an 8 piece microcontroller having a 14 advanced I/O pins, 6 simple info pins and 16M Hz precious stone oscillator.

OPTOCOUPLER: An optocoupler is a semiconductor gadget that utilizes a short optical transmission way to move an electrical sign between circuits or components of a circuit, while keeping them electrically secluded from one another.

VENTURE DOWN TRANSFORMER (12V-6V-12V)

It is static gadget which moves power from one circuit to the next circuit with consistent recurrence. It chips away at the rule of electromagnetic acceptance. Transformer doesn't have any turning parts so the proficiency of the transformer is high contrast with the all electrical equipment's. In the created equipment twocenter tap transformers of rating 12V-6V-12V are utilized. Information AC supply of 230V is given to essential windings of venture down transformer and auxiliary windings are associated with diode connect rectifier IC DB107 which is readymade.

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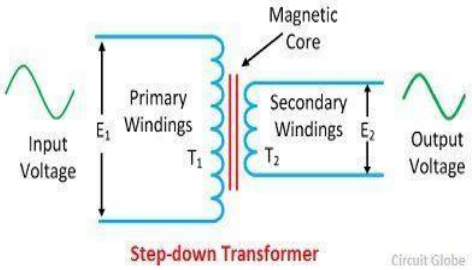
Ratings of step down transformer:
*Voltage rating: 25V
*Current rating: 1A



RECTIFIER (DB107)
It is a kind of converter which is utilized for changing over alternating current to direct current. The way toward changing over alternating current into direct current is called as correction. The yield voltage from a rectifier circuit has a throbbing character for example it contains undesirable alternating current (segments of flexibly recurrence f and its music) alongside direct current part. So as to lessen ac segments from the rectifier yield voltage a filter circuit is required.

Rating of rectifier:

- Maximum recurrent peak reverse voltage: 1000V
- Maximum RMS connect input voltage: 700V
- Maximum DC blocking voltage: 1000V
- Maximum normal forward yield current at TA = 40ºC: 1A

Bridge rectifier

CHANNEL/FILTER (1000µF CAPACITOR)
Channel is a segment which is utilized for the decrease of distortions to expel the undesirable segments from the framework. It assumes a very improvement job for improving the proficiency of the general framework. Channel is ordinarily developed from receptive circuit components, for example, capacitors and additionally inductors and resistors. Capacitor is utilized as channel circuit.

- Capacitor esteem = 1000µF
- Voltage rating = 25V

Filter as capacitor

7805 IC
This voltage controller discover applications in a large portion of the ventures where 78 shows that it is a positive voltage controller whereas the last digit 05 demonstrates that it keeps up 5V consistent yield voltage.

7805 IC rating and pin portrayal of LM7805 IC

- Input voltage go 7V - 20V
- Output Current rating is 0.5 mA to 1A
- Output voltage go VMax= 5.2V ,VMin=4.8 V
- Output Power rating ≤ 15W
- Operating temperature - 40ºC to 125ºC

Pin 1: Input voltage of 7V – 35V.
Pin 2: Connected to ground which is unbiased pin similarly for both information and yield.
Pin 3: Regulated yield of 5V (4.8 V to 5.2 V)

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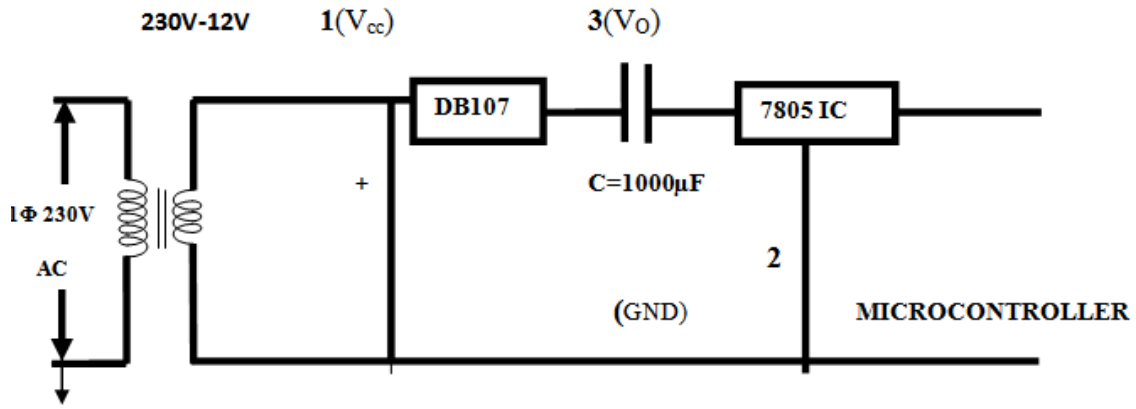

Pin diagram connection of 7805 IC

TLP 250 DRIVER CIRCUIT

The fundamental capacity of driver circuit is to intensify the signs produced from small scale controller. TLP driver circuit additionally gives confinement between the power circuit just as the control circuit.TLP250 is progressively reasonable for MOSFET and IGBT.

- Info flexibly = 10-35 V
- Info current = 11 mA (max)
- Yield current = ± 1.5 mA (max)
- Yield voltage ≤70ºC = 35V

MOSFET (IRF 840)

IRF 840MOSFET is the third era power MOSFET with the best mix of quick switching, ruggedized gadget configuration, low on-opposition and cost-effectiveness.it is favored for modern applications where power dispersal levels is around 50 W. The low warm opposition and low bundle cost add to its wide acknowledgment all through the industries.

N-channel MOSFET's are utilized as switching gadgets for structuring cascaded H - connect three level inverter. As per the switching table the MOSFET's are turned here and there for getting specific wanted level. The planned equipment creates 3 diverse voltage levels which have potential outcomes of three switching states (rehashed successions). The appraisals of IRF 840 MOSFET's are as per the following:

- Drain to source voltage (VDS) =500V
- Gate to source voltage (VGS) =500V
- Drain current ID =8A

IRF 840 is utilized in the created equipment as the outcome yield current is 0.24A with all out yield voltage V=24V and resistive burden R=100ω, consequently the appraised current ought to be more than 10-15 times the yield current

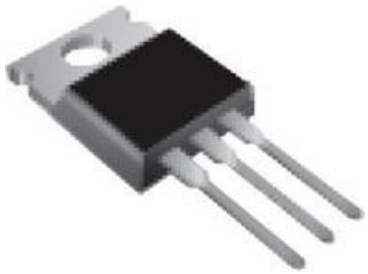

Fig IRF 840 n-channel MOSFET

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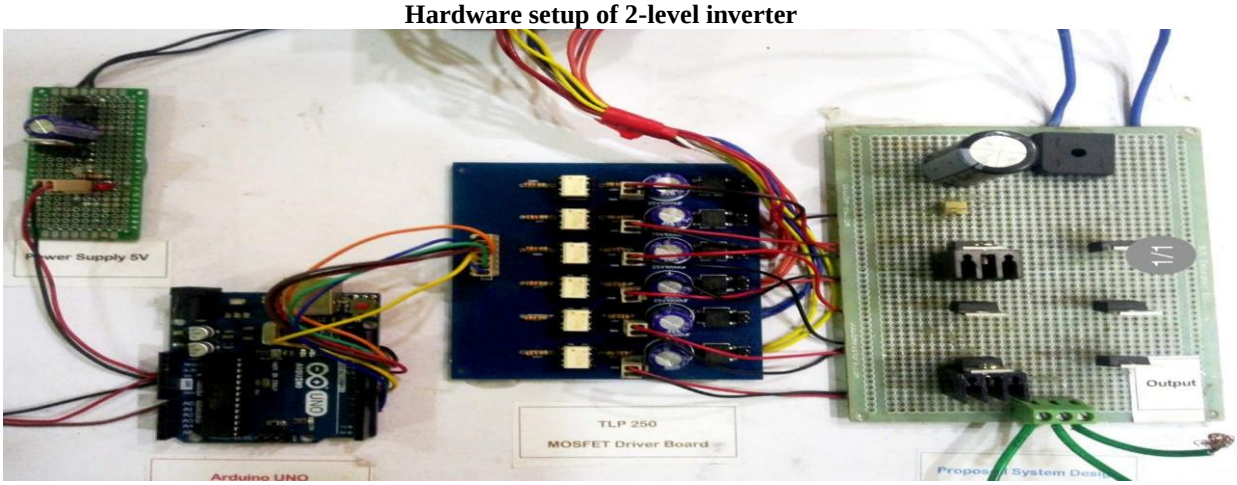
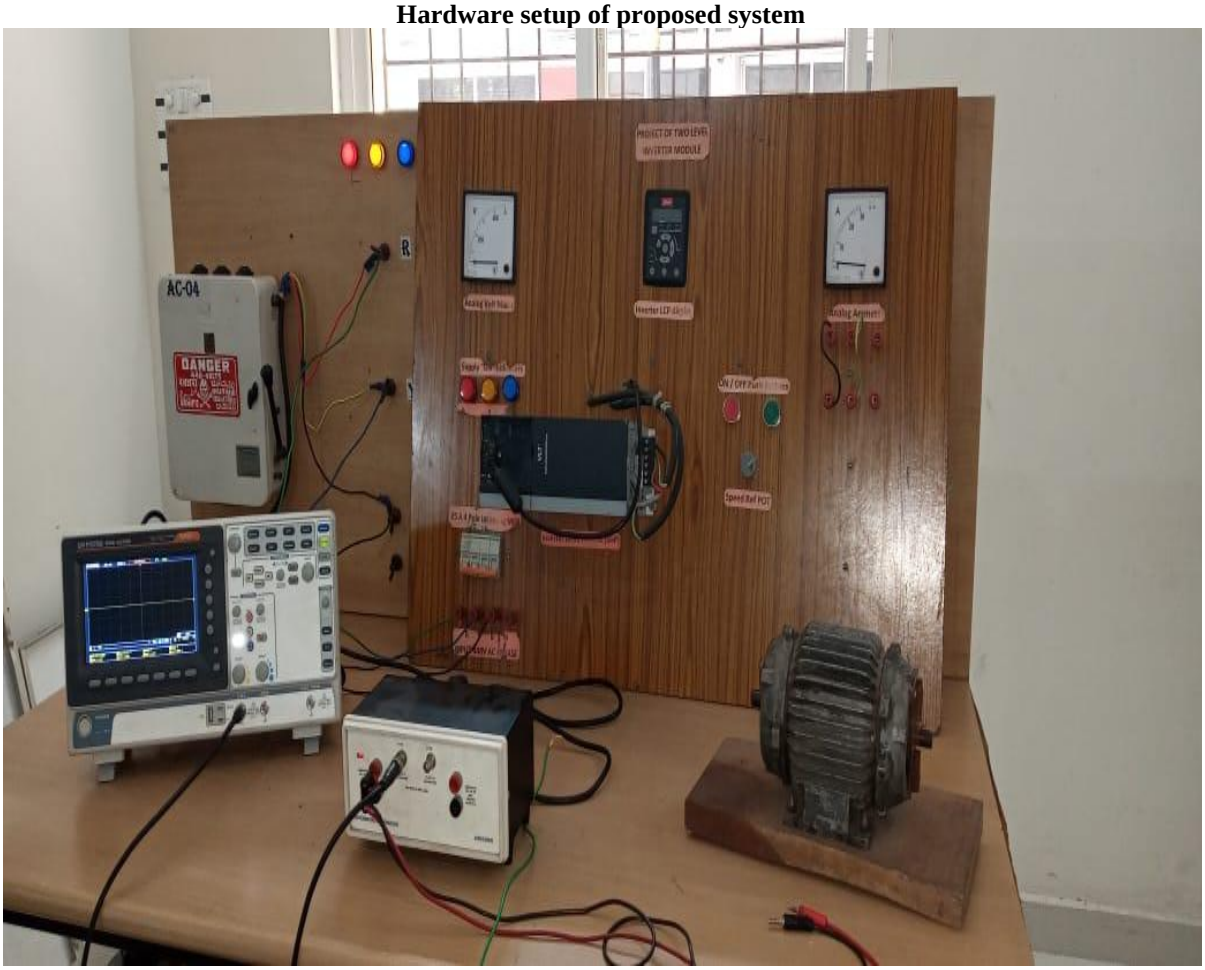
Hardware setup of 2-level inverter



Hardware setup of proposed system



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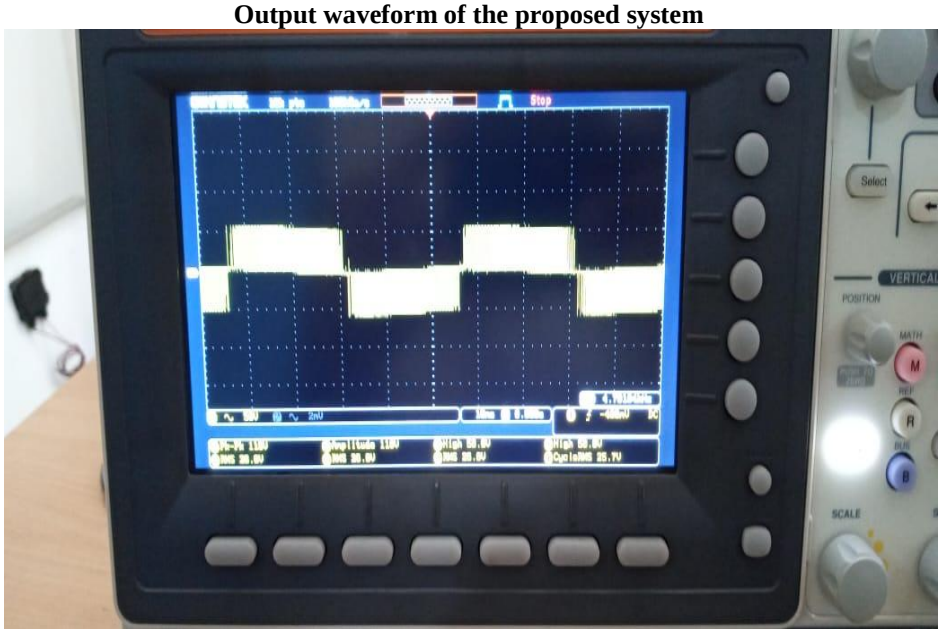
Output waveform of the proposed system

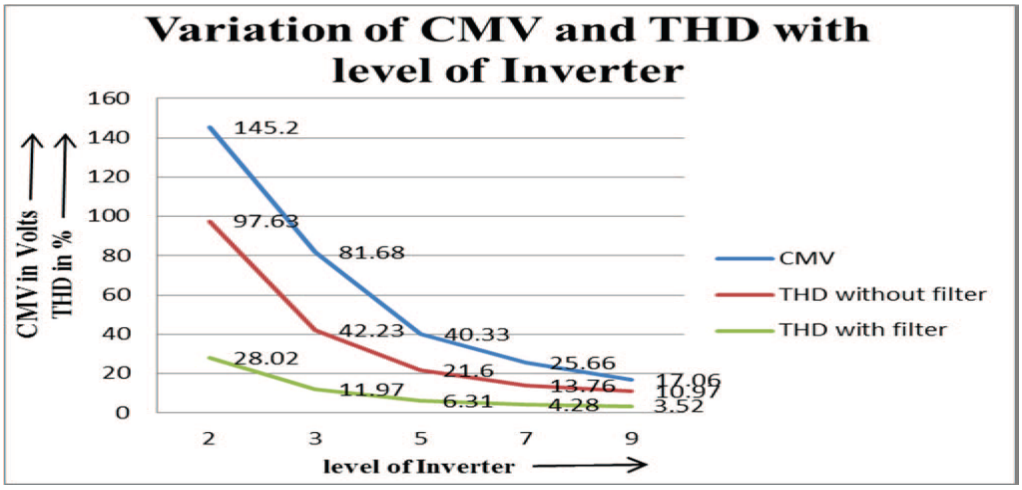


VI. TOTAL HARMONIC DISTORTION

Total Harmonic Distortion is the proportion of powerful estimation of harmonic components of a misshaped waveform. Nearness of nonlinear gadgets in power framework is reason for consonant twisting. IEEE Standard 519-1992 suggests the prerequisites for consonant control in electrical power frameworks. Inverter's yield voltage quality emphatically identified with absolute symphonious twisting. A numerical articulation for Total Harmonic Distortion is given as

$$THD = \frac{\sqrt{\sum_{h>1}^{hmax} V_h^2}}{V_1}$$

Where h is order of harmonics, 'Vh' is voltage of harmonics, and 'v1' is the major fundamental voltage. To do the Total Harmonic Distortion investigation of yield voltage of inverter, Fast Fourier change (FFT) is utilized. The calculation requires a lot of counts, yet with the assistance of MATLAB reproduction programming, estimations are done without any problem. Total Harmonic Distortion is additionally diminished alongside Common Mode Voltage in SPWM controlled Diode Clamped Multi-level inverter.



Variety of Common Mode Voltage and Total Harmonic Distortion with level of Inverter

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VII. SIMULINKIMPLEMENTATION& ITS RESULTS

INTRODUCTIONTO MATLAB/SIMULINK

MATLAB (Matrix Laboratory) was invented in late 1970s by Cleve Moler. Its high level language and interactive environment helps us to perform intensive tasks faster than the traditional programming languages such as C, C++ and FORTRAN. Another important feature of MATLAB is that it helps in modeling, simulating and analyzing dynamic systems. MATLAB is a high-performance language for technical computing. It integrates computation, visualization and programming in an easy to use environment where problems and solutions are expressed in familiar mathematical notation. Typical uses of MATLAB include.

- Math and Computation
- Algorithm development
- Data acquisition
- Modeling, Simulating and prototype
- Data analysis, exploration and visualization
- Scientific and engineering graphics
- Application development, including graphical user interface building

MATLAB 10a is an interactive system whose basic data element is an array that does not require dimensioning. This allows us to solve many technical computing problems, especially those with matrix and vector formulations, in a fraction of the time it would take to write a program in a scalar non interactive language such as C or FORTRAN.

SIMULINK is a toolbox extension of the MATLAB program. It is a program for simulating dynamic systems. SIMULINK has the advantages of being capable of complex dynamic system simulations, graphical environment with visual real time programming and broad selection of tool boxes. The simulation environment of SIMULINK has a high flexibility and expandability which allows the possibility of development of a set of functions for a detailed analysis of the electrical drive. Its graphical interface allows selection of functions blocks, their placement on a worksheet, selection of their functional parameters interactively and description of signal flow by connecting their data lines using a mouse device. System blocks are constructed of lower level blocks grouped into a single maskable block. SIMULINK simulates analogue systems and discrete digital systems. Modeling and simulation is usually used in designing permanent magnet drives compared to building system prototype because of the cost. Having selected all components, the simulation process can start to calculate steady state and dynamic performance and losses that would have been obtained if the drive were actually constructed. This practice reduces time, cost of building prototype and ensures that requirement is achieved.

KEYFEATURES

- Extensive and expandable libraries of predefined blocks.
- Interactive graphical editor for assembling and managing intuitive block diagrams.
- Ability to manage complex designs by segmenting models into hierarchies of design components.
- Model explorer to navigate, creates, configures and searches all signals, parameters, properties and generated code associated with your model.
- Application programming interfaces (APIs) that let you connect with other simulation programs and incorporate hand written code.
- Embedded MATLAB function blocks for bringing MATLAB algorithms into SIMULINK and embedded system implementations.

ROLEOFSIMULATIONDESIGN

Electrical power systems are combinations of electrical and electromechanical devices like motors and generators. Engineers working in this discipline are constantly improving the performance of the systems. Requirements for drastically improved efficiency have forced power system designers to use power electronic devices and sophisticate control system concepts that tax traditional analysis tools and techniques. Further complicating the analyst's role is the fact that the system is often so nonlinear that the only way to understand it is through simulation. SIM WERSYSTEMS is a modern tool that allows scientists and engineers to rapidly and easily build models that simulate power systems. SIM WERSYSTEMS uses the

SIMULINK environment, allowing building model using simple click and drag procedures. Not only can draw the circuit to logy rapidly, but analysis of the circuit can include its interactions with mechanical, thermal, control and other disciplines. This is possible because all the electrical parts of simulation interact with the extensive SIMULINK.

DESIGNANDSIMULATIONOFASIMPLECIRCUIT

modeling library. Since SIMULINK uses MATLAB R2013a as its computational engine, designers can also use MATLAB toolboxes and SIMULINK block sets.

SIMWERSYSTEMSLIBRARIES

Simpower systems can be made to work rapidly. The libraries contain models of typical power equipment such as transformers, lines, machines and power electronics. These models are proven ones coming from textbooks and their validity is based on the experience of the power systems testing and simulation laboratory of hydro Quebec, a large North American utility located in Canada and also on the experience of Ecole de technologies superieure and university Laval. The capabilities of sim power systems for modeling typical electrical systems are illustrated in demonstration files. And for users who want to refresh their knowledge of power system theory, there are also self-learning case studies. A Sim power system allows building and simulating of electrical circuits containing linear and non-linear elements. In this section it is possible to:

1. Explore thepowerlib library of Sim power systems.
2. Learn how to build a simple circuit from the powerlib library.
3. Interconnect simulink blocks with your circuit.

This section contains discussion of the following topics:

1. Building the electrical circuit with powerlib library.
2. Interfacing the electrical circuit with simulink.
3. Measuring voltages and currents.
4. Basic principles of connecting capacitors and inductors.
5. Using thepowerlib block to simulate sim power systems models.

DESIGNINGANELECTRICALCIRCUITWITH WERLIBLIBRARY

The graphical user interface makes use of the simulink functionality to interconnect various electrical components. The electrical components are grouped in a special library called powerlib. Sim power systems library is opened by entering the following command at the MATLAB prompt. WERLIB- This command displays a simulink window showing icons of different block libraries. It is possible to open these libraries to produce the windows containing blocks to be copied into given circuit. Each component is represented by a special icon having one or several inputs and outputs corresponding to the different terminals of the component.

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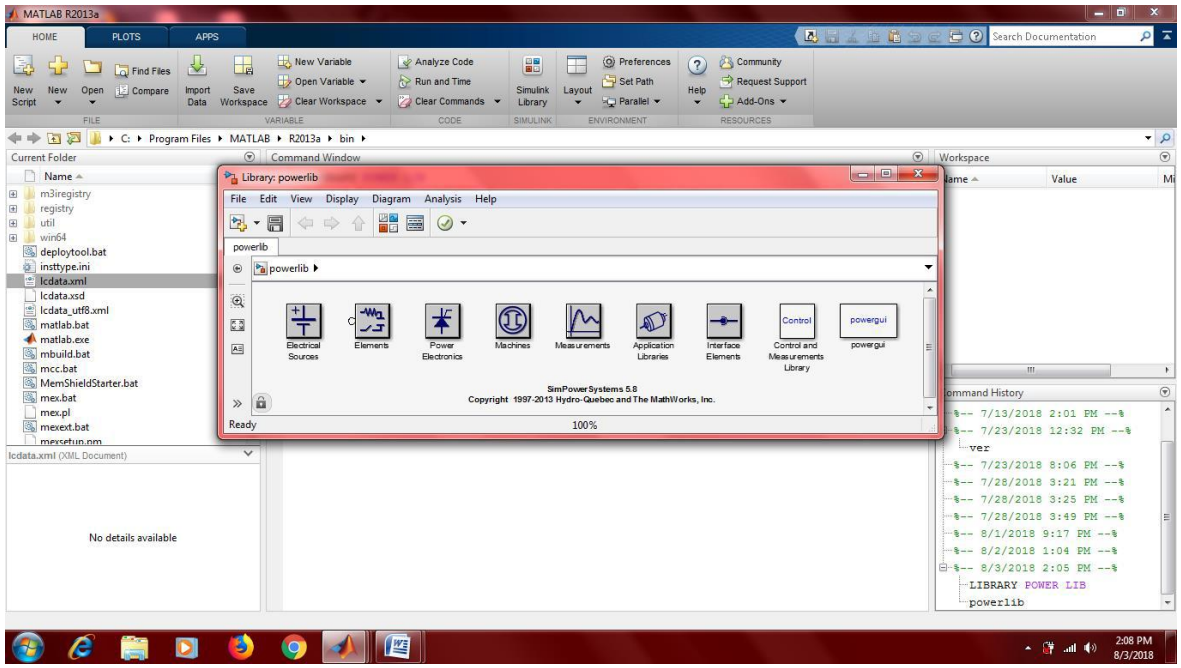


Powerlib library

INTERFACING ELECTRICAL CIRCUIT WITH SIMULINK

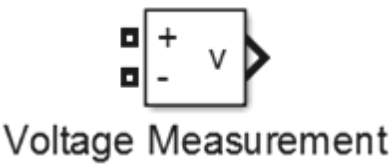
Thevoltagemeasurementblockactsasaninterfacebetweentheir powersystemsblocksandtheSimulinkblocks.Thevoltagemeasurementblockconvertsthemeasuredvoltageintotheir Simulinksignals.Thecurrentmeasurementblockfromthemeasurementslibraryofpowerlibcanalso be used to convert any measured current into Simulink signal. Itisalso possibletointerfacefromSimulinkblockstotheelectricalsystem.Forexample,itis possibletousethecontrolledvoltagesourceblocktoinjectavoltageinanelectricalcircuit.

MEASURINGVOLTAGESANDCURRENTS

Tomeasureacurrentusingacurrentmeasurementblock,the positivedirectionofcurrentisindicatedontheblockicon(positivecurrentflowingfrom positiveterminaltonegativeterminal).Similarly,when tomeasureavoltageusingavoltagemeasurementblock,themeasuredvoltageisthevoltageofthe positiveterminalwithrespecttothenegativeterminal. However,whenvoltagesandcurrentsoftheblocksfrom theelementslibraryaremeasuredusingthemulti-meterblock,thevoltageandthecurrent polaritiesarenotimmediatelyobviousbecauseblocks mighthavebeenrotatedandtherearenosignsindicating polaritiesontheblockicons.Unlikesimulinksignallines andinputandoutput ports,thephysicalmodelingconnectionlinesandterminals portsofsim powersystemslackintrinsicdirectionality.Thevoltage andcurrent polaritiesaredetermined,notbylinedirection,butinsteadbyblockorientation.

Voltagemeasurement

The voltage measurement block measures the instantaneous voltage between two electric nodes. The output provides a simulink signal that can be used by other simulink blocks.



Voltage Measurement Block

This species formats of an output signal, when the block is used in a phasor simulation. The output signal parameter is disabled when the block is not in a phasor simulation.

Currentmeasurement

The current measurement block is used to measure the instantaneous current flowing in any electrical block or connection line. The Simulink output provides a Simulink signal that can be used by other Simulink blocks.

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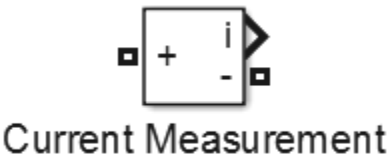

Current Measurement Block

• We get the MATLAB software version R2013a from the Google, download and install it and provide the license then key accept the terms and condition and it is ready to use.
• Open the MATLAB software in that open a new file, then a new window appears there we can construct the model to be simulate.
• Library browser there we can get the components to create a model.
• In the library browser go to simscape click on that, in that click on sim power system there we will get our components.
• wergui block is to be inserted first it is used whenever a sim power tool is used and the wergui block is there in sim power system.
• Then under sim power system go to power electronics where we will get thyristors, diodes, IGBT‟s and MOSFET‟s to place them in the model drag them to model or double click on the component it will appears in the model. In my work am using IGBT‟s and diodes.
• Then take a voltage and current sources from the electrical sources, to give the input voltage source is used and to measure the current, current source is used and product of current and voltage gives the power to display that power input and output blocks are used.
• To measure voltage and current measurements blocks are used those are available in sim power system.
• Scope is used to see the results of any block such as current and voltage waveforms.
• To display the values display is used.
This species formats of an output signal when the block is used in a phased simulation. The output signal parameter is disabled when the block is not used in phased simulation.
To develop the simulation part for the proposed system the following steps are followed
• The dragged components from the library browser are all connected by dragging the plus „+‟ point which comes when you click the block or component.
• After connecting all components give the simulation run time it decide how fast the simulation is to be done. It depends on the components which are used in the simulation model.
• To know about any components right click on the component then click on properties, if any changes are to make then we can change.
• Save the file name with .mdl extension, for example simulation.mdl.
• Then run the model by clicking simulation in the tool bar then click on run, after the run is completed it shows 100% then click on the scope to view the input and output waveforms and the values are displayed in the display box

STARTUSINGSIMULINK
To start Simulink from the MATLAB IDE:
Open MATLAB and select the Simulink icon in the Toolbar

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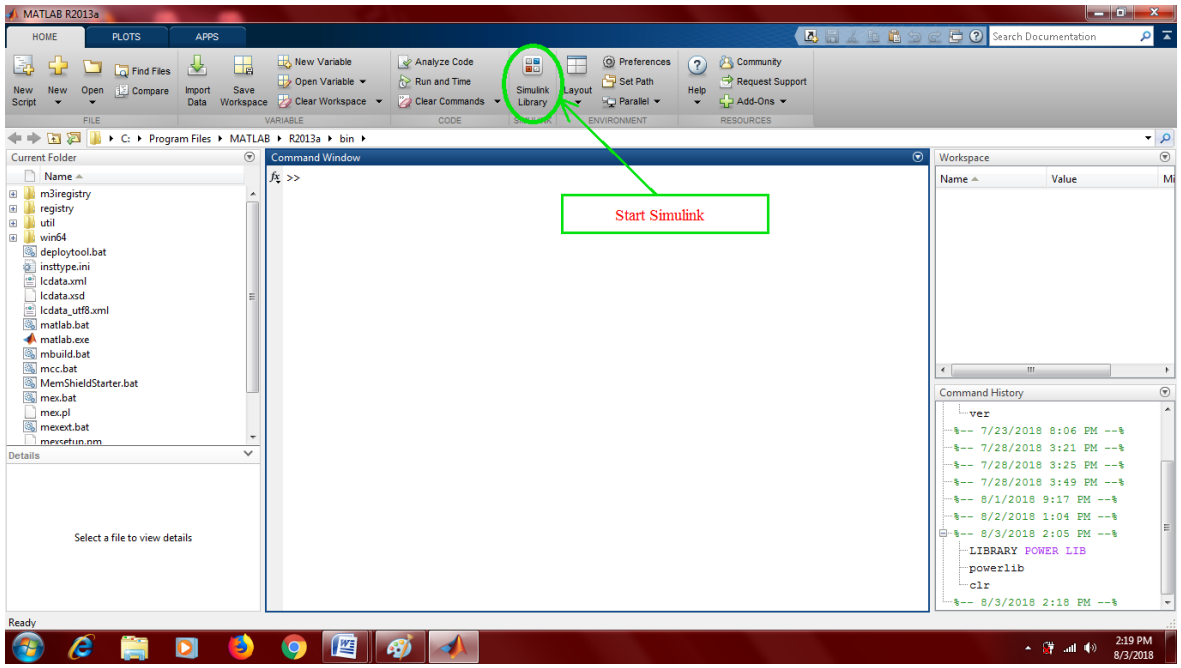
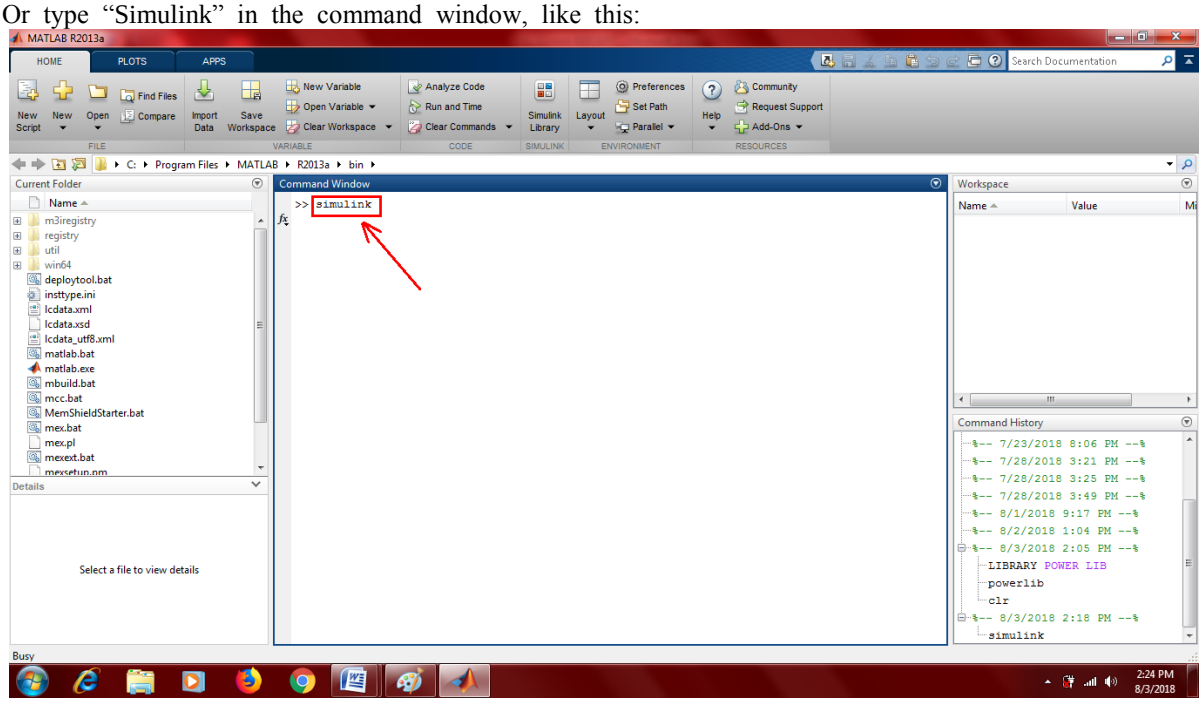


Or type "Simulink" in the command window, like this:



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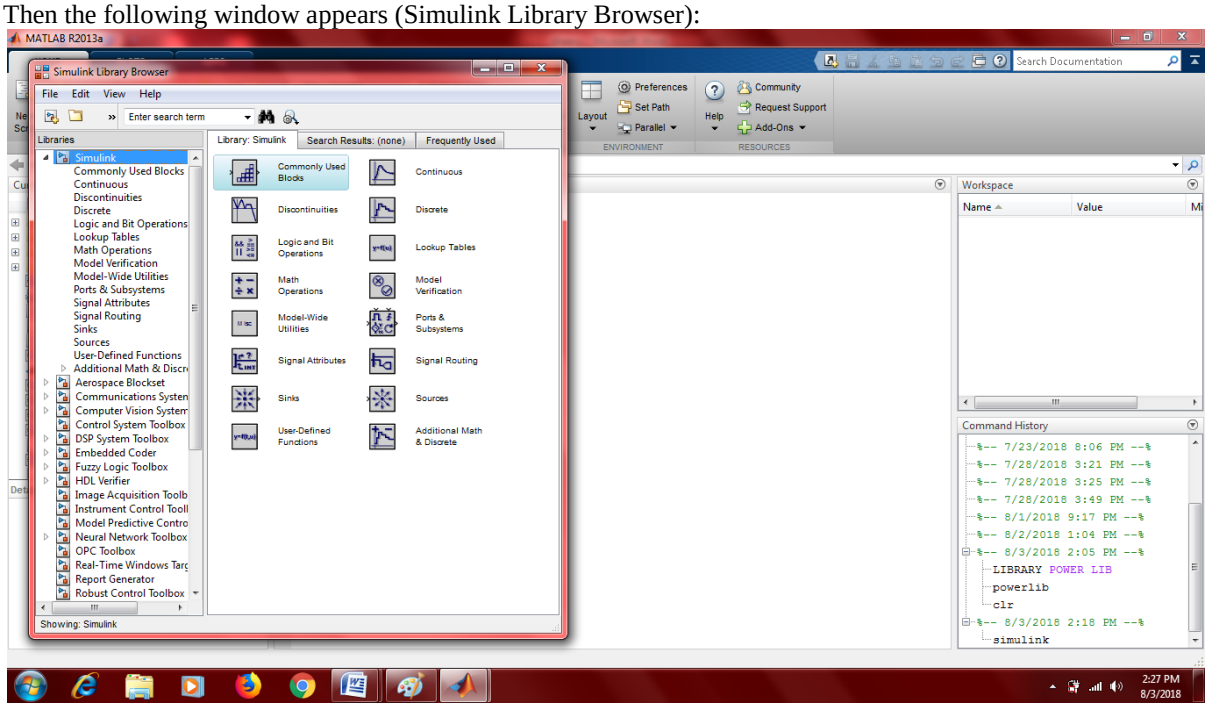
Then the following window appears (Simulink Library Browser):

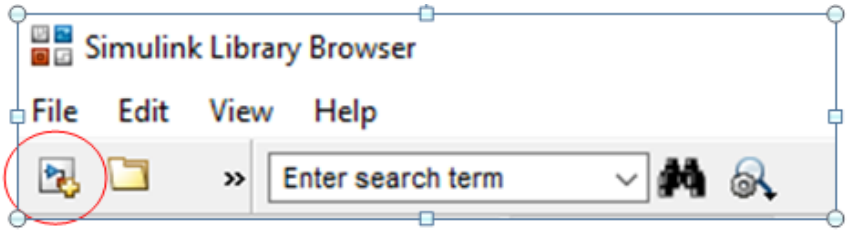


The Simulink Library Browser is the library where you find all the blocks you may use in Simulink. Simulink software includes an extensive library of functions commonly used in modeling a system. Theseinclude:

- Continuous and discrete dynamics blocks ,such as Integration, Transfer functions, Transport delay etc
- Math blocks, such as Sum, Product, Add etc.
- Sources, such as Ramp, Random Generator, Step etc.

CREATEANEWMODEL:

Click the New icon on the Toolbar in order to create a new Simulink model:



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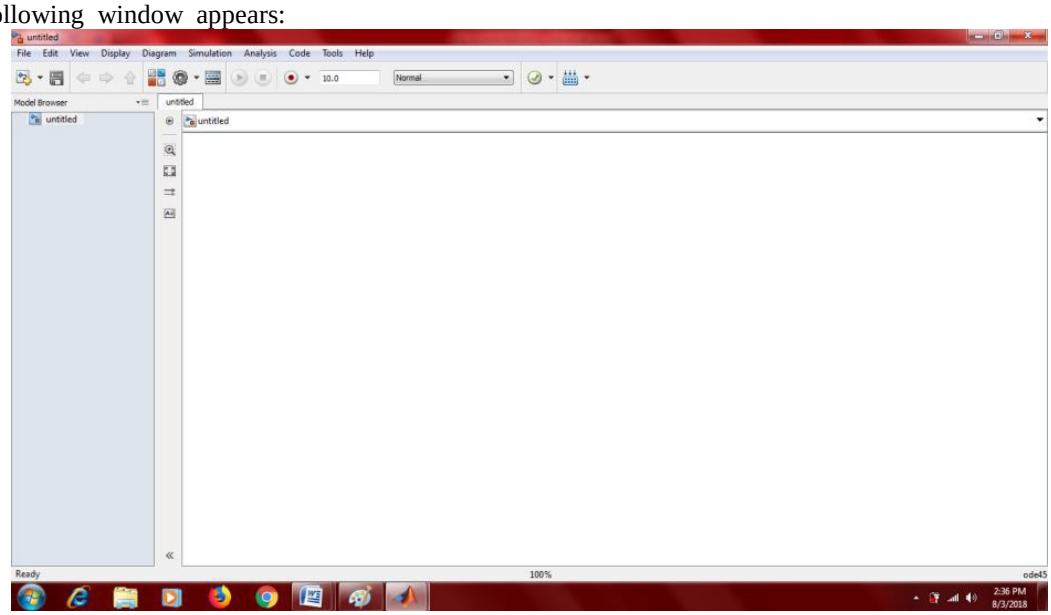
The following window appears:

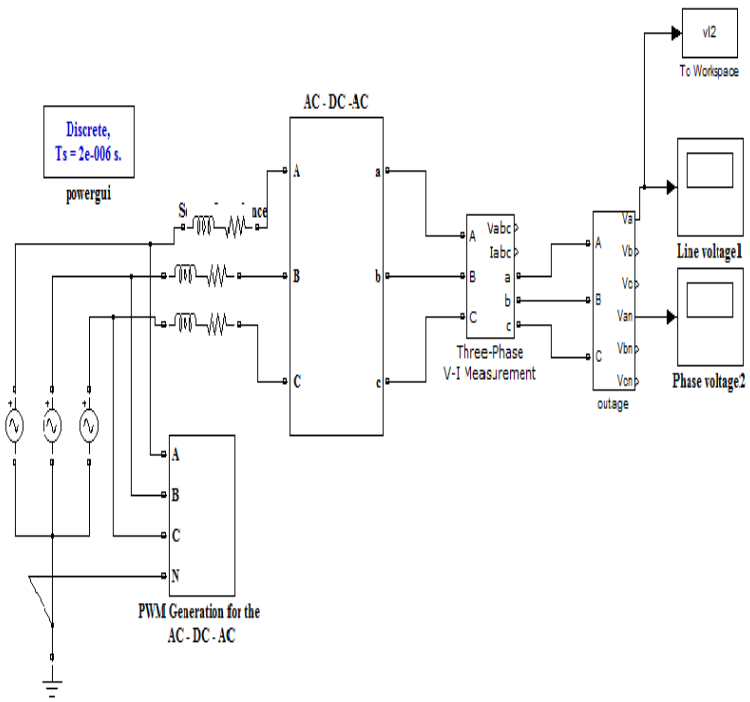


You may now drag the blocks you want to use from the Simulink Library Browser to the Model surface (or right-click on a block and select "Add to…").

SimulationofACLoadsetup

In this thesis we are representing AC simulation part for EMS as shown in fig 15 by referring fig 4. We are using MATLAB R2013a version for this simulation part and in fig 4 WER IGBT's are used for operation purpose but here we are using POWER MOSFET's for simulation as well as hardware purpose because POWER MOSFET's has lower voltages with higher communication speed and greater efficiency than POWER IGBT's.

Simulink model of 2-Level inverter fed IM using SPWM.



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Reenactment is completed utilizing MATLAB/SIMULINK programming. Fig above Shows SIMULINK model for 2-level inverter took care of IM drive utilizing SPWM procedure. PWM signals are created utilizing a high recurrence triangular wave, called the transporter wave, is contrasted with a sinusoidal sign speaking to the ideal yield, called the reference wave. At whatever point the transporter wave is not exactly the reference, a comparator produces a high yield signal, which turns the upper switch in one leg of the inverter ON the lower switch OFF. In the other case the comparator sets the terminating signal low, which turns the lower switch ON and upper switch OFF.SIMULINK model likewise incorporates Common Mode proportionate circuit with bearing model for estimation of shaft voltage and bearing current. Technique utilized in displaying of Induction Motor and Common Mode proportional circuit boundaries is as in the reference.

The SIMULINK model for 2 Level Inverter took care of IM drive utilizing SPWM method. Gating signals are created utilizing co-ordinate change a-b-c to d-q. Switching time length for every part and switching time of each switch is resolved and applied to the switching gadgets.

2-level Inverter recreation results

A two level inverter utilizing SPWM is reproduced in MATLAB Simulink for 440 V Input voltage, 1000Hz Carrier recurrence, 50 Hz essential recurrence. Figures below a & b shows recreation results for 2-level inverter. In SPWM controlled 2-level inverter the rms estimation of Common Mode Voltage is 145.1V what's more, Total Harmonic Distortion of 97.62% is seen in line voltage without filter. With LC filter Total Harmonic Distortion is decreased to 28.05%.

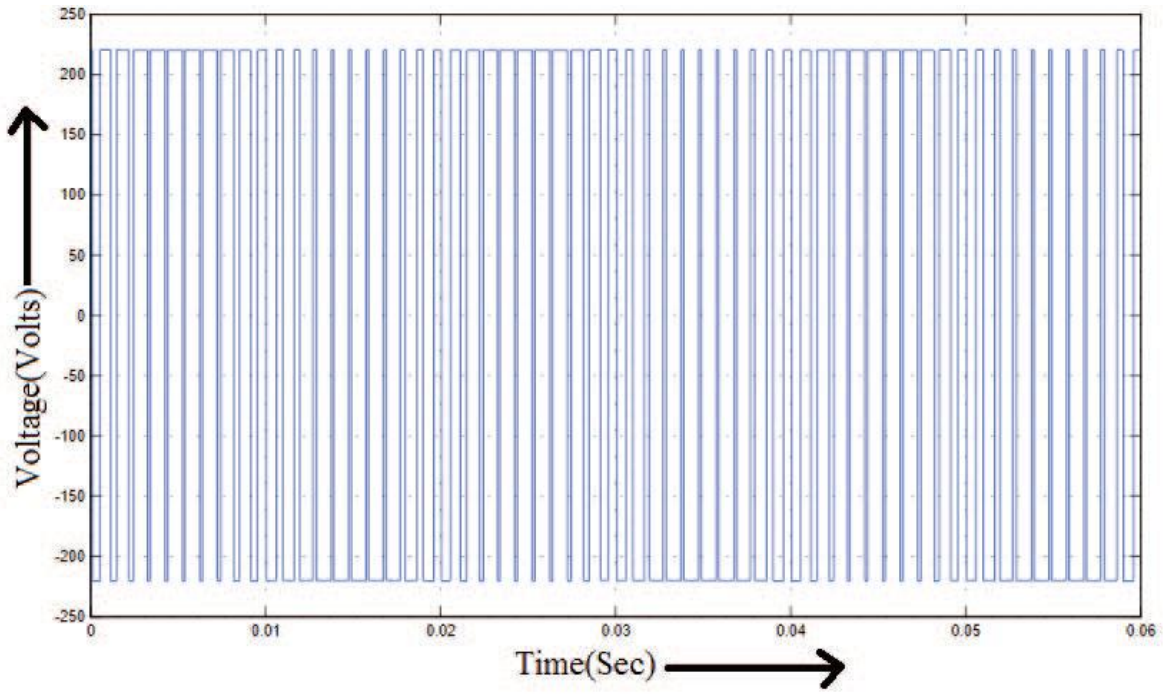

Fig a:-2-Level Inverter phase voltage Va0

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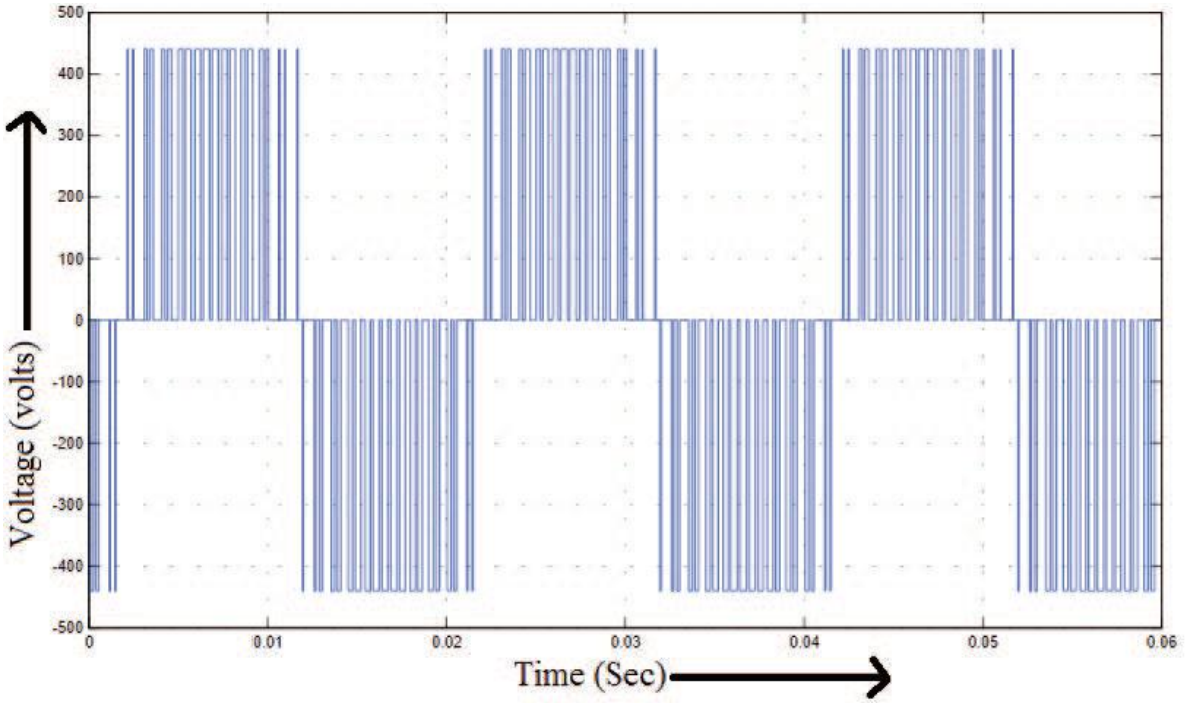

Fig b:- 2- Level Inverter line voltage Vab without filter

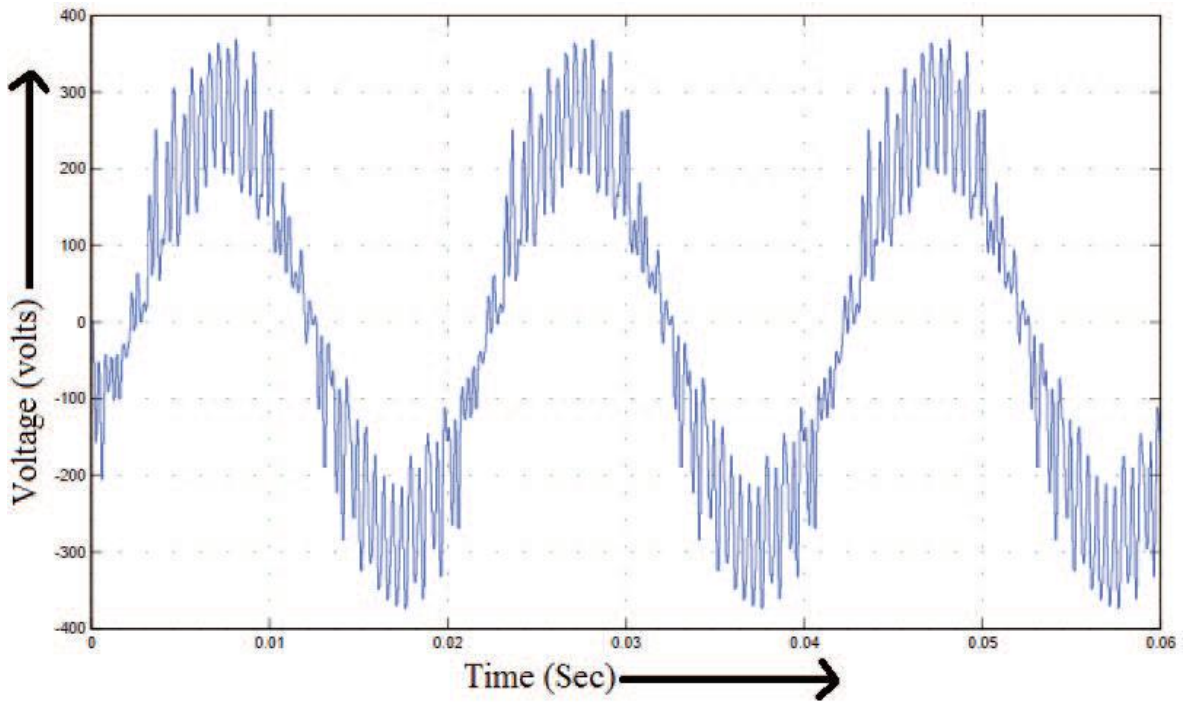

Fig c:- 2- Level Inverter line voltage Vab with filter

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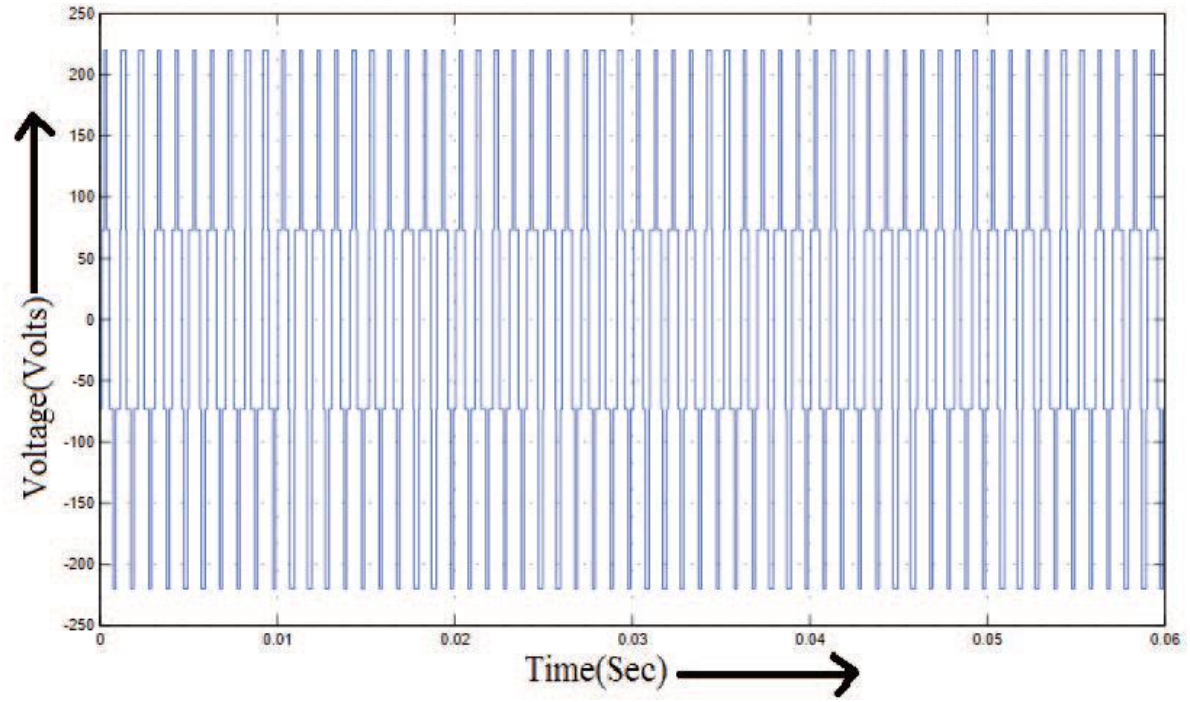

Fig d:-.2-Level Inverter Common Mode Voltage waveform

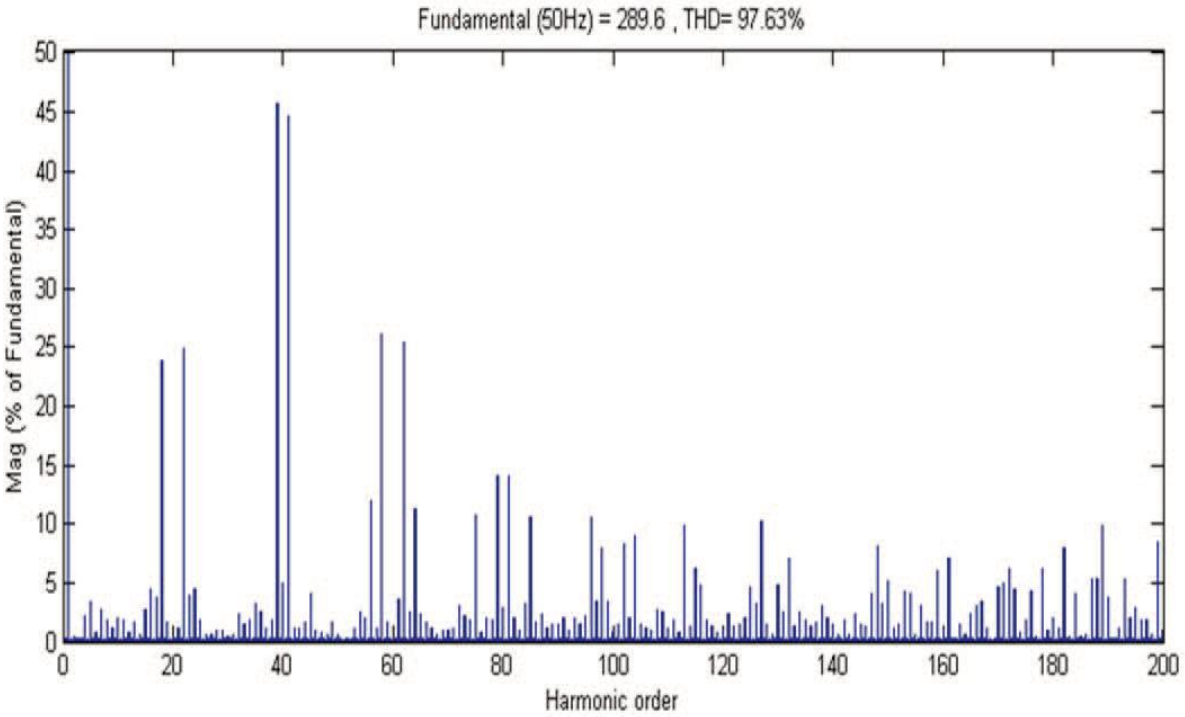

Fig e:- Line voltage THD analysis of 2-level inverter without filter

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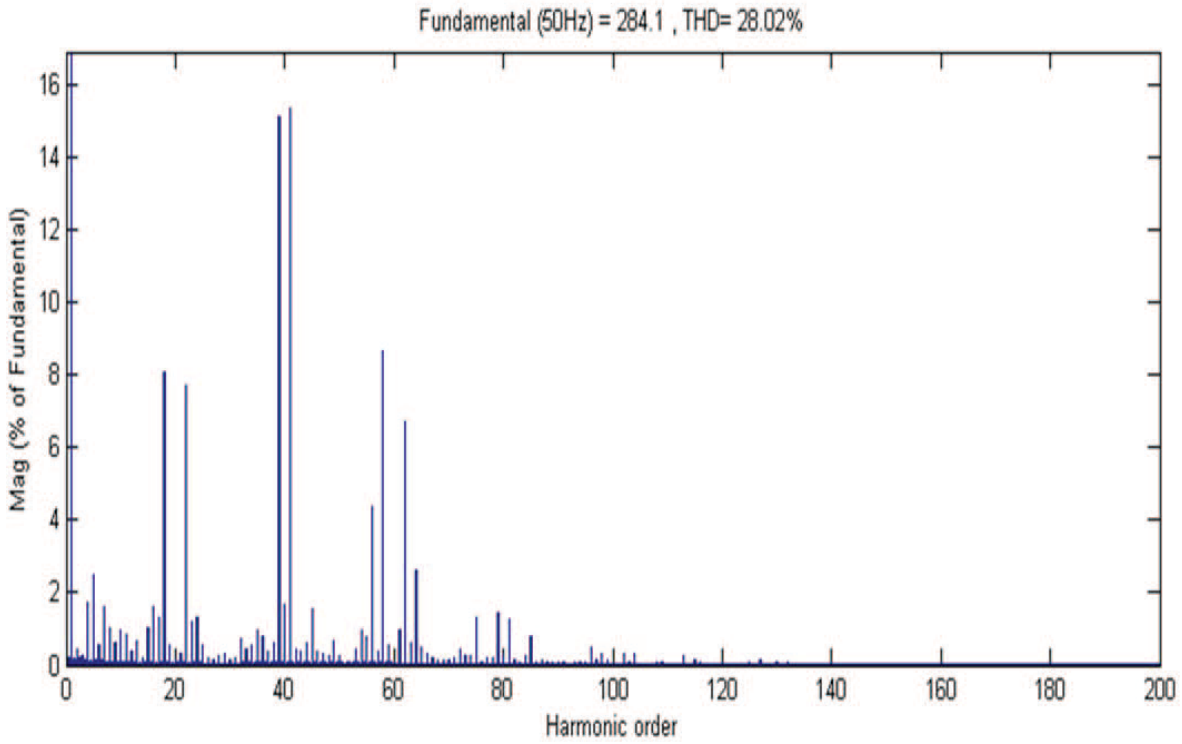
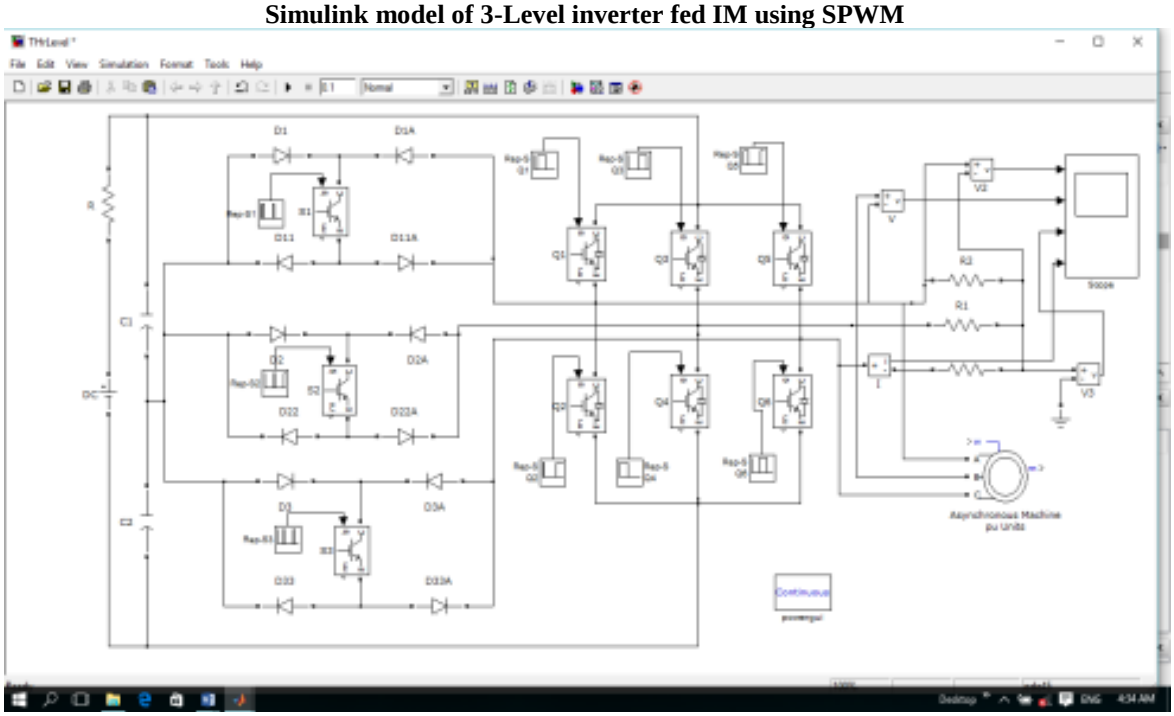


Fig f:- :- Line voltage THD analysis of 2-level inverter with filter

Simulink model of 3-Level inverter fed IM using SPWM



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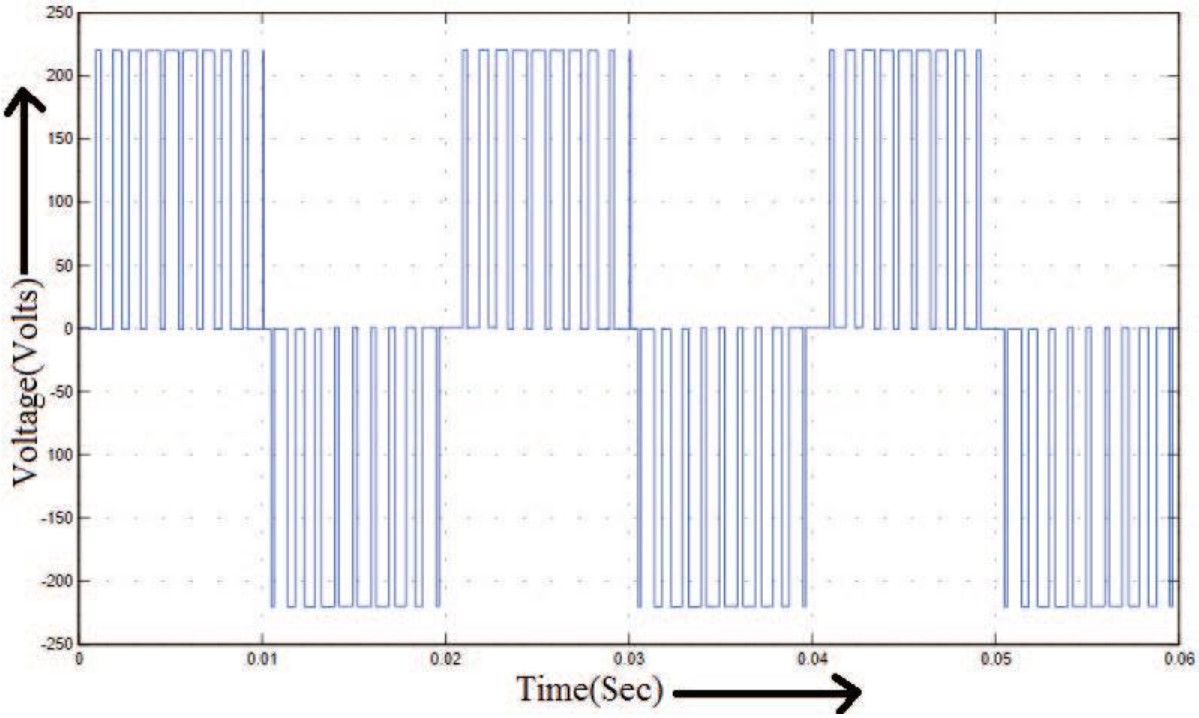

Fig 1:-3-Level Inverter phase voltage Va0

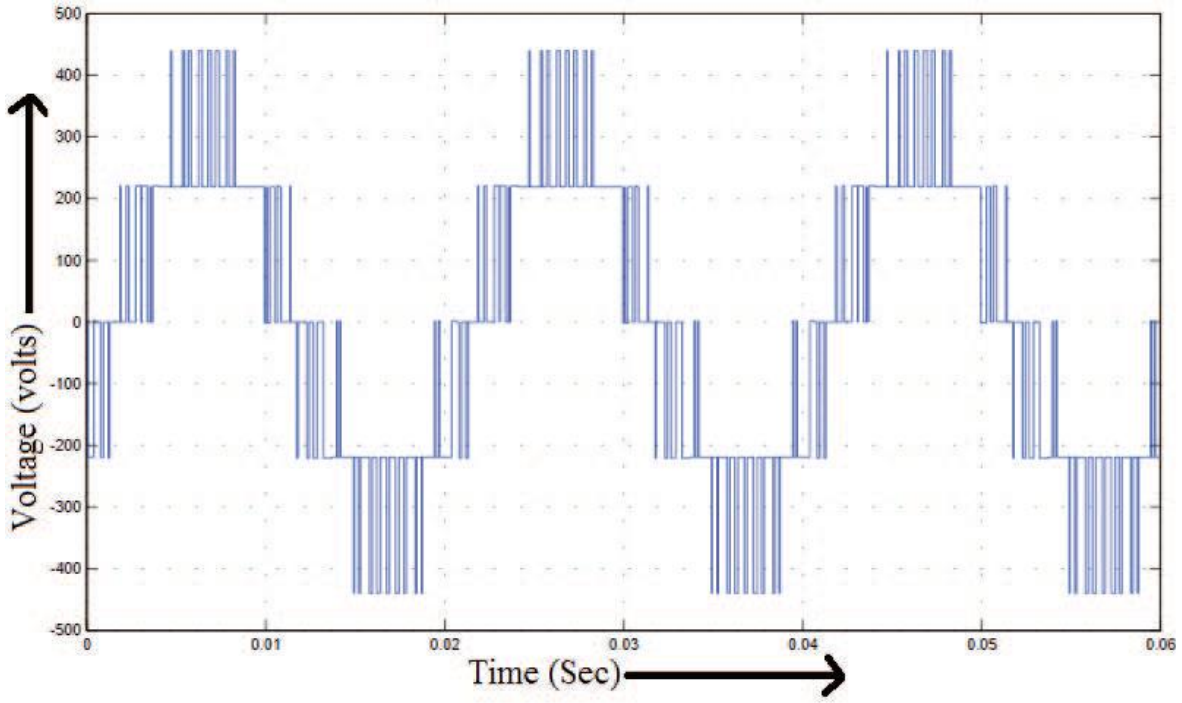

Fig b:- 3- Level Inverter line voltage Vab without filter

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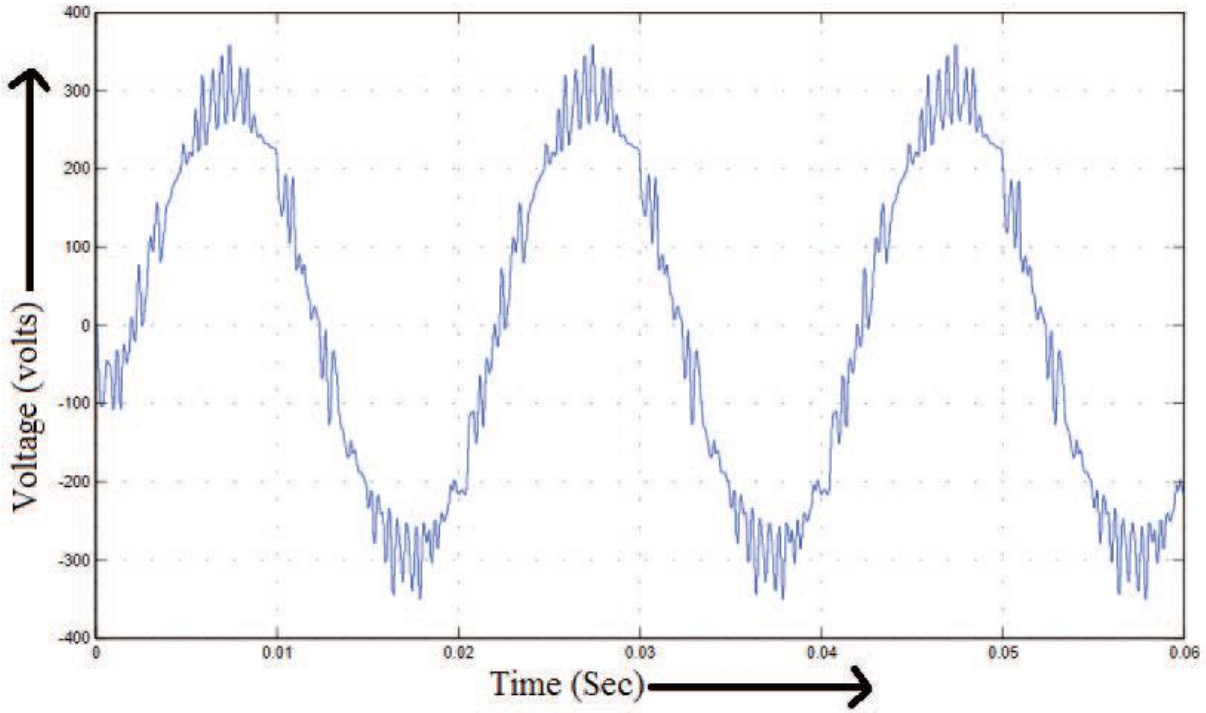
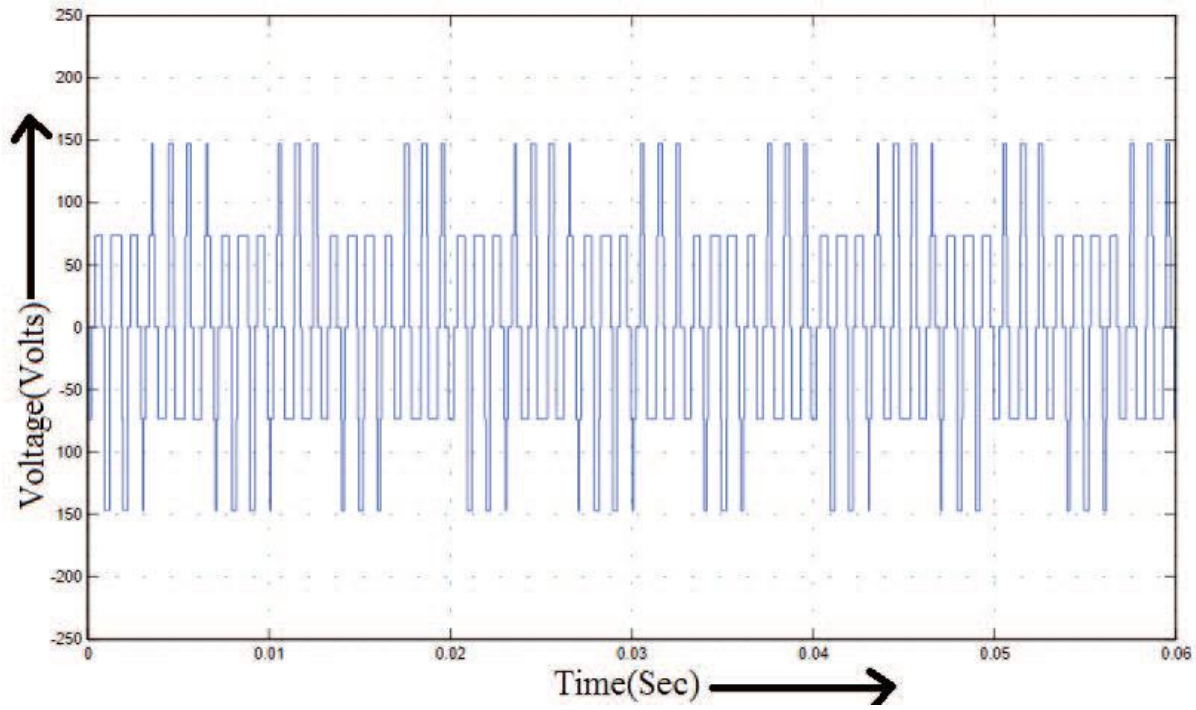


3- Level Inverter line voltage Vab with filter



.3-Level Inverter Common Mode Voltage waveform

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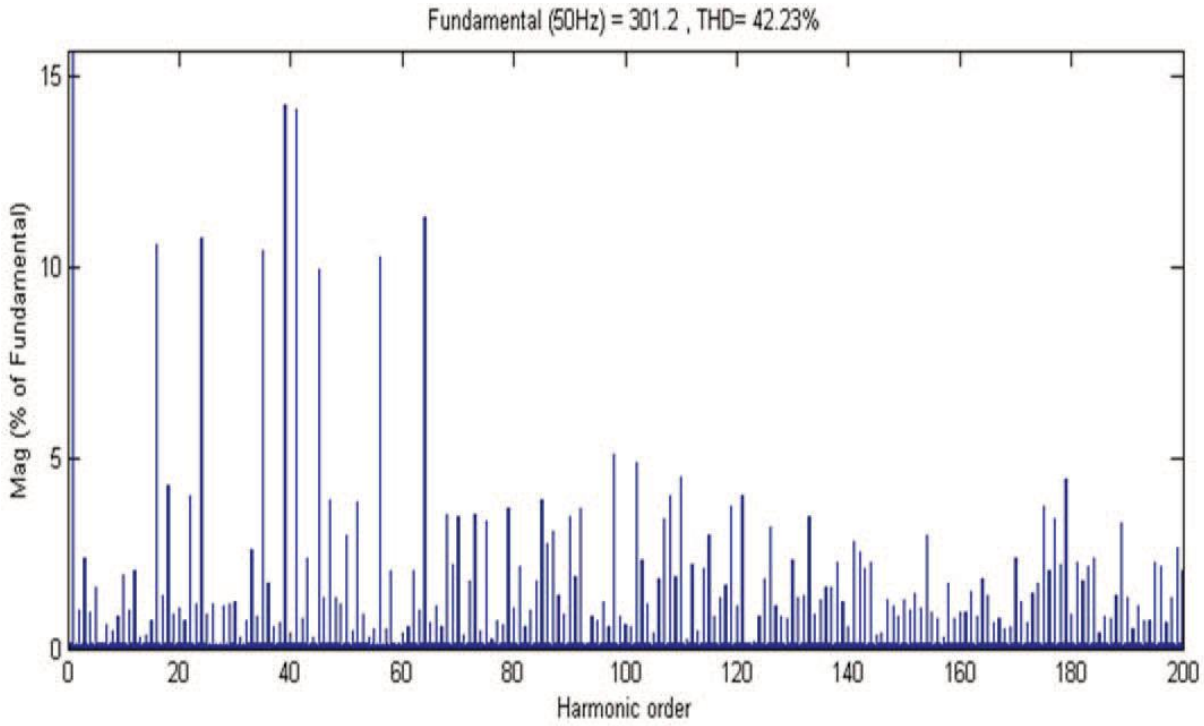
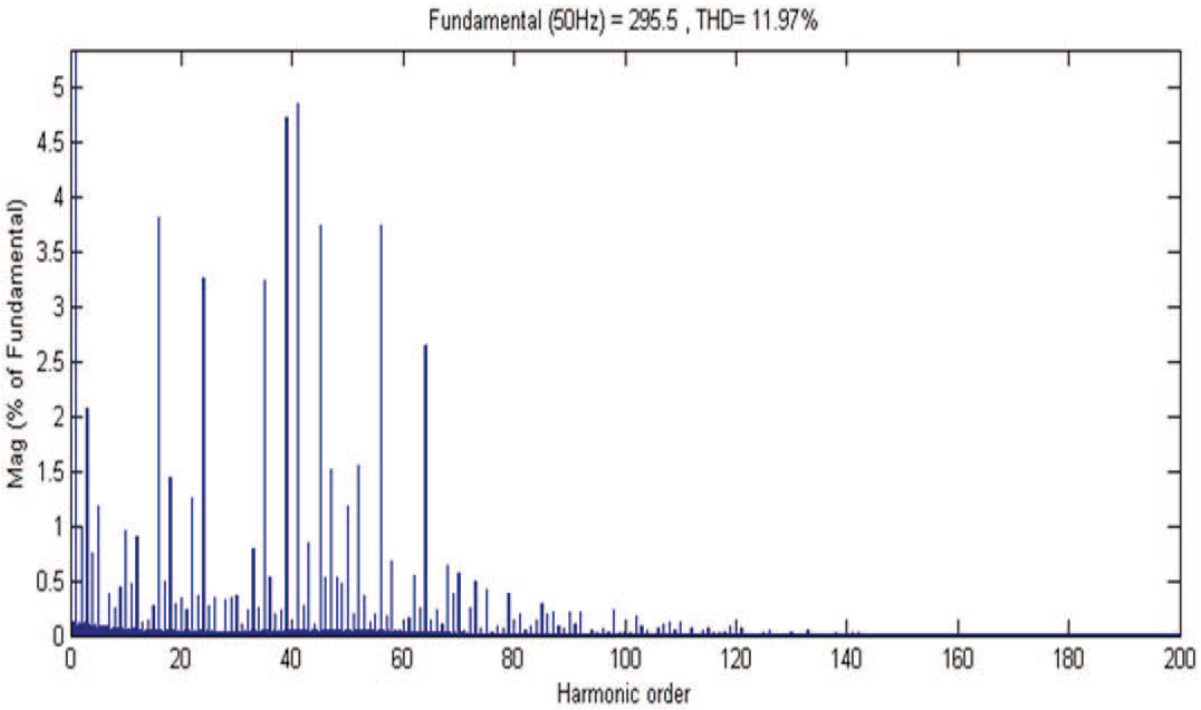


Line voltage THD analysis of 3-level inverter without filter



Line voltage THD analysis of 3-level inverter with filter

VIII. CONCLUSION

The proposed system gives the comparison result of three phase 2-level inverter with 6 devices & three phase 3-level inverter fed IM drive system for the harmonic components of the Common Mode Voltage. The amplitudes of CMV are reduced when the harmonics frequency increases. It has been verified that in the Common Mode Voltage, the harmonic frequencies are three times the fundamental frequency (For 50Hz, harmonics at 150, 450 and 750Hz… etc.). It is observed from the Table below that the 3-level inverter with 9 devices results are compared with the 2-level inverter that has the reduced Common Mode Voltage, Hence the harmonic content will also be lower and this would cause less stresses on Induction Motor winding insulation.

Parameters	2-level (6 devices)		
Frequency	30Hz	40Hz	50Hz
CMV(Simulation)	110V	155V	162V
CMV(Exptl.)	100V	151.5V	160V

Parameters	3-level (9 devices)		
Frequency	30Hz	40Hz	50Hz
CMV(Simulation)	110V	105V	100V
CMV(Exptl.)	95V	82V	80V

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