

Design and Simulation Analysis of Cascaded H Bridge Multi Level Inverter with Reduced the Number of Switches and THD

MD. Samdani¹, Dr.R.Kannan² and Dr. S. Chandrashekar Reddy³

Research Scholar, Department of Electrical Engineering, Annamalai University,
Annamalai Nagar, Tamilnadu, India¹

Associate Professor, Department of Electrical Engineering, Annamalai University,
Annamalai Nagar, Tamilnadu, India²

Professor, Department of Electrical Engineering, Christu Jyothi Institute of
Technology & Science, Jangaon, Warangal, Telangana.³



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inverter.

ABSTRACT

Nowadays multilevel inverter (MLI) technologies become extremely main choice in the area of high power medium voltage energy control. Although multilevel inverter has a number of advantages it has drawbacks in the layer of higher levels because of using large number of semiconductor switches. This may leads to large size and price of the inverter is very high and also increase in losses. So in order to reduce these difficulties in the new multilevel inverter is proposed to reducing the switches. The increase in the level of output, number of switching equipments besides with the switching states enhances. As a consequence, higher switching losses occurs that prompts power loss. Accordingly, the efficiency of the complete conversion network diminishes. The significant characteristics of this submitted work is that the module can be accomplished as sub multiple level assembly. Progressively, with minimal rise in the switching elements, all number of levels can be elongated. This paper is subdivided into introduction explaining in short about the structural components of the inverter then after that analysis of the proposed inverter that is switching strategy and operational principles are given. This paper represents Symmetric Cascaded Multilevel inverter which utilizes variable frequency carrier predicated pulse width modulation techniques. This topology helps in decreasing total harmonic distortion and helps to reduce the switching losses for various level inverters. The simulation study about the performance and operation of the suggested topology has been performed in MATLAB/SIMULINK. The objective of this paper is to implement less number of switches and DC power source to achieve a different level of MLI as compared to the traditional converter topologies.



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1. INTRODUCTION

Multilevel inverters have actually obtained even more focus utilized for their capability on high-power and moderate voltage procedure. It has advantages such as high power quality, reduced order harmonics, reduced switching losses, as well as better electromagnetic disturbance [1] it can produce a stepped voltage waveform by using number of dc voltage sources as input as well as appropriate plan of the power semiconductor tools. Three primary structures of the multilevel inverters are "diode secured multilevel inverter," "flying capacitor multilevel inverter," and also "cascaded multilevel inverter". Multilevel inverters are becoming recent trends, due to its modularity as well as simplicity of control to produce particular variety of degrees. Multilevel inverters have a variety of applications such as ups, in power grid, as solar inverter, induction heating and variety of other applications [2] by increasing the number of dc voltage sources, a sinusoidal like waveform can be created. Therefore the overall harmonic distortions reduce which has a terrific importance in power grid applications. A sine wave result is desirable because numerous electric items are crafted to work best with a sine wave a/c power source [3] The common electrical energy power tries to give a power source that is a good approximation of a sine wave [4]

This problem increases the concept of decrease in switch. In this paper, a unique plunged multilevel inverter topology with the lowered variety of power switches is suggested as well as their different modulation techniques have actually been discussed. The power loss is less due to less variety of buttons [5], [6]. When the degree of inverters is enhanced, the result voltage is high. Harmonic contents are much less in output waveform of multilevel inverter; hence it relocates more towards the sinusoidal waveform. Effectiveness of the proposed geographies has actually been demonstrated by simulations and also evaluation of it in this study. Finally, Simulation implementation of a recommended geography has been done in order to accomplish the feasibility of the topology [7].

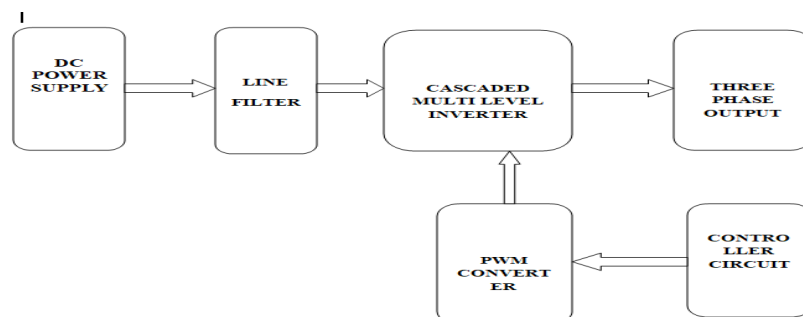


Figure 1. Block diagram of research method

2. ABOUT RESEARCH PAPER

The paper proceeds with, section II describes the asymmetrical cascaded H Bridge multilevel inverter and analysis of conduction and switching losses, section III elaborates the proposed CHB-MLI circuit description with switching state analysis with the analysis of operating modes of converter, section IV validates the simulation results and section V concludes the proposed CHB-MLI continued with the references.

3. RELATED STUDY

Multi Level Inverter

Multilevel inverters have surely drawn top notch fee of interest in the strength marketplace. They gift an emblem-new set of capabilities which might be nicely matched for utilization in reactive strength charge [1]

it is probably tons less difficult to create a high-power, high voltage inverter with the multi level framework due to the manner in which the system voltage tensions are managed in the framework. Increasing the style of voltage tiers within the inverter without needing higher ratings on man or woman gadgets can beautify the electricity score. The particular framework of multilevel voltage supply inverter lets in them to attain high voltages with decreased harmonics without making use of transformers or series connected synchronized switching tools. As the form of voltage ranges boosts, the harmonic content of the result voltage waveform reduces appreciably [2, 3] the fashionable framework of the multilevel inverter is to synthesize a close to sinusoidal voltage from several degrees of dc voltages, usually acquired from capacitor voltage sources. As the kind of ranges increases [7], the manufactured result waveform has even greater steps, which generate a staircase wave that comes close to a favoured waveform. Also, as even more actions are delivered to the waveform, the harmonic distortion of the final results waveform reduces, drawing close no because the style of degrees complements [8] As the wide variety of degrees increases, the voltage that may be spanned by summing several voltage stages likewise boosts. The advantages of Multilevel Inverters are they deliver a low output voltage THD and also an excessive effectiveness and also electricity variable [9] they are appropriate for excessive voltage in addition to excessive present packages. They have better effectiveness because the equipment can be switched over at a radio frequency. They do no longer experience Electromagnetic Interference (EMI) issues. Multilevel inverters are frequently categorized proper into three sorts especially; Diode secured kind, flying capacitor kind, and Cascaded H-Bridge kind [10].

Cascaded H-Bridge

Cascaded multi diploma inverter makes use of diminished wide variety of electricity switches and also it produces a sinusoidal like waveform. Plunged multilevel inverter is collection hyperlink of electricity switches as well as dc voltage sources [7] Plunged multilevel inverters have a number of blessings while in comparison to different topologies. The number one benefits of the use of the plunged multilevel inverters are the high energy top quality waveforms as a result of the discount within the complete harmonic distortion and likewise the lower of dv/dt strain and anxieties at the load, plunged multilevel inverters can be categorized as symmetrical and also uneven multilevel inverters [11] The number one distinction between symmetrical and crooked setup is the dimensions of dc assets. In symmetrical arrangement magnitudes of dc sources are same, whereas in the crooked configuration sizes of the dc resources are distinct. By utilizing the cascaded multilevel inverters favoured form of end result voltage levels can be gotten by means of series connection of an expansion of dc voltage sources [11] A variety of different topologies have definitely existed in the literature. Countless primary devices also are presented inside the literary works. The disadvantage of the symmetric configuration is that it calls for lots extra range of electricity switches while contrasted to the crooked configurations. Yet the dc voltage size is extraordinarily high in those papers. Single degree as well as three degree multilevel inverters may be generated by using the collection hyperlink of a top notch deal of the simple gadgets [12].

Survey of Research

Suresh Kumar Anisetty et. Al, "A logo-new plunged H-bridge multilevel inverter with reduced switch trouble" [01] this script suggests an emblem-new component for plunged multi-diploma inverter. It uses reduced amount of buttons with lots better variety of result steps. Due to loads much less switches, purpose pressure circuits, conduction losses and converting losses are minimized. By affixing numerous modules in collection setup we get preferred variety of final results rates. The forecasted MLI framework includes collection related components in addition to one extra block generates best all un-bidirectional notable

voltage. To obtain bidirectional voltage an H-Bridge is hooked up. In this script recommended MLI uses SPWM approach. In fundamental L segment multi carrier SPWM calls for $(L-1)$ carrier vendors. But $i \eta$ endorsed topography best $(L+1/2)$ providers are enough. As a end result of a whole lot less utility of carriers regulating circuit will come to be tons less facility, dimension in addition to set up charge also decreases. Mohammed Rasheed et. Al, "Harmonic reduction of a 3 area cascaded H-bridge multilevel inverters" [02] this paper affords the assessment and also consequently the style of a three-segment plunged H-Bridge multilevel inverter (CHB-MLI) sustained Newton-Raphson method controller for every development techniques in harmonic decrease of the inverter result. The projected maker has become constructed of 2 apart DC belongings, three-phase 5-stage CHB-MLI, and additionally its controller supported Newton-Raphson. One of the most features of this paper had been to fashion, variation, construct, CHBMLI for a three-phase machine. The forecasted controller turns out to be achieved to CHB-MLI. The protection of this approach had controlled to cut back the harmonic materials of the inverter end result. Besides, the results of the evolved are stated. On top of that, the whole overall performance of the suggested tool ended up being in comparison among simulation consequences for an Optimization technique that is obtaining the lowest values of THDv in addition to THDi. Modulation index really worth of no.84 has sincerely been picked. The Optimization of this gadget had simply been capable in decreasing the harmonic contents of the inverter output. Therefore, development of the CHB-MLI system had definitely been with success incontestable at some time of this look at.

Vamsi Mulpuri "Asymmetrical multilevel inverter for Greater Outcome Voltage Degrees" [03] Currently each day the growth of rate of hobby in building and creation inverters has been elevating because of there are enormous applications of there in FACTS as well as agency drives and additionally several others., though there are various geographies of framework inverters in literary works, in fashion among them are cascaded H-bridge. Generally the administration techniques of these plunged inverters are designed an assumption of acquiring all dc supply voltages identical for all H-bridges. This paper discusses the capabilities of plunged form electric powered converter to deliver extra output voltage levels with same type of H-bridges, but with totally tremendous cross into voltage ratios. The top-notch nature of move into dc voltage sources is found out as a benefit on this paper.

Bharatkar, Sachin S. Et. Al, "Evaluation of three section Plunged H-Bridge multilevel inverter For Balanced & Asymmetrical Arrangement" [04] the preceding research have shown the drawbacks of traditional inverters, particularly for leading energy software application. From the start of 21st century, forceful growth inside the harmonic account in addition to inflated electrical energy rating of MLI created them very well-favoured for excessive stamina software. MLI's are huge used in enterprise subject using motor drives, constant stamina unit compensators as well as eco-friendly electricity structures, and so forth. Basically output voltage of a MLI has several tiers as examine to traditional inverters. This increment in output voltage stages drastically have an effect on the harmonic distortion approach to that the output voltage is negligibly distorted and also main amazing of result wave is received.

4. RESEARCH METHODOLOGY

The crucial tool for the counselled in proportion multilevel inverter is confirmed in Fig. 1. In this circuit, on the equal time as a result of the fact the switch S is have ended up being off, the modern-day flows using the diode, but at the equal time as a result of the fact the button S is improved to land up on, the diode receives

opposite discriminative as well as additionally the current circulations from capacitor and also alternate S which is probably related in series [8] As a result thru using fashion of the use of this method the result voltage is probably controlled. The counselled region consists of locations in the beginning degree generator it's far chargeable for the advancement of tipped voltage waveform and additionally 2nd of all the polarity generator it actually is liable for generating the polarity of the end result voltage. Concurrently, the ins and out of the circuit establishes with even greater degrees of outcome in addition to consequently normal key conventional basic overall performance diploma lowers. Maintaining this in concepts, reducing the headaches in the actual time application, it is charming to consume the quantity of buttons. These results in modulator further to entire masses a good deal a super offer entire masses loads less changing loss. Because of that it's an awful lot vital turning down the quantity of MLI result, if the buttons exploited in the circuit association is reduced, it is a whole lot practical to signify inside the numerous buttons ended up and additionally the quantity of tiers [9] [10] [11].

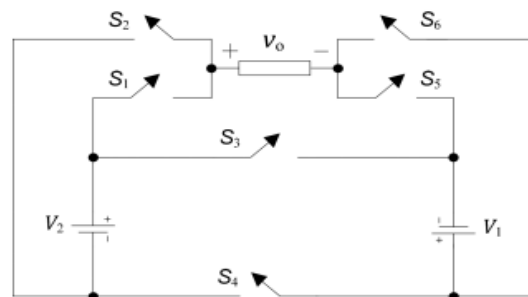


Fig.2. Basic module of multi level inverter

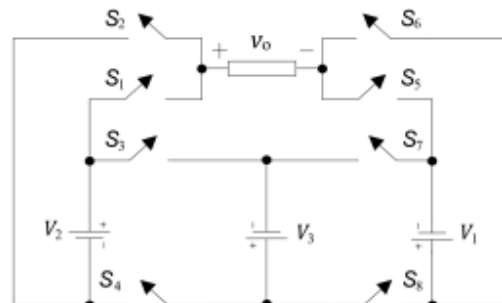


Fig.3. 15 levels of Multilevel inverter

One of the important factors in the designing of MLI topology is the complete popularity voltage. It is described due to the reality the sum of most voltage stress performing for the duration of switch for all the ranges generated on the output. For the number one unit of the proposed MLI topology, the maximum voltage strain at some stage in every transfer is given as:

$$VS1 = VS2 = V2$$

$$VS3 = VS4 = V2 + V3$$

$$VS5 = VS6 = V1$$

$$VS7 = VS8 = V3 - V1$$

Where VS1, VS2, VS3, VS4, VS5, VS6, VS7, and VS8 are the voltage strain of switches S1, S2, S3, S4, S5, S6, S7, and S8. For the sake of decreasing the complexity of real time execution, it's miles compulsory in minimizing the form of switches that has the opportunity to generate all normal or possibly ranges at the

output voltage.

$$V_{\text{standing, 3}} = VS1 + VS2 + VS3 + VS4 + VS5 + VS6 + VS7 + VS8 = 4(V2 + V3).$$

ABOUT 15 LEVEL INVERTER:

Here a brand new multilevel inverter topology is proposed making use of primary device which uses a bargain less amount of energy digital buttons further to dc voltage assets. After that, thru attaching numerous switches and moreover dc voltage property with fundamental tool to minimise the style of electricity switches, driving pressure circuits in addition to elevate the degree in output voltage waveform, a emblem-new geography is proposed as a generalised multilevel inverter. The advised MLI geography is in comparison to a number of existing MLI geographies to analyze its superiority. Lastly, the general usual overall performance of the proposed topology in growing all voltage levels is set up by way of experimental end quit end result the usage of 15-level endorsed inverter.

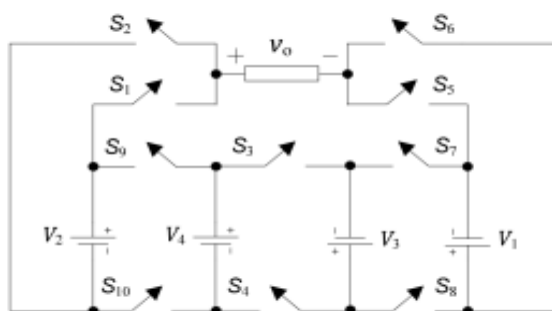


Fig.4. Proposed inverter with switches.

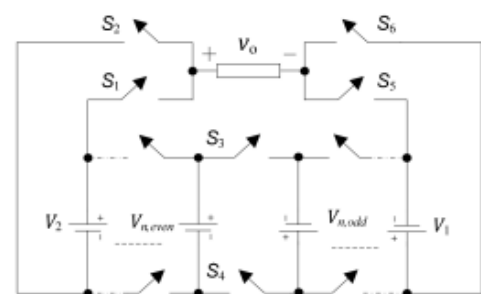


Fig.5. General Structure for proposed topology.

So, it is primary that via way of the use of presently ruling out the amount of the multilevel inverter result, if the switches laboured within the circuit assembly are reduced, afterwards it is much possible to take the hazard of in most of the people of the kind of consequences ranges in addition to the type of buttons confirmed. So a extended method, plenty of configurations have absolutely been despatched focusing in the deterioration of lowering the device completed. This reduce fee will not very awesome beautify the effectiveness of the circuit, furthermore the use of pressure circuits positioned for every single transfer alongside anti parallel diodes are reduced. All the ones blessings will genuinely deliver the modular circuit association this is very small extra to moreover charge range outstanding one. As an assisting nature, the focus of these images is extenuating the large form of equipments made use of inside the in share and also additionally unbalanced circuit. This affiliation can be arranged for as sub greater than one degree configuration accepting the excessive gratifying remaining end outcomes voltage top great with the guide of unmarried H bridge circuit [12] [13]

5. PROPOSED TOPOLOGY FOR MULTILEVEL INVERTER

The multilevel inverters synthesize a stepped output voltage waveform with walking the power virtual buttons in a fixed collection making use of some of reduced dc voltage possessions. These styles of inverters are mainly categorised in impartial detail secured inverter (NPC), flying capacitor multilevel inverter (FCMLI) and plunged H-bridge (CHB) multilevel inverter. In NPC multilevel inverter, the precept disadvantage is unequal voltage sharing some of the occasion linked capacitors and an excessive form of securing diodes are required because of the truth the substantial form of charges in result voltage progression. In FCMLI topology, flying capacitors are made use of due to the truth the clamping devices. It has a few

advantages over NPC geography as redundant segment leg state that distributes the changing anxiety furthermore several of the semiconductor gizmos. However, a massive kind of storage capacitors is needed because of the truth the movement in final results voltage advanced. In CHB multilevel inverter, securing diodes and flying capacitors aren't used. This inverter uses smooth modify method, on the whole reliable, modularity fit in addition to calls for masses brilliant offers a phenomenal offer loads a good buy less preliminary charge shape of energy electronic buttons to create a sure diploma in output voltage. Generally, the ones inverters are break up proper into agencies: symmetric in addition to choppy multilevel inverters [11] in symmetric multilevel inverter topologies, the worths of dc voltage assets in H-bridges are very identical, whilst in choppy multilevel inverter; worth of dc voltage homes are unequal. An unequal multilevel inverter can generate more diplomas in result voltage with an awesome bargain masses tons an awful lot less widespread style of strength electronic buttons. There are strategies for spotting the significance of dc voltage belongings in CHB asymmetrical multilevel inverter, binary and additionally trinary arrangements. Trinary configuration can create extra degree on the identical time as in evaluation with binary setup. Basic manipulate techniques, a bargain a terrible excellent deal bunches a horrible extremely good deal a lot much less massive shape of semiconductor switches, dc voltage belongings in addition to car drivers circuit are the top elements in mastering the charge in addition to period of the MLI [12].

6. PROPOSED STRUCTURE

Here a brand-new multilevel inverter topology is proposed utilising general gadget which makes use of less variety of energy digital switches as well as dc voltage sources. After that, by connecting unique buttons as well as dc voltage assets with general device to reduce the quantity of energy switches, vehicle driver circuits and to boom the extent in outcome voltage waveform, an emblem-new geography is recommended as a generalised multilevel inverter. The proposed MLI geography is compared with several current MLI geographies to investigate its superiority. Ultimately, the performance of the proposed topology in producing all voltage tiers is proven through experimental final results utilising 15-degree advised inverter.

7. SIMULATION RESULTS

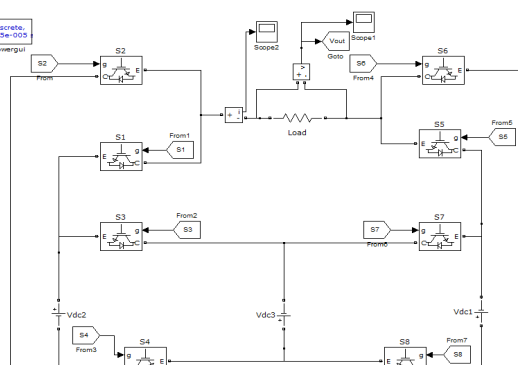


Fig.6. Simulation model.

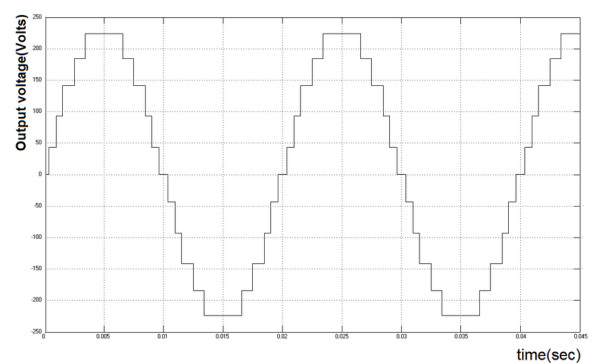


Fig.7. 15 level OUTPUT

The easy circuit of the proposed multilevel inverter topology is demonstrated in Number 1. The simple circuit includes four dc voltage assets as well as ten switches which synthesize thirteen- degree output voltage within the path of unbalanced situations in addition to 15-degrees output voltage all through asymmetrical scenarios. The excellent tiers of output voltage obtained at a few degrees in the problem throughout symmetrical state of

affairs are showed in below. Throughout Asymmetrical state of affairs, the relevance of all dc voltage possessions is same to Vdc. There are taken into account thought approximately specific switching combos are realistic to synthesize any sort of required diploma of output voltage [14]. The unique percent of the buttons is summed up for the output voltage of the endorsed affiliation of the MLI in which 1 and zero applications ON and OFF circumstances of the switching device's respectively. When dc voltage home are picked with equal amplitude (Asymmetric setup), the quantity of end result voltage diploma minimizes and to enhance voltage tiers unequal voltage houses (irregular association) are determined on. Table 1 suggests viable extraordinary levels of voltages in the direction of AB. Voltages are fed to the H- Bridge to create viable final results ranges in amazing and additionally terrible at Vo.

Table 1 Switching times

State	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	V_o
1	1	0	0	1	1	0	1	0	$V_3 + V_2$
2	1	0	0	1	0	1	1	0	$V_3 + V_2 - V_1$
3	0	1	0	1	1	0	1	0	V_3
4	0	1	0	1	0	1	1	0	$V_3 - V_1$
5	1	0	0	1	1	0	0	1	$V_1 + V_2$
6	1	0	0	1	0	1	0	1	V_2
7	0	1	0	1	1	0	0	1	V_1
8	0	1	0	1	0	1	0	1	0
	1	0	1	0	1	0	1	0	
9	1	0	1	0	0	1	1	0	$-V_1$
10	0	1	1	0	1	0	1	0	$-V_2$
11	0	1	1	0	0	1	1	0	$-(V_1 + V_2)$
12	1	0	1	0	1	0	0	1	$-(V_3 - V_1)$
13	1	0	1	0	0	1	0	1	$-(V_3)$
14	0	1	1	0	1	0	0	1	$-(V_3 + V_2 - V_1)$
15	0	1	1	0	0	1	0	1	$-(V_3 + V_2)$

It is discovered from the variety that the value of obstructed voltage is both favourable or truly no and there's no terrible voltage. This truth confirms that encouraged topology calls for unidirectional switches. In addition magnitude of blocked voltage by using switches S1, S3, S7 and S5, respectively. Considering the amount of obstructed voltages through buttons, equations for optimum blocked voltage by means of buttons are properly established.

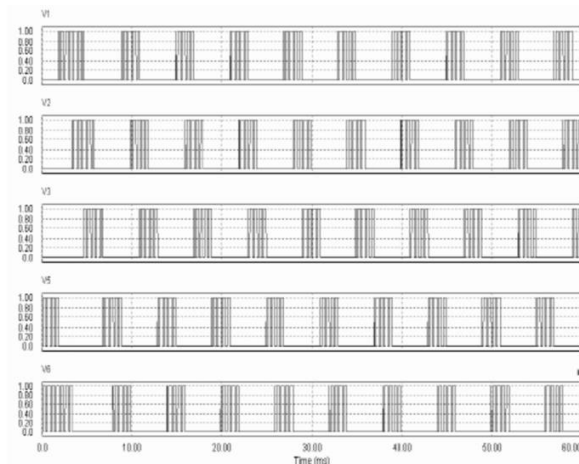


Fig.8. Switching pulses with respective of time.

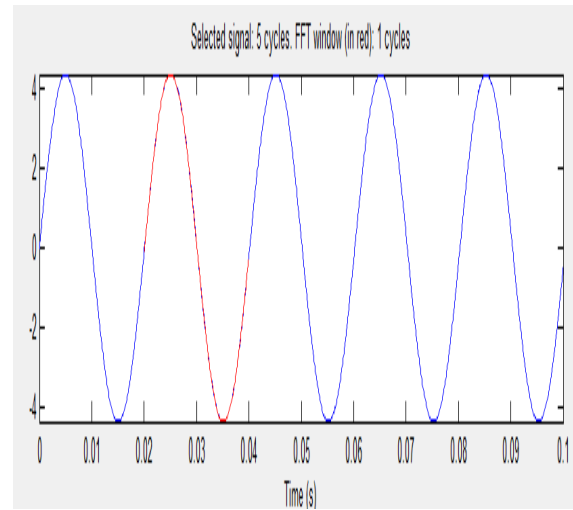


Fig.9. FFT current signals.

For evaluating the highlighted paintings, MATLAB/SIMULINK is chosen due to the truth the software program software platform. Switching series referred to in Table 1 is located. Figure 2 and three illustrates the inverter output voltage and present day-day. Quality of output energy is measured by using manner of the usage of way of calculating THD diploma of the voltage and modern. FFT tool in MATLAB beneficial aid for this execution. The spectrum output of THD degree for every voltage and modern-day-day is said down as 5% to zero.75% (Figure 4 and 5). MOSFET gate pulses produced is exhibited in determine 6.

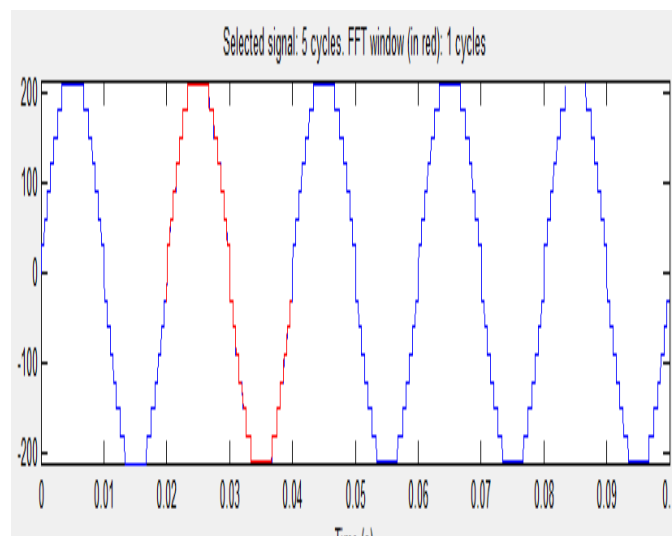


Fig.10. FFT voltage signals

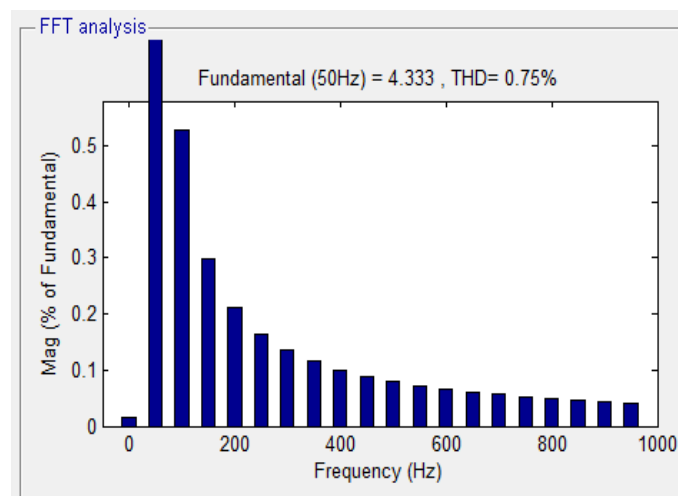


Fig.11. THD value with respective of time

8. CONCLUSION

An abnormal multilevel inverter composed of cascaded connection of the clean devices is usually recommended with a discounted amount of factors. According to the simulation and experimental influences, and assessment with presently presented multilevel inverter geographies, inside the proposed inverter the massive kind of components is drastically decreased. It is showed that the proposed inverter has a lower kind of DC voltage private assets, IGBT modifications, and entrances using pressure circuits and additionally the tremendous ratio of output voltage degree amount to IGBT array than a few currently furnished multilevel inverters in literature. The suggested inverter has a discounted contemporary-day-day acceptability voltage and changing loss than the modular multilevel converter. One of the maximum premium topology of the recommended inverter in some of layout dreams is finished with the aid of manner of the usage of the use of the use of DC voltage possessions in each most important systems, it's far a excellent gain. The encouraged inverter is correctly ideal for low- to medium-voltage packages, in which it indicates the advantage of a far better power extremely good and also a decline massive form of substances. The advised topology is benefit in assessment to offer geographies in expressions of favour of switches, large fashion of diodes, and amount of possessions with amount of stages generated. The 15-degree cascaded multilevel inverter is offers proper effects in terms of percentage of THD.

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