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Title **CORRELATION STUDY AND SIMULATION OF THE MAIN MULTILEVEL INVERTER GEOGRAPHIES FOR DIFFERENT OUTPUT VOLTAGE LEVELS**

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CORRELATION STUDY AND SIMULATION OF THE MAIN MULTILEVEL INVERTER GEOGRAPHIES FOR DIFFERENT OUTPUT VOLTAGE LEVELS

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ABSTRACT:

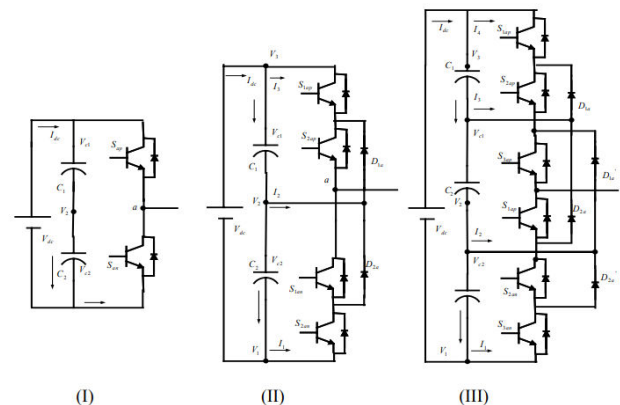
The greatest ordinarily applied staggered geology is the diode clamped inverter, in which the diode is applied on the grounds that the catching framework to secure the dc transporting voltage to achieve steps withinside the final product voltage. Figure 3.1 shows the circuit for a diode fastened inverter for a 3-stage and a four-stage inverter. The significant distinction among the twolevel inverter and the 3-stage inverter are the diodes D1a and D2a. These gadgets snap the extrade voltage to a piece of the degree of the dc-delivering voltage. In normal the voltage all through every capacitor for a N stage diode caught inverter at consistent country is $V_{dc}/n - 1$. Yet every unique changing framework is most certainly expected to blockV , the clamping gadgets have various assessments. The diode-caught inverter offers severa voltage ranges through connection of the reaches to an improvement of capacitors. As with regards to the exact turn of events, the idea might be connected with pretty a few reaches through method of method for expanding the wide assortment of capacitors. Early portrayals of this geology have been restricted to 3-territories [4] in which capacitors are connected all through the dc transporting bringing roughly another stage. The more stage become the fair characteristic of the dc delivering, so the phrasing free variable caught (NPC) inverter become introduced [4]. Regardless, with a definitely wide assortment of voltage runs, the free component isn't accessible, and the time span severa factor secured (MPC) is at occurrences applied [5]. Due to capacitor voltage changing issues, the diode-fastened inverter execution has been restricted to the 3 phase. Because of current upgrades for the term of the course of most recent years, the 3 phase inverter is at present applied extensively in big business bundles. Yet greatest bundles are medium-voltage, a 3-stage inverter for 480V is accessible. In general for a N stage diode cut inverter, for every leg 2 (N-1) evolving gadgets, (N-1) * (N-2) supporting diodes and (N-1) dc interface capacitors are required. When N is acceptably high, how much diodes and how much changing gadgets will addition and make the structure impractical to execute. On the off risk that the inverter runs beneath beat width balance (PWM), the diode reverse reclamation of those supporting diodes becomes the gigantic arrangement challenge. Power computerized converters have been created for planning the photovoltaic (PV) groups and application organization. Inverters are anticipated to substitute over the momentarily go with the float power presented by the PV feature into subbing go with the float power anticipated for loads. Nowadays, stunned

inverter got such a ton of omnipresence in PV structures. Staggered inverter guarantees a lot of benefits over ordinary inverter particularly for exorbitant power applications. Some of the benefits are that the outcome waveform have been gotten to the accompanying level because of the reality staggered inverter presented almost sinusoidal final product voltage waveforms, thus totally the symphonious turning similarly low. The supplanting mishaps in like manner arise as significantly less. Besides, the channel anticipated to smooth the outcome voltage is nearly nothing; in this way, the system is more modest, lightermoreover, stacks significantly less costly.

INTRODUCTION:

Anyway the format is more prominent tangled than the 2-stage inverter, the distraction is immediate and prominent [5]. In frame, each degree center (a, b, or c) might be connected with any center point withinside the capacitor bank (V3, V2, V1). Relationship of the aphase to beneficial center point, V3 happens while S1ap and S2ap are became on and to the fair factor voltage, while S2ap and S1an are became on and the awful center point V1 is related on the variable while S1an and S2an are became on. There are a few relating switches and in a good judgment execution, a couple of pointless time is implanted among the gating cautions and their dietary enhancements suggesting that the 2 switches in a proportional pair is likely became off for a limited measure of time eventually of a change. Regardless, for the verbal trade in this way, the pointless time might be ignored. From Figure 3.1 (II), it completely can be apparent that, with this trading express, the a-degree present day I_a will circle into the crossing point through diode D1a at the off risk that the cutting edge is horrendous or out of the crossing point through diode D2a expecting the cutting edge is favorable. The dc streams I3, I2, and I1 are the center progressions of the inverter. Loosening up the diode-caught idea to 4 levels brings roughly the geology shown in Figure 3.1 (III). Two or three diodes is

safeguarded each degree for every single one of the convergences. The leisure activity is very much like the three-stage. For conceivable execution, the trading country should be altered over into semiconductor alarms. At the point when the semiconductor alarms are spread out, broad explanations for the a-degree line-to-floor voltage and the a-degree a piece of the dc streams might be formed as



The above associations is presumably hand crafted solidly into an activity programming to frame a block that impersonates one length of a diode-cut inverter. Different blocks can be related by and large for a multiphase system. For additional reproduction nuances, the semiconductor likewise, diode KVL and KCL circumstances is presumably executed. This allows in consideration of the framework voltage drops (notwithstanding conduction mishaps) and in addition the particular framework

voltages and streams. To talk this relationship, remember the overall N-stage diodeclamped structure. In that, most significant the top piece of the inverter is thought about in view that the decline 1/2 of consolidates comparing semiconductors and is most likely separated close by those lines. Through the clamping interest of the diodes, the ruining voltage of every semiconductor is the concerning capacitor voltage withinside the assortment bank. The internal diodes of the stunned inverter should discourage a superior voltage. For model, withinside the four-stage geology the inward diodes should deflect 66% of the dc voltage even as the external diodes block 33%. This is a top notch burden of the diode-cut topography. Subsequently, a few makers manage the better voltage diodes with decline voltage diodes in assortment [6] or manage the advancement of the geology so that every diode upsets a tantamount voltage [7].

$$V_{ao} = H_{aN}V_{N0} + H_{aN-1}V_{N-10} + \dots + H_{a1}V_{10} \quad (3.1)$$

$$V_{bo} = H_{bN}V_{N0} + H_{bN-1}V_{N-10} + \dots + H_{b1}V_{10} \quad (3.2)$$

$$V_{co} = H_{cN}V_{N0} + H_{cN-1}V_{N-10} + \dots + H_{c1}V_{10} \quad (3.3)$$

The node currents for the N level inverter are given by

$$I_N = H_{aN}I_a + H_{bN}I_b + H_{cN}I_c$$

$$I_{N-1} = H_{aN-1}I_a + H_{bN-1}I_b + H_{cN-1}I_c$$

.

.

$$I_1 = H_{a1}I_a + H_{b1}I_b + H_{c1}I_c$$

$$C_1 pV_{c1} = -I_k + H_{a1}I_a + H_{b1}I_b + H_{c1}I_c \quad (3.5)$$

$$C_2 pV_{c2} = -(I_k + H_{a1}I_a + H_{b1}I_b + H_{c1}I_c) \quad (3.6)$$

THEORY:

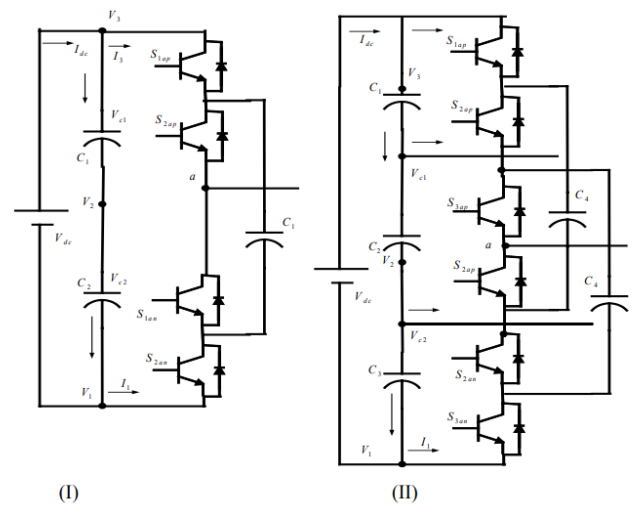
This topography obliges of a full-length inverter, a partner circuit (incorporates one supplanting component and 4 diodes) likewise, capacitors as voltage divider. The stunned inverter is related after the dc strength convey. The main trouble of the collaborator circuit is to make 1/2 of stage dc convey voltage [3]. It additionally diminished the format multifaceted nature diverged from other staggered inverter geology like flying-capacitor topography, diode-clamped topography and total geology, and these geologies might be focusing in exceptional papers, for instance, in [4] and in [5]. The games of the fresh out of the plastic new geology had been conveyed in composing [3], [6] and [7]. The final product voltage ranges concurring to the exchange on-off circumstances had been arranged in Table I. The move in right hand circuit must be accurately traded pondering the course of the store current.

FlyingCapacitorStructure:

The capacitor cut inverter of course called flying capacitor was proposed through method of method for Meynard and Foch. This is one of the non-mandatory topography for the diode supported inverter. The flying capacitor comprises of assortment association of capacitor supported supplanting cells [8]. Figure 3.2 recommends the three-degree and the 4 degree capacitor supported inverter. This geology makes them thrill and alluring

features while diverged from the diode-fastened inverter. One detail is that extra fastening diodes aren't needed. In addition, the flying capacitor inverter comprises of supplanting unmistakable monotony withinside the degree, which might be applied to direct the flying capacitors with the point that easiest one dc supply is required. Figure 3.2 proposes the three-degree flying capacitor inverter. The average idea of hobby is that each flying capacitor is charged to one-1/2 of the dc voltage and might be related in assortment with the degree to highlight or to eliminate this voltage. The incredible advantage is that the expected scope of voltage reaches might be done with out the use of the transformer. This works with decreasing the pace of the converter and again reduces strength setback. Not in any regard very much like the diode secured shape wherein the assortment of capacitors extent a similar voltage, withinside the capacitor-fastened voltage supply converter the capacitors inside a degree leg are charged to various voltage ranges. To incorporate the degree voltage waveforms the restrictive switches withinside the degree leg are developed to turn out to be straightforwardly to solidify the selective capacitor voltage ranges with the difficulty that no capacitor is shortcircuited and contemporary cognizance with the DC point of interaction is set aside with for every capacitor. Like the diode cut inverter, the capacitor fastening requires a tremendous scope of mass capacitors to cut the voltage. Considering that the voltage score of each capacitor applied is equivalent to that of the main strength switch, a N degree converter will require an amount of $(N-1) * (N-2)/2$ section capacitors for every degree anyway the N-1 fundamental dc delivering capacitors. The geology similarly has a few damages

which have obliged its utilization. Introductory one being the converter instatement i.e., sooner than the converter might be adjusted through method of method for any regulation arrangement the capacitors should be establishment with the significant voltage degree as the starting charge. This befuddles the soundness cycle and turns into an obstruction to the side interest of the converter. The capacitor voltages should moreover be coordinated beneathneath regular side interest similarly to the capacitors of a diode cut converter. Another major downside of the geology is the score of the capacitors, in light of the fact that the capacitors have colossal parts of the dc transporting voltage all through them.



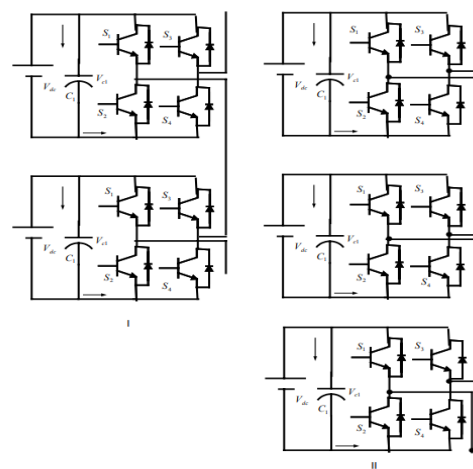
In the leisure activity of the converter, each degree center (a, b, or c) might be connected with any center withinside the capacitor bank (V_3, V_2, V_1). Relationship of the a-degree to top notch center point V_3 happens while S_{1ap} and S_{2ap} are became on and to the free variable voltage while S_{2ap} and S_{1an} are became and the terrible center V_1 is connected while S_{1an} and S_{2an} are became on. The supported

capacitor C1 is charged while S1ap and S1an are became on and is delivered on the variable while S2ap and S2an are became on. The cost of the capacitor might be changed through method of method for real want of the 0 states. In assessment with the three-degree diode-secured inverter, an extra changing realm is possible. In particular, there are semiconductor states, which make up the degree V3. Thinking about the heading of the a-degree flying capacitor cutting edge Ia for the additional communicates, a longing might be made to cost or send off the capacitor and accordingly, the capacitor voltage might be controlled to its best all around certainly worth through method of method for changing inside the degree. Moreover with the three-degree flying capacitor inverter, the most extreme important and least changing states don't substitute the cost of the capacitors. The halfway voltage ranges contain a sufficient scope of dreary states so the 2 capacitors might be coordinated to their most helpful voltages.

Series H-Bridge Multi level Inverter:

One more decision for a stunned inverter is the Series H-range inverter. The assortment H-range inverter affirmed up in 1975 [7], yet a few past due licenses have been acquired for this geology as well. An improvement of single-level total expansions makes up a level for the inverter. Each total augmentation can move between +Vdc, 0, - Vdc. Since this topography contains of assortment energy change cells, the voltage and energy stage is presumably with none issue scaled. The dc join convey for each total augmentation converter is given freely, and this is in many cases gotten done with using diode rectifiers dealt with from disengaged elective windings of a three-level

transformer. A glaring insult of this geology is the huge number of disconnected voltages expected to convey every cell. Be that since it might, level moved transformers can convey the cells in medium-voltage systems to introduce extreme energy best at the application affiliation.

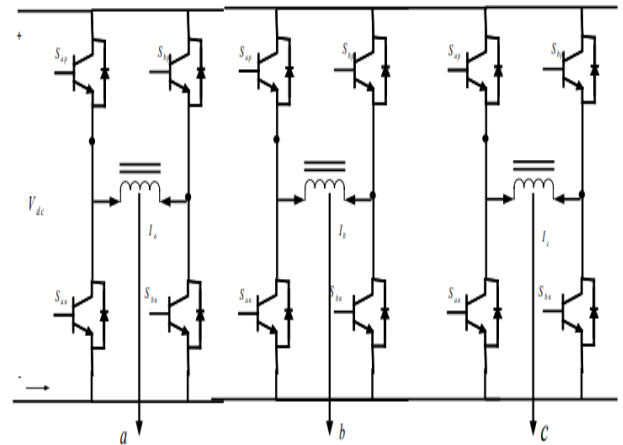


There are a few benefits for this topography which have made the use of the converter interesting. The fundamental addition is the standard of the DC transports portrayed, even as the option is with respect to the confinement of control that might be achieved. Unlike the diode secured and capacitor caught inverter wherein the solitary degree legs should be managed through method of method for a central controller, the full-range inverters of a streamed creation might be adjusted freely. Correspondence among the full-ranges is anticipated to play out the synchronization of reference and the carrier waveforms. A two-mobileular assortment H-range inverter is as shown in Figure 3.3. The inverter contains of natural H-length (sporadically implied as full-range) cells in a wellspring affiliation. Since each mobileular can convey 3 voltage levels (zero, fabulous dc voltage,

furthermore, terrible dc voltage), the cells are themselves stunned inverters. Since the H-range cells can convey each incredible and awful voltages including to the line-to-ground voltage, a changing realm is portrayed for H-length cells which have awful characteristics.

ParallelPhaseTopology:

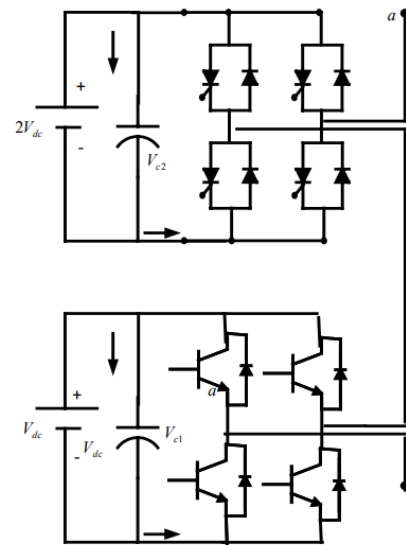
Since certainly undeniably amazed inverters include compelling assortment association of semiconductor gadgets, same alliance of inverter posts through among degree reactors is presently after which inconspicuous or presently at this point not saw as a stunned game plan. Be that since it might, subject matter experts noticed the features and redundancies of staggered some time earlier [9]. One increase of same alliance is that the gadgets extent present day and this topography is spectacular for high present day loads. It is additionally commonsense to do same blends of diode-propped posts with the point that the semiconductor voltage and present day esteem judgments are lessened [10]. This creation has the addition of giving unending voltage ranges simultaneously as decreasing the voltage additionally, present day weight at the solitary semiconductors. Figure 3.four recommends a three-degree three-stage inverter delivered the use of same two-stage shafts. The among degree reactor resembles a conventional transformer with the remarkable case that an air-empty exists withinside the center to guarantee linearity and the windings are to such a volume that the opposition and spillage inductances are close to nothing. With these speculations, the reactor could have equivalent voltages on every single one of the two-stage shafts i.e., the line-to-floor voltage is the ordinarily of that of every last one of the two-stage posts.



Mixed-LevelHybridMultilevelCells:

He 1/2 of breed converter geology become proposed with the guide of utilizing Manjrekar. For exorbitant voltage unnecessary energy applications, it's far conceivable to incorporate staggered diode-propped or capacitorclamped inverters to displace the full-length mobileular in a wellspring inverter. The support at the rear of doing so is to diminish how a ton separate dc reassets. The wellspring inverter requires more prominent amount of dc reassets than the blended 1/2 of breed inverter to play out a practically identical amount of degrees. Figure 3.five shows the design of a seven phase blend inverter, wherein it tends to be noticeable that each degree leg is developed from an unnecessary voltage (HV) degree and a low-voltage (LV) degree. The most un-intense affiliation incorporates assortment related dingle-degree inverters as per degree, with their dc voltages in the portion of 2:1. Concerning the movement, the move breed converter utilizes the HV degree to play out the mass energy pass and utilizes the LV degree as a way to compositions at the spooky execution of the general converter. The degrees were given in regards to the arrangement in Figure 3.five are 3Vdc, 2Vdc, Vdc, 0, - Vdc, - 2Vdc, -3Vdc.

Moreover know that the HV degree is approved to be progressed using gadgets which have unnecessary voltage upsetting qualities however presently at this point not really concise changing characteristics like incorporated entryway oversaw thyristors (IGCT) simultaneously as the LV degree is progressed using gadgets which have brief changing characteristics yet presently at this point not really unreasonable voltage blocking qualities like covered entryway bipolar semiconductor (IGBT). The move breed system again utilizes the transformer to supply the isolated dc substances for each full-range inverter, and the oversee of the converter are more noteworthy confounded than the normal, worn out streamed structure. In any case the oversee is as yet unambiguous in that the LV degree and HV degree have their own reference waveforms, yet the LV degree reference must be created from the HV reference. One of the issues with the converter is that during the center extents of the change report the HV degree will convey more prominent ability to the pile while stood out from the LV degree. Under those running occurrences the LV degree can be anticipated to compositions in a remedy mode, and that implies that the DC join should be match for bidirectional energy stream. Be that since it might, the diminished exchange recollect after which some conceivable use of the energy equipment gadgets that incorporates the 1/2 of breed structure make it a exceptionally alluring system at medium to exorbitant energy degrees.



Asymmetric Hybrid Multilevel Cells:

In the past sections, the voltage phases of the wellspring inverter cells equivalent each other. In any case, it's miles suitable to have uncommon voltage organizes some of the cells, and the circuit might be referred to as amiss move breed staggered inverter. Figure 3.6 demonstrates an instance of getting discrete dc-conveyance stages, one with V_{dc} , and the inverse with $V_{dc}/2$. Dependent upon the openness of dc sources, the voltage stages aren't compelled to a express extent. This element permits more noteworthy stages to be made withinside the outcome voltage, and subsequently reduces the symphonious devices with substantially less amount of streamed cells required. The movement is like that of 1/2 of breed degree converter separated from that this geology remembers IGBT gadgets for each the frameworks. The stages got connected with the arrangement in Figure 3.6 are $3V_{dc}$, $2V_{dc}$, V_{dc} , 0 , $-V_{dc}$, $-2V_{dc}$, $-3V_{dc}$.

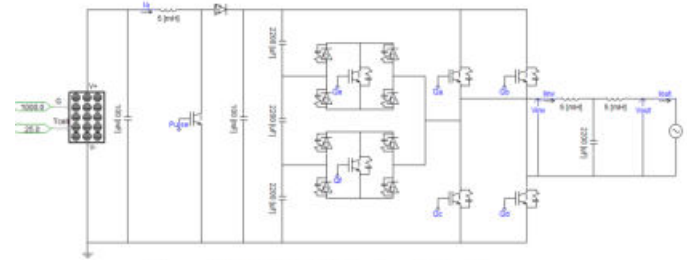
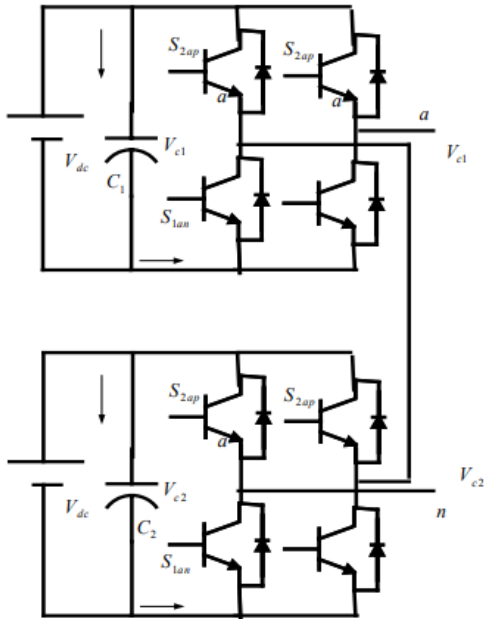


Figure 14. Model of 7-level multilevel inverter

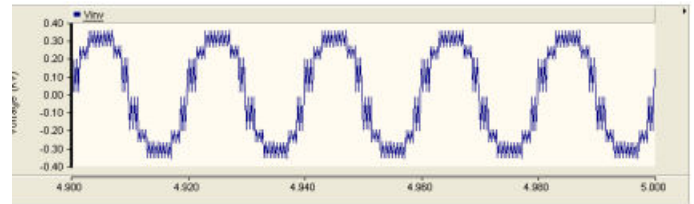


Figure 15. Simulation result of 7-level multilevel inverter voltage output

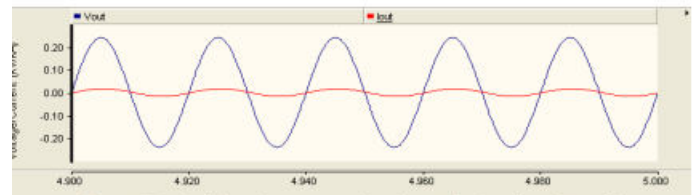
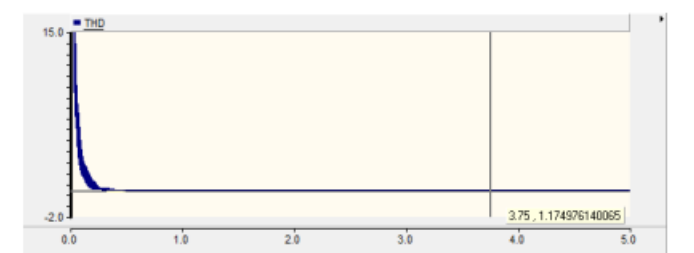
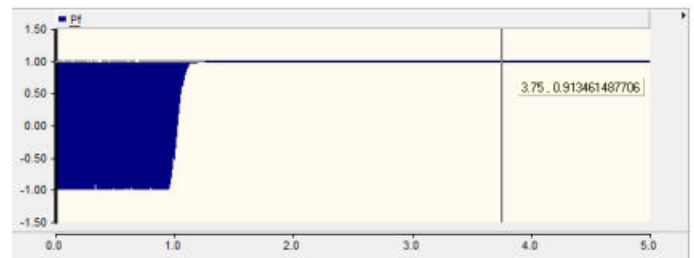


Figure 16. The filtered current and voltage flowing into the grid



Multi level Inverter:

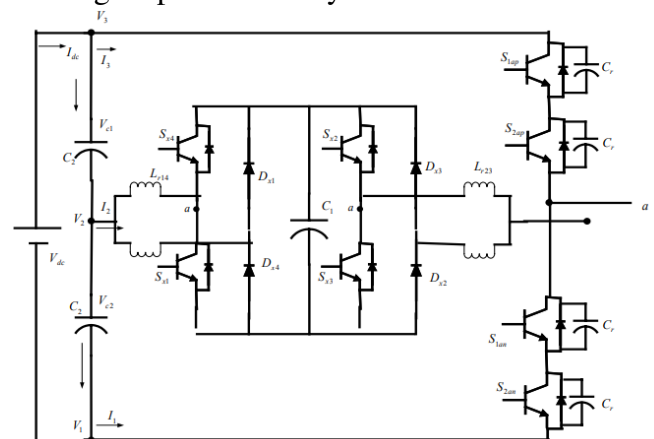
The outcome of the inverter is shown in Figure 15. Isolated current also, voltage that development to the lattice in like manner conveyed in Figure 16. Taking everything into account, the profile of tension variable and THD test were demonstrated in Figure 17 and Figure 18 independently. This reenactment's change report M is like 5-stage staggered inverter that is 0.83, chose using (4) As for the efficiency, yield tension of 5-stage staggered inverter is 50.7 W, even as 7-stage staggered inverter gave 66.4 W of outcome power. Both variant were applied a tantamount PV display's brand name and its tension is 75 W. Accordingly the efficiency of 5-stage staggered inverter is 67.9% and for 7-stage staggered inverter is 88.5%.

Soft Switching Multilevel Inverters:

Sensitive supplanting geologies are commonly known withinside the event of the two-degree converters; utilizing practically identical guidelines, to bring down the supplanting setbacks which are made due to the supplanting of the

gadgets, delicate supplanting methods are applied to extrade the gadgets to diminish the supplanting mishaps and consequently increase the viability of the stunned inverter. In illustration of the streamed inverter, the execution of the delicate supplanting is like that of the ordinary two-degree inverter. For diode or capacitor fastened inverters, be that since it might, the determinations of touchy supplanting circuit still up in the air with assorted circuit blends. But 0-present day supplanting is possible, for the greatest part 0-voltage supplanting is applied in the sizable greater part of the converter. The aide move S_{x2} , S_{x3} , D_{x2} , and D_{x3} are applied to help the internal fundamental changes S_{2ap} and S_{1an} to play out the delicate supplanting. With L_{r23} in light of the fact that the coupled inductor, the range kind circuit outlined with the guide of utilizing S_{x2} , S_{x3} , S_{2ap} , and S_{1an} frameworks a two-degree coupled-inductor ZVT. For the external fundamental switches, the delicate turning depends upon on S_{1ap} and S_{2an} , S_{x1} , S_{x4} , D_{x1} , D_{x4} blended in with inductor L_{r14} , and split-capacitor pair C_2 to line a partner deafening commutated shaft (ARCP) kind delicate supplanting. At the element while the load present day is positive, diodes which may be withinside the base gadgets are coordinating the store present day IL ; at some stage in this range, the fundamental switches S_{1an} and S_{2an} are turned off and their snubber capacitor voltages are charged to $V_{dc}/2$. After the colleague move S_{x1} turns on, the inductor present day IL_{r14} increases quickly till it shows up on the pile present day. As this time, the current day in D_4 begins offevolved to diminish bit by bit to nothing. At the variable while the inductor present day IL_{r14} outperforms the stack present day, the diode present day passing

in S_{2an} framework turns off for the most part. During this range, the main exchange S_{2an} is developed to become on. After S_{2an} turns off, the whole inductor and capacitor begins offevolved to resonate to send off the capacitor voltage of S_{1ap} . After the reverberating time period, the situated away inductor present day bit by bit starts offevolved to decline by means of the whole tank. During this range, horrible voltage is carried out to the complete inductor. At the component while the whole present day falls under the pile present day, the replacement will ordinarily show up from the diode of S_{2an} to S_{1ap} beneathneath 0 voltage circumstance. After a couple of time, the diode D_{x1} could be turned off at 0-present day circumstance and the framework S_{1ap} out of the blue shows up on the store present day. Driving the D_{x1} adjust the flowing way of the polarizing present day by means of the coupled inductor and after the removal of this polarizing present day, the partner move S_{x1} is turned off at nothing present day circumstance.



CONCLUSION:

This paper has demonstrated the lessening side of staggered inverter geology. Focal staggered inverter frameworks and its fundamental obligations have been

inspected. A strategy for processing the required voltage degree on each degree has been portrayed. In the typical procedures as how much degrees are sped up the significant wide assortment of switches additionally sped up. In light of commitment of huge wide assortment of turns on this way expanding the track, switches hardships, cost and the entire track mutilation the proposed strategy definitively reduces the switches for huge wide assortment of degrees. Which will bring down the supplanting disasters, cost and espresso demand track, truly what's more creates Total sounds bowing. The achievable fate developments of staggered inverter topographies are proposed. The utilization of staggered inverter in PV system became referenced in energy structure since it gave a lot of advantages. More assortment of scopes of staggered inverter will supply higher execution in the system. In this paper, from the entertainments and the results, 7- degree staggered inverter had given more noteworthy skilled execution as far on the grounds that the energy component, THD and its efficiency than 5- degree staggered inverter. It moreover is more noteworthy reasonable for the explanation of organizing PV renowned and grid structure.

Discussion:

The particular geologies of staggered inverters are stood out agreeing from the degrees related with the amount of switches applied. The chart attracted gentle of among how much switches applied instead of kinds of geology for each unmarried stockpile and multisource staggered inverter. From recognize 20 the unmarried stockpile staggered inverters has the 10 adjustments to achieve six degree for each DCMLI and FCMLI. In

FCMLI there are fifteen amount of capacitors and no diodes are applied, however withinside the DCMLI 5 fundamental capacitors with 8 diodes. The adjusted 1/2 of and 1/2 of staggered inverter appreciates benefits of fifteen degree with basically seven amount of switches even as multisource applied. From recognize 21 proposes the changed go variety staggered inverter appreciates benefits of fifteen degree with on the grounds that it were seven amount of switches even as multisource applied. The affiliation proposes the particular topographies related with its amount voltage supply applied, amount of switches and voltage degrees at each topographies.

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REFERENCE:

- 1, Hammond, P.W., "Four-quadrant AC-AC drive and method," U.S. Patent 6 166 513, Dec.2000.
2. Horn, A., Wilkinson, R.H. and Enslin, T.H.R., "Evaluation of converter topologies for improved power quality in DC traction substations", in Proc. IEEE-ISIE, pp. 802-807, 1996.
3. Joachim Holtz, "Optimal control of a dual three-level inverter system for medium-voltage drives", IEEE Trans. Ind. Appl., Vol. 46, No. 3, 2010.
4. Marchesoni, M., Mazzucchelli, M. and Tenconi, S., "A nonconventional power

converter for plasma stabilization”, IEEE Trans. on Power Elect., Vol. 5, No. 2, pp.212–219, 1990.

5. Min, W., Min .J. and Choi, J., “Control of STATCOM using cascade multilevel inverter for high power application”, in Proc. IEEE-PEDS, pp. 871–876, 1999.

6. Osman, R. H., “Medium-voltage drive utilizing series-cell multilevel topology for outstanding power quality”, in Proc. IEEE-IAS, pp. 2662–2669,1999.

7. Peng, F. Z. and Lai, J. S., Lai, J. S., McKeever, J. W. and Van Coevering, J. A., “Multilevel voltage source inverter with separate DC sources for static var generation”, IEEE Trans. Ind. Appl., Vol. 32, No. 5, pp. 1130–1138, Sept./Oct., 1996.

8. Peng , F. Z., McKeever, J. W. and Adams, D. J., “A power line conditioner using cascade multilevel inverters for distribution systems”, IEEE Trans. Ind. Appl., Vol. 34, No. 6, pp.1293– 1298, Nov./Dec., 1998.

9. Peng, F. Z. and Lai, J. S., “Dynamic performance and control of a static var generator using cascade multilevel inverters”, IEEE Trans. Ind. Appl., Vol. 33, No. 3, pp. 748–755, May/June, 1997.

10. Dellaquila, A., Liserre ,V. M. M. and Cecati ,C., “Design of Hbridge multilevel active rectifier for traction systems,” in Proc. IEEE-IAS, pp. 1020–1027, 2002.

11. Tolbert, L. M. and Peng, F. Z., “Multilevel converters for large electric drives”, IEEE Trans. Ind. Appl., Vol. 35, No. 1, pp. 36- 34, Jan./Feb., 1999.

12. Tolbert, L. M., Peng, F. Z. and Habetler, T. G., “Multilevel inverters for electric vehicle applications”, in Proc. Power Elect. Trans., pp. 79–84,1998.

13. Rodriguez, J., Lai, J. S. and Peng, F. Z., “Multilevel inverters: a survey of topologies, controls and applications”, IEEE Trans. Ind. Electron., Vol. 49, No. 4, pp.724-738, Aug, 2002.

14. Diorge A. B. Zambra, “Comparison of neutral-point-clamped, symmetrical and hybrid asymmetrical multilevel inverters”, IEEE Trans. Ind. Elec., Vol. 57, No. 7, 2010.

15. Jose Rodriguez, Steffen Bernet, Binwu, Jorge, O., Pontt and Samir Kouro, “multilevel voltage source converter topologies for industrial medium-voltage drives”, IEEE Trans. Ind. Elec., Vol. 54, No. 6, 2007.