A Comprehensive Study on Medium Voltage Cascaded H-Bridge Multi-Level Inverter Medium Voltage Drives

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Abstract:- The basic idea of a multilevel converter to accomplish higher power is to utilize a progression of energy semiconductor switches with a few lower voltage dc sources to play out the power change by integrating a staircase voltage waveform. Capacitors, batteries, and sustainable power source voltage sources can be utilized as the numerous dc voltage sources. The replacement of the power switches total these different dc sources keeping in mind the end goal to accomplish high voltage at the yield; however, the evaluated voltage of the power semiconductor switches depends just upon the rating of the dc voltage sources to which they are associated. Expansive electric drives and utility applications require propelled control hardware converter to meet the power demands. Minimum harmonic distortion can be obtained by controlling the conducting angles at different converter levels. Each H- bridge unit generates a quasi-square waveform by phase shifting its positive and negative phase legs" switching timings. Each switching device always dependably leads for 180° (or half cycle) regardless of the pulse width of the quasi-square wave. This switching method makes all of the switching devices current stress equal. The proposed work examine the effect of dynamic load on control framework and techniques are used to improves the performance of the whole system in terms of harmonics, dv/dt stresses, and stresses in the bearings of a Medium voltage drives (MVDs).

Index-Terms- Multi-Level Inverter, cascaded multilevel inverter, Cascaded H-Bridge Multilevel Inverter, Medium Voltage Drives (MVDs).

I. INTRODUCTION

It has been perceived for over two decades that portrayal of power system loads for dynamic execution investigation can have critical effect on power systems stability. As power systems are designed and worked with less stability edge, sufficient load models are of real significance. Presently a-days, power prerequisites of current ventures have come to megawatt level. Specifically, high-power medium voltage drives requires power in megawatt go and is normally associated with the medium voltage network. It is troublesome to interface a solitary power semiconductor change straightforwardly to medium voltage grid (2.3kV, 3.3kV, 4.16kV or 6.9 kV). For this reasons, multilevel inverter have emerged as a cost effective solution for high voltage and high power applications including power quality and motor drive problems.

As a cost effective solution, multilevel converter accomplishes higher voltage and current appraisals, as well as empowers the utilization of low power application in sustainable power sources. These converters are reasonable in high voltage and high power applications because of their capacity to integrate higher voltages with a restricted most extreme gadget rating, less symphonious bending, producing of smaller common-mode voltage (CM), less electromagnetic compatibility (EMC) problems and attain higher voltage with a limited maximum device rating.

Cascaded H-Bridge (CHB) configuration has recently become very popular in high- power AC supplies and adjustable-speed drive applications. A cascade multilevel inverter comprises of a series of H-bridge (single-phase full bridge) inverter units in each of its three stages. Every H-connect unit has its own dc source, which for an induction motor would be a battery unit, energy component or sunlight based cell. Each SDC (isolate D.C. source) is related with a solitary stage full-bridge inverter. The ac terminal voltages of different level inverters are connected in series.

Minimum harmonic distortion can be acquired by controlling the directing points at various converter levels. Each H- bridge unit produces a semi square waveform by stage moving its positive and negative stage legs" switching timings. Each switching device directs for 180° (or half cycle) regardless of the pulse width of the quasi-square wave. This exchanging strategy makes the greater part of the switching devices current anxiety measure up to. In the motoring mode, power streams from the batteries through the course inverters to the engine. In the charging mode, the course converters go about as rectifiers, and power streams from the charger (ac source) to the batteries. The course converters can likewise go about as rectifiers to help recoup the dynamic energy of the vehicle if regenerative braking is utilized. The cascade inverter can

also be used in parallel HEV configurations. This new converter can avoid extra clamping diodes or voltage balancing capacitors.

Identical H-bridge inverter units can be utilized, thus improving modularity and manufacturability and greatly reducing production costs. Battery-fed cascade inverter prototype driving an induction motor at 50% and 80% rated speed both the voltage and current are almost sinusoidal. Electromagnetic interference (EMI) and common mode voltage are also much less than what would result from a PWM inverter because of the inherently low dv/dt and sinusoidal voltage output.

II. CASCADED H-BRIDGE MULTILEVEL INVERTER

Although virtually no literature exists that reviews the cascaded H-bridge inverter's execution in wind systems, writing exists that reviews the inverter's execution in FACTS applications. It is critical to look at this writing for general cascaded H-bridge ideas, as well as for specific FACTS contemplations since, similar to a STATCOM, the fell H-connect based breeze cultivate must have the capacity to supply reactive power for voltage support.

The cascaded inverter topology has a few points of interest that have made it attractive in medium to high-power applications. The first is its measured quality. Every DC source is fed into an individual full bridge inverter so it is anything but difficult to connect to more separate DC sources without changing the measurement of the system. In addition, the exchanging worry for each switch gadget would be not as much as the general two level topology since the switch and diode require just withstand one separate DC voltage. In the event that the Harmonic Selective Modulation strategy is utilized, the exchanging frequency will be at the essential frequency which diminishes the exchanging loss [8]. At long last, as said over, the yield voltage waveform is about sinusoidal which diminish the cost of the filter.

The Cascaded H-Bridge (CHB) multilevel inverter is based on the series con- nection of single phase H-bridge inverters with separate DC sources. The topology is shown in Figure 2.1.

The Cascaded H-Bridge (CHB) Multi Level Inverter (MLI) is a cascade of H-Bridges, or H-Bridges in a series configuration. A CHB MLI consists of a string of H-Bridge (single-phase full bridge configuration) inverter units in each of its three phases. An example of a CHB MLI is shown in Figure 2.1(a).

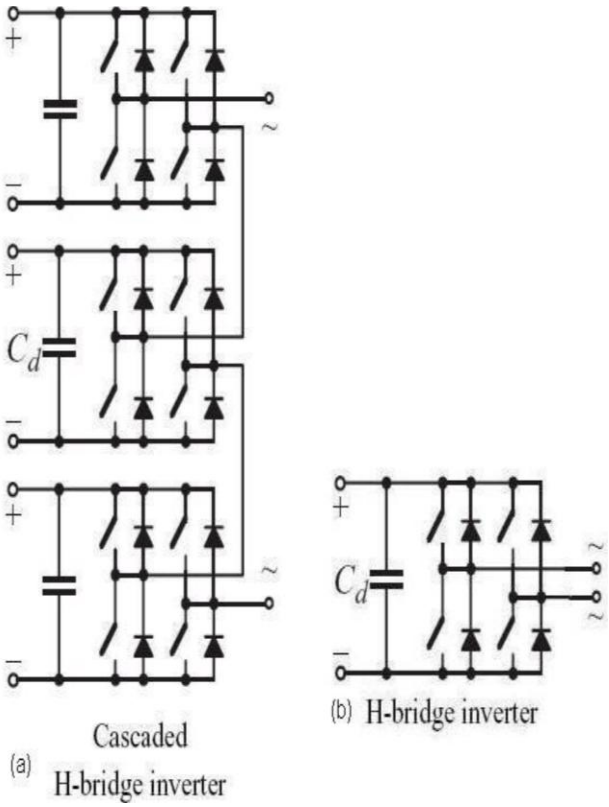

Figure 2.1 Cascaded H bridge Inverter.

The three-level converter has the same configuration as a single H-Bridge inverter, a single phase full bridge inverter used in unipolar PWM. The four switches S1, S2, S3 and S4 are operated within limits to generate three discrete outputs Vab with levels of -Vdc, 0 or +Vdc. When S2 and S3 are on the output is -Vdc, when either pair S1 and S2 or S3 and S4 are on the output is 0,and when S1 and S4 are turned on the output is +Vdc. The simplest inverter i.e. a H- Bridge inverter is illustrated in (Figure.2.1b).

Modulation Methods

There are two commonly used modulation methods for CHB are represented below.

- Selective Harmonic Elimination

The basic idea of the selective harmonic elimination is to pre-determine the switching angle for each module to get the expected waveform of the output.

- Phase Shifted Pulse Width Modulation

Phase shifted PWM is one of the most commonly used modulation method in CHB multilevel inverter since it is very suitable for the modularity of the topology. For each module, the reference signal is the same.

III. RELATED WORK

Sr. No.	Title	Author	Year	Approach
1	Load Model for Medium Voltage Cascaded H-Bridge Multi-Level Inverter Drive Systems	X. Liang and J. He	2016	cascaded H-bridge multi-level inverter drive and induction motor systems
2	Analysis and simulation of cascaded H-bridge multi level inverter using level-shift PWM technique	A. K. Ranjan, D. V. Bhaskar and N. Parida,	2015	The performance of mentioned level has been analyzed through simulation using level-shift PWM technique
3	Nine level cascaded H Bridge Inverter (For High Performing UPS Applications)	P. D. H. Darmawardana, T. D. Kahingala, K. M. C. G. Karunarathna, L. B. S. N. Kularatne and J. P. Karunadasa,	2015	a nine level Cascaded H-Bridge Multi-Level Inverter, realized via Distortion Minimization PWM technology
4	Hybrid topology of asymmetric cascaded multilevel inverter with renewable energy sources,	S. Boobalan and R. Dhanasekaran,	2014	a discrete binary topology for multilevel converters is proposed using cascaded sub-multilevel Cells
5	Simulation and experiment of hybrid modulation strategy with common-mode voltage reduction for seven-level hybrid cascaded inverter,	N. L. H. Bang, N. V. Nho, N. K. T. Tam and N. M. Dung,	2014	a simple and flexible technique to reduce common-mode voltage for a seven level hybrid cascaded inverter topology
6	Novel multilevel inverter with reduced number of switches and batteries,	R. Deepak, V. S. Kasturi, L. Sarkar, Y. R. Manjunatha and B. R. Lakshmikantha,	2013	a new concept of switching with reduced number of switches and batteries.
7	Multilevel inverters with level doubling network: A new topological variation	S. K. Chattopadhyay and C. Chakraborty	2013	The proposal of the LDN opens up a new topological variation for the existing configurations.

X. Liang and J. He,[1] Medium voltage drives (MVDs) are regularly utilized as a part of high-power applications and show noteworthy effect on the general system flow because of their extensive size and high power request. Albeit point by point exchanging models for MVDs can be constructed utilizing MATLAB/Simulink, such models can't be utilized as a part of extensive scale reproduction programming for power system dynamic examinations. To take care of this issue, the dynamic load demonstrate for the medium voltage cascaded H-bridge multi-level inverter drive and acceptance engine systems, which is reasonable for power system dynamic investigations, is proposed in this investigation. Explanatory recipe of the model is displayed. The model incorporates the totaled impact of a MVD, an acceptance engine, and their control system, and hence, it can precisely speak to the dynamic reactions of the engine drive system under aggravations. Both voltage and frequency reliance are considered in the model. The exactness of the model is confirmed by a contextual investigation. An affectability think about is led to assess the effect of the model parameter minor departure from dynamic reaction qualities. The created load model can be promptly embedded in the extensive scale power system reproduction programming for power system dynamic examinations.

A. K. Ranjan, D. V. Bhaskar and N. Parida,[2] For medium voltage and high power applications, multilevel inverter has been acknowledged as a superior option; as it has better waveform quality, low weights on exchanging devices and better execution. Among the different topology of multi level inverter cascaded H-bridge inverter has been found as more dependable, simple to execute and better execution. This investigation examinations the execution of cascaded H-bridge inverter for 5-level, 7-level, 9-level, 11-level, 13-level and 21-level for single stage and furthermore three stages. The execution of said level has been dissected through recreation utilizing level-move PWM system i.e. for every one of the levels utilizing As a part of Phase Disposition, Phase Opposition Disposition and Alternate Phase Opposition Disposition. An examination between add up to symphonious contortions at regulating frequency 1 KHz and 4 KHz for the sum total of what levels has been improved the situation different strategies for level moved PWM methods.

P. D. H. Darmawardana, T. D. Kahingala, K. M. C. G. Karunarathna, L. B. S. N. Kularatne and J. P. Karunadasa,[3] This investigation proposes a nine level Cascaded H-Bridge Multi-Level Inverter, realized by means of Distortion Minimization PWM innovation which

is joined in a Uninterrupted Power Supply (UPS), working in the low power end. The proposed UPS is equipped for providing four run of the mill PCs all the while. Because of the expanded number of exchanging power shafts utilized, exchanging frequency per gadget is diminished, limiting the exchanging stress per gadget. In this way a delayed lifetime of the inverter can be foreseen. Additionally, the appropriateness of Distortion minimization PWM for this inverter design is talked about contrasted with Selective Harmonic Elimination PWM (SHEPWM): a standout amongst the most well known PWM techniques for multilevel inverters. Moreover, so as to join the designed inverter in an UPS application to such an extent that cost, weight and size are limited while guaranteeing a decent transient reaction at the disappointment of the mains supply, a novel approach named "Disconnected Synchronization": an endeavor to consolidate the benefits of both disconnected UPSs and Online UPSs is presented.

S. Boobalan and R. Dhanasekaran,[4] This investigation introduces a double topology of Multi-module level inverters create a staircase yield voltage from inexhaustible DC voltage sources. The MLI (Multi Level Inverter) Requires many number of semiconductor switches is primary disadvantage of multilevel inverters. The MLI can be delegated two technique, one is symmetric and another deviated converters. In symmetrical multilevel inverter can apply same voltage level to all cascaded circuit, in hilter kilter multilevel inverters can be change input source voltage at each cascaded H-bridge by utilizing parallel calculation. In this investigation, a discrete twofold topology for multilevel converters is proposed utilizing cascaded sub-multilevel Cells. This sub-multilevel converter can create sixty three levels of voltage from five discrete DC source. The Total Harmonic Distortions (THD) is limited by discrete twofold topology. The working operation and execution of the proposed multilevel inverters considers has been checked by reenactment of utilizing SIMULINK/MATLAB result.

N. L. H. Bang, N. V. Nho, N. K. T. Tam and N. M. Dung [5] Since the improvement of sustainable power source like sunlight based, wind power, the multi-level topologies turned out to be more ready to apply and control the sustainable power source systems. Despite the fact that, the multi-level inverter create a typical mode voltage not as much as the two-level inverter. The basic mode voltage issue still analysts ponder and comprehend. This investigation will be introduced a basic and flexible strategy to lessen regular mode voltage for a seven level mixture cascaded inverter topology. This multilevel inverter topology was set up in view of five levels H-bridge cascaded inverter. Inside, two isolated DC sources had the esteem proportion correlative E/2E. This strategy likewise decreases the exchanging loss and easy to actualize in a typical processor. Reenactment brings about Matlab/Simulink and exploratory outcomes with R-L load will be accounted for approval.

R. Deepak, V. S. Kasturi, L. Sarkar, Y. R. Manjunatha and B. R. Lakshmikantha,[6] Design of an inverter has developed from straightforward two leveled yield to complex multi level yield in the current years. With the interest for high power inverter unit, multilevel inverters have been drawing in broad consideration from the scholarly community and in addition industry. Among the best-known topologies are the H-bridge course inverter, the capacitor bracing inverter and the diode cinching inverter. The huge focal points of multilevel setup are voltage sharing both statical ly and powerfully and it creates better voltage waveforms with less symphonious substance. A traditional multilevel inverter requires `n' DC sources to get 2n + 1 yield voltage levels. One specific burden is, it increments more prominent number of power semiconductor switches. This investigation proposes another idea of exchanging with decreased number of switches and batteries. This idea decreases the multifaceted nature of changing contrasted with other regular techniques and DC Link partners. Proposed multilevel inverter having seven level yield is tentatively approved with a straightforward resistive load.

S. K. Chattopadhyay and C. Chakraborty,[7] Expanding number of levels has dependably been a noteworthy inspiration in the examination of multi level inverters. This investigation proposes a level multiplying network and utilize this to double the quantity of levels of a multilevel inverter topology. While the approach is reasonable to all the current setups, the unit works best for cascaded H-bridge topology. It has been demonstrated that the level multiplying network (LDN) does not devour any power over a total cycle. The LDN is essentially a capacitor fed half bridge topology where the capacitor voltage is self managed. The proposition of the LDN opens up another topological variety for the current designs. Operation of the circuit is checked by reproduction result utilizing MATLAB/Simulink and investigations from research facility model.

IV. PROBLEM STATEMENT

Since several years, there has been a developing interest for medium and high voltage power change systems fit for giving medium and high voltage yield signals having great unearthly execution and simple control. Cases of such systems are HVDC joins, static VAR compensators, medium voltage variable speed drives and active filtering. In ower systems, a load show is a scientific portrayal of the

connection between the transport voltage (extent and frequency) and the real and reactive power streaming into the transport; it might refer to the conditions themselves [1]. or on the other hand the conditions in addition to particular esteems for the parameters (e.g., coefficients, types) of the conditions. There are two sorts of load models: static and dynamic load models. The static load display includes mathematical conditions. It is basically utilized for static load parts, for example, resistive and lighting loads. The dynamic load display includes contrast or differential conditions [1]. Cascaded multilevel inverters can be utilized to deliver high power, high voltage with the multilevel structure, by controlling voltage weights on power electronic devices. The unique structure of these multilevel inverters allows them to reach high voltages with low harmonics even without the use of transformers [2] [3].

V. CONCLUSION

Presently industries get low-voltage high-current ac motor drives with megawatt control level utility necessities. For medium voltage grid, troublesome to associate just a single power semiconductor switch specifically. Coming about, multilevel power conversion structures have been presented as an option solution for high power and medium voltage frameworks. A multilevel power change accomplishes high power appraisals, as well as utilization with sustainable power sources, for example, photovoltaic, wind, and energy components joined effectively to a multilevel power transformation framework for high power applications. H-brige inverter can be directly connected in series with the electrical network for static var compensation (SVC). Cascaded H-bridge inverters are ideal choice for connecting renewable energy sources with ac grid, since need for separate dc sources which is applicable for photovoltaic and/or fuel cells. The Proposed work has presented a brief survey of literature on the cascaded multilevel inverter and its application in power electronics.

REFERENCES

[1] X. Liang and J. He, "Load Model for Medium Voltage Cascaded H-Bridge Multi-Level Inverter Drive Systems," in IEEE Power and Energy Technology Systems Journal, vol. 3, no. 1, pp. 13-23, March 2016.

[2] A.K. Ranjan, D. V. Bhaskar and N. Parida, "Analysis and simulation of cascaded H-bridge multi level inverter using level-shift PWM technique," 2015 International Conference on Circuits, Power and Computing Technologies [ICCPCT-2015], Nagercoil, 2015, pp. 1-5.

[3] P. D. H. Darmawardana, T. D. Kahingala, K. M. C. G. Karunarathna, L. B. S. N. Kularatne and J. P. Karunadasa, "Nine level cascaded H Bridge Inverter (For High Performing UPS Applications)," 2015 Moratuwa Engineering Research Conference (MERCon), Moratuwa, 2015, pp. 76-81.

[4] S. Boobalan and R. Dhanasekaran, "Hybrid topology of asymmetric cascaded multilevel inverter with renewable energy sources," 2014 IEEE International Conference on Advanced Communications, Control and Computing Technologies, Ramanathapuram, 2014, pp. 1046-1051.

[5] N. L. H. Bang, N. V. Nho, N. K. T. Tam and N. M. Dung, "Simulation and experiment of hybrid modulation strategy with common-mode voltage reduction for seven-level hybrid cascaded inverter," 2014 International Conference and Utility Exhibition on Green Energy for Sustainable Development (ICUE), Pattaya, 2014, pp. 1-7.

[6] R. Deepak, V. S. Kasturi, L. Sarkar, Y. R. Manjunatha and B. R. Lakshmikantha, "Novel multilevel inverter with reduced number of switches and batteries," 2013 International conference on Circuits, Controls and Communications (CCUBE), Bengaluru, 2013, pp. 1-5.

[7] S. K. Chattopadhyay and C. Chakraborty, "Multilevel inverters with level doubling network: A new topological variation," IECON 2013 - 39th Annual Conference of the IEEE Industrial Electronics Society, Vienna, 2013, pp. 6263-6268.

[8] IEEE Task Force on Load Representation for Dynamic Performance, ‘‘Load representation for dynamic performance analysis [of power systems],’’ IEEE Trans. Power Syst., vol. 8, no. 2, pp. 472–482, May 1993.

[9] IEEE Task Force on Load Representation for Dynamic Performance, ‘‘Standard load models for power flow and dynamic performance simula- tion,’’ IEEE Trans. Power Syst., vol. 10, no. 3, pp. 1302–1313, Aug. 1995.

[10] A. Merdassi, L. Gerbaud, and S. Bacha, ‘‘A new automatic average mod- elling tool for power electronics systems,’’ in Proc. IEEE Power Electron. Specialists Conf. (PESC), Jun. 2008, pp. 3425–3431.

[11] J. Sun and H. Grotstollen, ‘‘Averaged modelling of switching power converters: Reformulation and theoretical basis,’’ in Proc. IEEE 23rd Annu. Power Electron. Specialists Conf. (PESC), vol. 2. Jun./Jul. 1992, pp. 1165–1172.

[12] S. Cuk and R. D. Middlebrook, ‘‘A general unified approach to modelling switching-converter power stages,’’ in Proc. IEEE Annu. Power Electron. Specialists Conf. (PESC), Jun. 1976, pp. 18–31.

[13] A. Griffo, J. B. Wang, and D. Howe, ‘‘State-space average modelling of 18-pulse diode rectifier,’’ in Proc. 3rd Int. Conf. Sci. Comput. Comput. Eng. (IC-SCCE), Jul. 2008, pp. 1–8.

[14] T. A. Meynard, M. Fadel, and N. Aouda, ‘‘Modeling of multilevel convert- ers,’’ IEEE Trans. Ind. Electron., vol. 44, no. 3, pp. 356–364, Jun. 1997.

[15] A. Uan-Zo-li, R. P. Burgos, F. Lacaux, F. Wang, and D. Boroyevich, ‘‘Assessment of multipulse converter average models for stability studies using a quasistationary small-signal technique,’’ in Proc. 4th Int. Power Electron. Motor Control Conf., vol. 3. Aug. 2004, pp. 1654–1658.

[16] S. Rosado, R. Burgos, F. Wang, and D. Boroyevich, ‘‘Large- and small- signal evaluation of average models for multi-pulse diode rectifiers,’’ in Proc. IEEE Workshops Comput. Power Electron. (COMPEL), Jul. 2006, pp. 89–94.