ISSN (Online) 2395-2717

International Journal of Engineering Research in Electrical and Electronic Engineering (IJEREEE)
Vol 3, Issue 9, September 2017

Fuzzy Logic Control of a Mult- Level Converter with a Floating Bridge for Open-Ended Winding Motor Drive Applications

[1] A.Prathima, [2] P.Suneetha
[1] PG Student, [2] Professor,
Department of Electrical and Electronics Engineering, Annamacharya Institute of Technology and Sciences, Tirupati, Andhra Pradesh-517507, INDIA

***Abstract*: -- This paper shows a double three phase open end winding enlistment motor drive. The drive comprises of a three phase enlistment machine with open stator phase windings and double bridge inverter provided from a solitary DC voltage source. To accomplish multi-level output voltage waveforms a floating capacitor bank is utilized for the second of the double bridges. The capacitor voltage is directed utilizing redundant switching states at half of the fundamental dc link voltage. This specific voltage proportion (2:1) is utilized to make a multi-level output voltage waveform with three levels. An adjusted modulation plot is utilized to enhance the waveform nature of this double inverter. This paper additionally analyzes the misfortunes in double inverter system interestingly with single sided three-level NPC converter.**

***Index Items*— Field oriented control, floating bridge, Open End Winding Induction Machine (OEWIM), space vector**

I. INTRODUCTION

Different multi-level converter topologies have been proposed during the most recent two decades [1-4]. A few converter topologies have been examined to accomplish multi-level output voltage waveforms, among them the diode clipped [3], flying capacitor [5, 6] and fell [4] converters are usually utilized. Multi-level converters have bring down dv/ d t and lessened symphonious twisting alongside bring down semiconductor switching gadget blocking voltage necessities, in this way multi-level converters are favorable in medium voltage, high power or low voltage, high recurrence applications [7]. Among the course converters, double two-level inverter topology has gotten consideration because of the effortlessness of the power organize and the game plan's blame tolerant limit. Conventional double two-level inverter topologies utilize two standard three-phase inverters to accomplish a multi-level voltage output. This topology does not have the nonpartisan point vacillations found in NPC converters, utilizes less capacitor than the flying capacitor topology and requires less secluded supplies than H-bridge converters.

Moreover double inverters are more dependable, on the grounds that if there should arise an occurrence of a disappointment in one converter the outputs of the converter can be short-circuited and the system would then be able to work as a standard single sided three phase inverter. To accomplish multi-level voltage waveforms and to cut the way of normal mode current stream two detached dc sources are utilized for conventional double inverter topology, expanding the size and weight of the system. In this paper a double two-level inverter is displayed which diminishes the size and weight of the system for an open end winding enlistment motor drive application. Double inverter topologies have been considered in various papers for various applications.

The customary double inverter topologies (utilizing two detached dc sources) have been dissected, with various space vector modulation plans used to create the multi-level output voltage waveforms. A piece graph of a conventional open phase load and converters is appeared in Fig. 1. It is conceivable to utilize a solitary supply for the double inverters with a typical mode disposal procedure. These topologies utilize particular switching curves that create measure up to regular mode voltages which scratch off at load terminals. A decrease in the quantity of voltage levels and lower dc bus voltage use are the fundamental impediments of this variety of the topology. A regulation method to adjust the power stream between the two inverters in a double inverter system has additionally been proposed. This topology still uses a detachment transformer; the span of this transformer can be lessened to the detriment of decreased modulation file. The coasting capacitor connect topology alongside a reasonable control plan to permit the supply of reactive power was presented. Different creators have displayed techniques to make up for supply voltage droop with a specific end goal to

ISSN (Online) 2395-2717

International Journal of Engineering Research in Electrical and Electronic Engineering (IJEREEE)
Vol 3, Issue 9, September 2017

keep the drive operational in consistent power mode. This topology utilizes a drifting capacitor extension to counterbalance the voltage droop in rapid machines.s

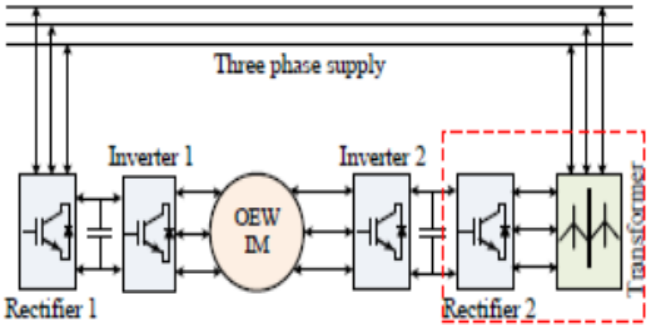

Fig. 1.Conventional open end winding IM drive topology

In this paper, a circuit topology is broke down which is utilized as a three-level open end winding enlistment motor drive. This topology utilizes double inverters with just a single DC voltage source at the essential side of the converter. The second bridge converter is connected with a floating capacitor bank. The point of this topology is to dispose of the necessity for a cumbersome detachment transformer while accomplishing multi-level output voltage waveforms. The voltage over the floating capacitor bank is controlled utilizing the redundant switching vectors alongside a changed SVM plot which stays away from undesirable voltage levels in the phase voltage waveforms during the dead-time interims, along these lines enhancing the by and large waveform quality.

II. PROPOSED SYSTEM

A. Floating capacitor bridge inverter

The floating bridge capacitor double inverter based topology has been broke down for various applications. The topology can be utilized to supply reactive energy to a machine and to make up for any supply voltage droop, however the likelihood of multi-level output voltage waveforms were not considered. A control plan to charge the drifting capacitor connect alongside multi-level output voltage waveforms has been displayed. In this technique the primary converter works in six phase mode and the gliding converter is called molding inverter as it is enhancing the waveform quality. The work depicted in this paper is to control the voltage over the drifting inverter connect capacitor utilizing the redundant switching states, accordingly expelling the requirement for any segregation transformer and enabling the converter to accomplish multi-level output voltage waveforms. Fig. 2 demonstrates a piece graph of the double inverter with a drifting bridge and related capacitor. The utilization of a dc interface voltage proportion of 2:1 enables the double bridge inverter to create up to a three levels in the output voltage waveform. The power phase of the proposed topology is appeared in Fig.3.

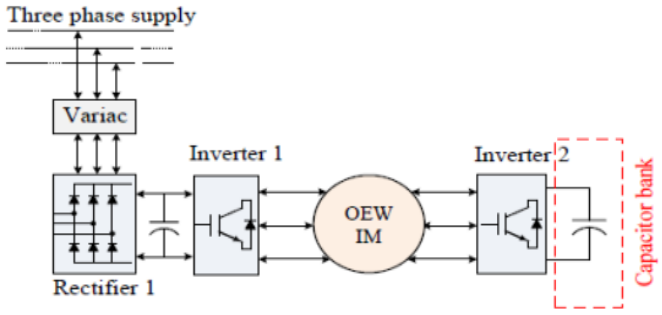

Fig. 2. Block diagram of proposed floating bridge topology.

B. Principles of operation

To indicate how the coasting capacitor can be charged and released the conceivable switching states are investigated. The space vector outline for the topology is appeared in Fig.4, which is inferred by accepting that the two converters as being provided from confined DC sources with a voltage proportion of 2:1. In Fig.4 the red numbered switching curves release the gliding capacitor, while the green numbered switching mixes charge the coasting capacitor. The blue numbered switching curves hold the last condition of capacitor and are subsequently unbiased as far as the condition of charge of the coasting capacitor. For instance state (74) appeared in Fig.5 gives the switching successions for both converter's best switches 7 (1) speaks to the best three switches for principle inverter and 4 (0 1) speaks to the switching states for top three switches of the floating converter

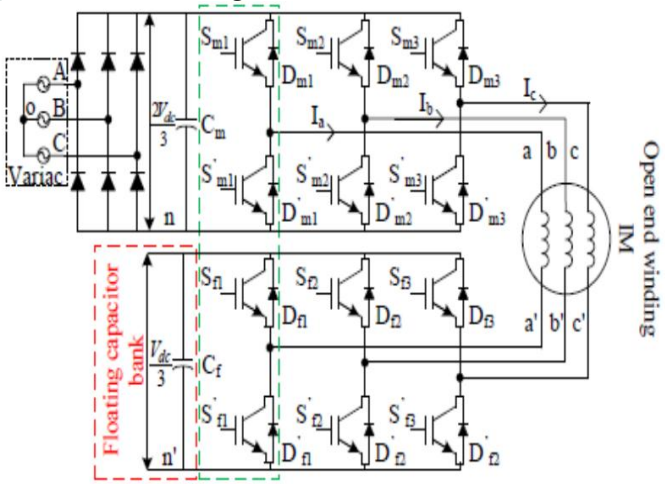

Fig. 3. Power phase of the floating bridge topology (the floating capacitor is charged to half of the main DC link voltage).

ISSN (Online) 2395-2717

International Journal of Engineering Research in Electrical and Electronic Engineering (IJEREEE)
Vol 3, Issue 9, September 2017

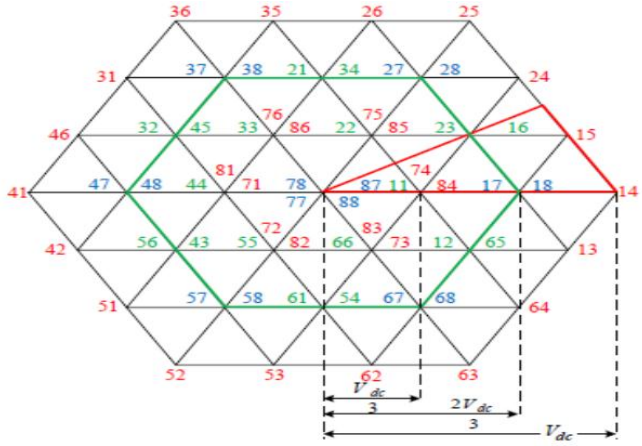

Fig. 4. Space vector of dual two-level inverter (source ratio 2:1).

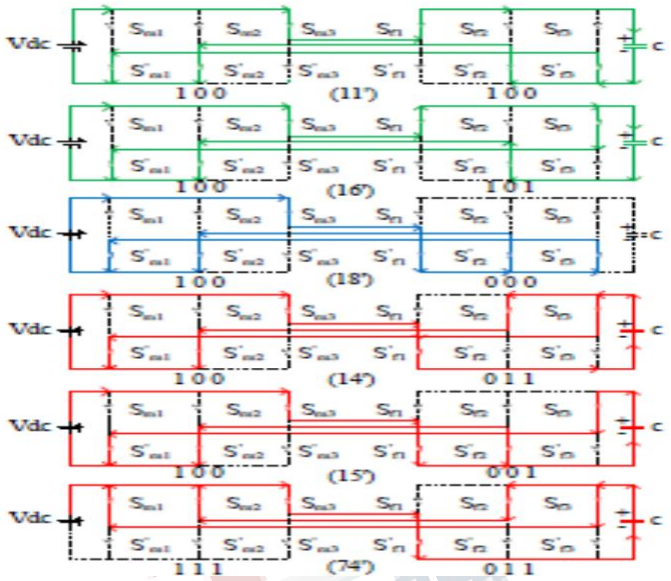

Fig. 5. Current flow for different switching state.

It can be seen from the Fig. 5 that curves (11) and (16) will guide the current through the positive to negative terminal of the gliding capacitor hence will act to charge the capacitor. Curves (14), (15) and (74) will bring about a current the other way and will in this way demonstration to release the capacitor. Mixes finishing with 7 (111) or 8 (000) are zero states and will in this manner have no effect of coasting capacitor's voltage. It is obvious from Fig. 4 that if the reference voltage is in external hexagon at that point there are just two switching curves in every segment to charge the gliding capacitor. During inductive load operation capacitor release rate will be slower and will cause cheating if the reference voltage lies in external hexagon. Additionally, because of absence of charging states, the drifting capacitor will release if the machine is drawing dynamic power. To maintain a strategic distance from these two marvels a limitation must be forced on balance list. Therefore the maximum useable number voltage levels over the load will be diminished to nine (thirteen for confined sources) alongside a somewhat lower than perfect DC bus voltage usage. In this way the floating capacitor can charge to half of the fundamental DC connect capacitor voltage just if the balance record (m) is restricted as appeared in condition (1).

$$m = 0.66 \quad (1)$$

This is 33% decrease of DC bus use conversely with a double inverter provided by two separated sources. The double inverter with a zero series disposal procedure likewise utilizes single supply with 15% diminishment in DC bus use and can accomplish five-level voltage over the load.

C. Modulation strategy

A decoupled space vector regulation technique has been utilized for this double inverter gliding span topology. Switching mixes are chosen such that the normal produced voltage for each of the converters is 180 degree phase moved from the other [Fig.6 (a)]. These voltages will then include at load terminal to coordinate general voltage reference [Fig.6 (b)]. Recognizable proof of the subsectors, stay time count and the switching grouping configuration can be found. To accomplish better outcomes, the output switching successions are adjusted. The alteration of the beats is important to limit the undesirable voltage levels because of dead-time interims in each phase leg. When all is said in done, the output voltage of a converter is administered by load current during dead-time interims and the voltage is equivalent to one of the voltage levels earlier or after the dead-time interims. The double inverter with unequal voltage sources will demonstrate an alternate trademark, rather than cinching the output voltage to one of the voltage levels earlier or after the dead-time interim voltage levels; it braces the output voltage to some other voltage levels. This is valid for synchronous switching for each phase legs of the converters**.**

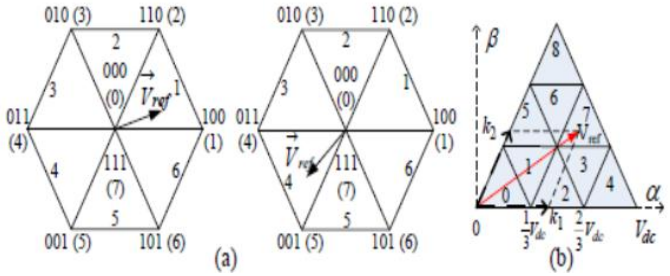

Fig. 6. (a) Space vector diagram of individual converter (not in scale). (b) Space vector diagram of the dual inverter system with source ratio of 2:1.

ISSN (Online) 2395-2717

International Journal of Engineering Research in Electrical and Electronic Engineering (IJEREEE)
Vol 3, Issue 9, September 2017

For an illustration, consider phase legs inside green dabbed line in Fig. 3 for positive load (current spilling out of fundamental to floating converter). On the off chance that the best switches of the legs (Sm1 and Sf1) are on then the load current will experience switch Sm1 and diode Df1. Presently, if the two legs go to its dead-time in the meantime the load current will alter course and will experience diode D'm1 and diode Df1. At last when both the converter legs base switches (S'm1 and S'f1) turned on current will experience diode D'm1and switch S'f1. Plainly during dead-time interim, voltage level is distinctive to the voltage levels prior and then afterward the dead-time interim. To maintain a strategic distance from this undesirable voltage level, in this situation, the fundamental converter leg will go into its dead-time first and afterward second converter will go to its dead-time interim when the principle converter takes a break interim. A summed up series is appeared in Fig. 7 for positive load current. It can be seen from the Fig. 7 that the beats are deferred relying upon the switching states advances.

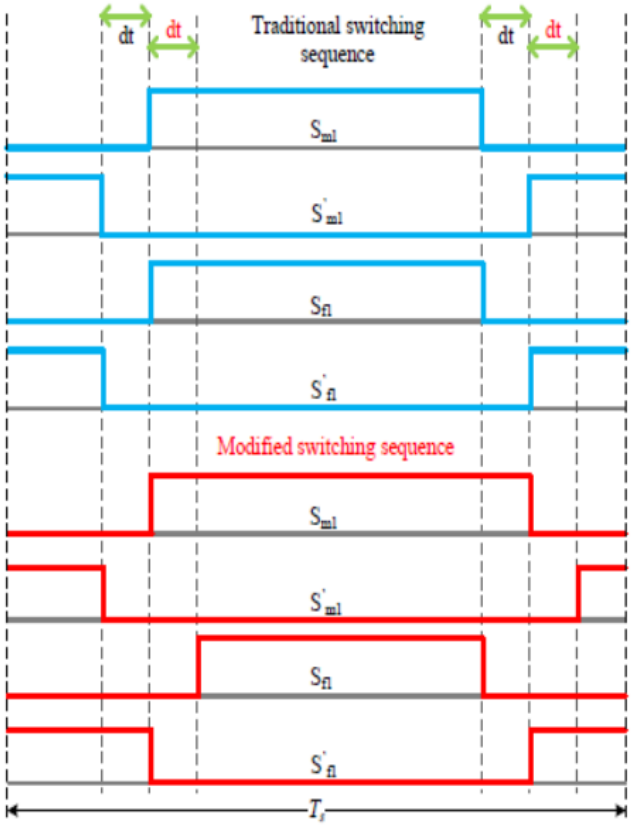

Fig. 7. Delayed dead-time intervals in both converters when current direction is positive

Because of the altered switching series, the present heading does not change during the dead-time. The condition of the drifting capacitor will rely upon the current just before the event of dead-time interim. For instance, if the capacitor was charging then it will continue charging when the converter is in dead-day and age. The estimation of dead-time is too little for the any cheat or release to change the capacitor voltage radically

III. SIMULATION RESULTS

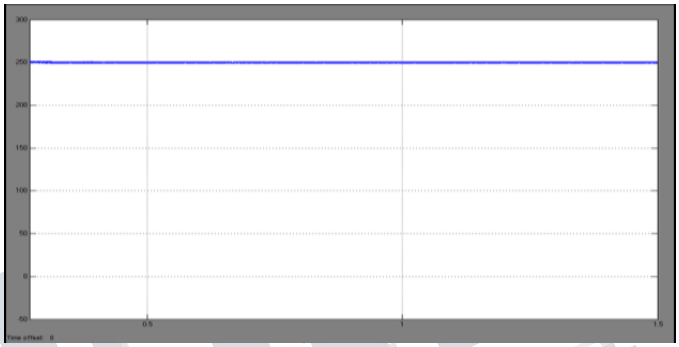

Fig. 8.a. Open loop v/f control IM drive Top to bottom: Floating DC link Voltage

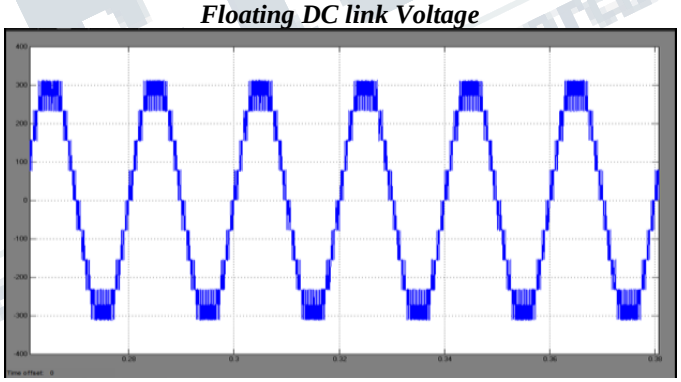

Fig. 8.b. Open loop v/f control IM drive Top to bottom: Phase Voltage

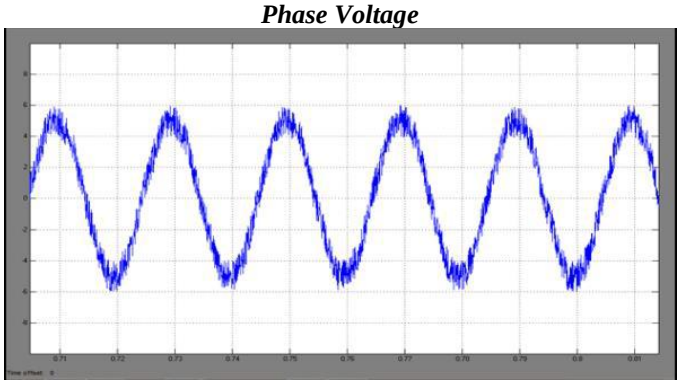

Fig. 8.c. Open loop v/f control IM drive Top to bottom: Phase current

ISSN (Online) 2395-2717

International Journal of Engineering Research in Electrical and Electronic Engineering (IJEREEE)
Vol 3, Issue 9, September 2017

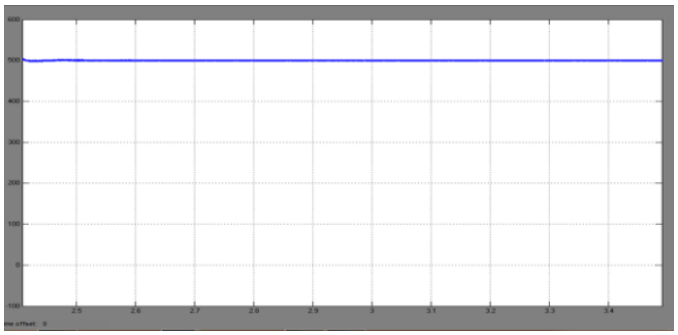

Fig. 9.a. Open loop v/f control IM drive Top to bottom: Main DC link Voltage

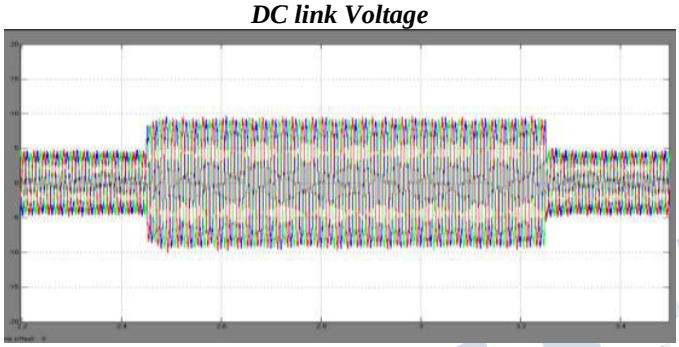

Fig.9.b. Open loop v/f control IM drive Top to bottom: Three Phase current

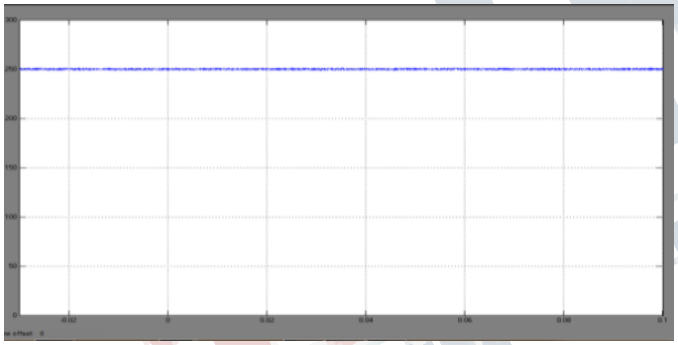

Fig. 10.a. Vector control when machine is loaded. Top to bottom: Floating DC link Voltage

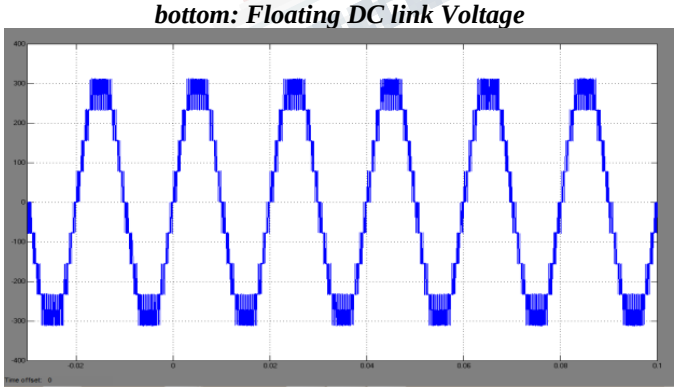

Fig. 10.b. Vector control when machine is loaded. Top to bottom:: Phase Voltage

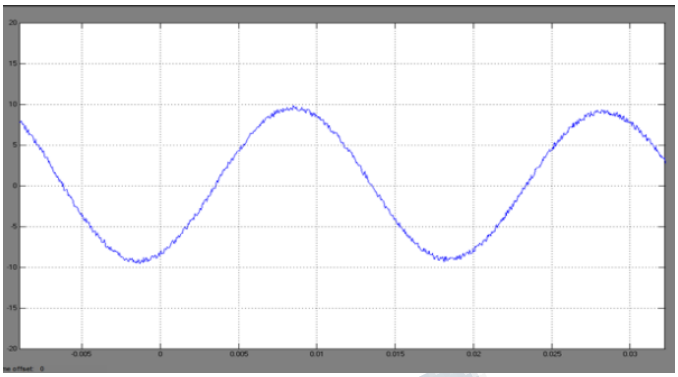

Fig. 10.c. Vector control when machine is loaded. Top to bottom: Phase current.

Fuzzy logic is a complex mathematical method that allows solving difficult simulated problems with many inputs and output variables. Fuzzy logic is able to give results in the form of recommendation for a specific interval of output state, so it is essential that this mathematical method is strictly distinguished from the more familiar logics, such as Boolean algebra.

Advantages of Fuzzy Controller over PI Controller

Usage of conventional control "PI", its reaction is not all that great for non-linear systems. The change is striking when controls with Fuzzy logic are utilized, acquiring a superior dynamic reaction from the system. Or The PI controller requires exact direct numerical models, which are hard to get and may not give tasteful execution under parameter varieties, load unsettling influences, and so forth. As of late, Fuzzy Logic Controllers (FLCs) have been presented in different applications and have been utilized as a part of the power devices field. The benefits of fuzzy logic controllers over ordinary PI controllers are that they needn't bother with a precise scientific model, Can work with uncertain information sources and can deal with non-linarites and are more powerful than traditional PI controllers.

IV. CONCLUSION

A motor drive utilizing open stator winding acceptance machine and a double bridge inverter topology with a gliding capacitor connect has been investigated and useful outcomes are illustrated. The proposed system charges the gliding span capacitor to a proportion of 2:1 concerning principle connect DC link voltage sufficiency. This specific DC connect voltage proportion enables the converter to accomplish multi-level output voltage waveform. The drifting DC link voltage is kept at a steady voltage by the methods for charging and releasing the coasting span capacitor. This is accomplished by choosing between the charging and releasing excess conditions of the converter. A changed space vector balance system is received

to dispense with the undesirable voltage levels during the dead-time interims, subsequently enhanced the waveform quality for this floating bridge topology. An open circle v/f control drive was executed to approve the execution of the capacitor control.

REFERENCES

[1] P. Wheeler, L. Xu, L. Meng Yeong, L. Empringham, C. Klumpner, and J. Clare, "A review of Multi-level Matrix Converter topologies," IET Conf. on Power Electron., Machines and Drives PEMD, pp. 286-290, 2008.

[2] J. Rodriguez, L. Jih-Sheng, and P. Fang Zheng, "Multilevel inverters: a survey of topologies, controls, and applications," IEEE Trans. Ind. Electron., vol. 49, pp. 724-738, 2002.

[3] J. Rodriguez, S. Bernet, P. K. Steimer, and I. E. Lizama, "A Survey on Neutral-Point-Clamped Inverters," IEEE Trans. Ind. Electron., vol. 57, pp. 2219-2230, 2010.

[4] M. Malinowski, K. Gopakumar, J. Rodriguez, and M. A. Perez, "A Survey on Cascaded Multilevel Inverters," IEEE Trans. Ind. Electron., vol. 57, pp. 2197-2206, 2010.

[5] D. Janik, T. Kosan, P. Kamenicky, and Z. Peroutka, "Universal precharging method for dc-link and flying capacitors of four-level Flying Capacitor Converter," IEEE Conf. on Ind. Electron. Soc. IECON, pp. 6322-6327, 2013.

[6] E. C. dos Santos, F. Gulpinar, and E. R. C. da Silva, "Flying capacitor four-level H-Bridge converter," Power and Energy Conf. at Illinois PECI, pp. 1-6, 2014.

[7] E. Levi, "Multiphase Electric Machines for Variable-Speed Applications," IEEE Trans. Ind. Electron., vol. 55, pp. 1893-1909, 2008.

[8] S. Kouro, J. Rodriguez, W. Bin, S. Bernet, and M. Perez, "Powering the Future of Industry: High-Power Adjustable Speed Drive Topologies," IEEE Industry App. Mag., vol. 18, pp. 26-39, 2012.

[9] N. Bodo, M. Jones, and E. Levi, "PWM techniques for an open-end winding five phase drive with a single DC source supply," IEEE Conf. on Ind. Electron. Soc. IECON, pp. 3641-3646, 2012.

[10] E. Levi, M. Jones, and W. Satiawan, "A multiphase dual-inverter supplied drive structure for electric and hybrid electric vehicles," IEEE Vehicle Power and Prop. Conf. VPPC, pp. 1-7, 2010.

[11] K. Ramachandrasekhar, S. Mohan, and S. Srinivas, "An improved PWM for a dual two-level inverter fed open-end winding induction motor drive," Int. Conf. on Electrical Machines ICEM, pp. 1-6, 2010.

[12] E. G. Shiva Kumar, K. Gopakumar, S. K. Sinha, A. Pittet, and V. T. Ranganathan, "Space vector PWM control of dual inverter fed openend winding induction motor drive," IEEE Applied Power

Electron. Conf. and Expo. APEC, pp. 399-405 vol.1, 2001.

[13] V. T. Somasekhar, K. Gopakumar, A. Pittet, and V. T. Ranganathan, "A novel PWM inverter switching strategy for a dual two-level inverter fed open-end winding induction motor drive," IEEE Int. Conf. on Power Electron and Drive Systems Proc., pp. 196-202 vol.1. , 2001

[14] Y. Zhao and T. A. Lipo, "Space vector PWM control of dual three phase induction machine using vector space decomposition," IEEE Trans. Industry App., vol. 31, pp. 1100-1109, 1995.

[15] M. R. Baiju, K. K. Mohapatra, R. S. Kanchan, and K. Gopakumar, "A dual two-level inverter scheme with common mode voltage elimination for an induction motor drive," IEEE Trans. Power Electron., vol. 19, pp. 794-805, 2004.

[16] B. A. Welchko, "A double-ended inverter system for the combined propulsion and energy management functions in hybrid vehicles with energy storage," IEEE Conf. on Ind. Electron. Soc. IECON, p. 6 pp, 2005.

[17] K. A. Corzine, M. W. Wielebski, F. Z. Peng, and W. Jin, "Control of cascaded multilevel inverters," IEEE Trans. Power Electron., vol. 19, pp. 732-738, 2004.

[18] K. A. Corzine, S. Lu, and T. H. Fikse, "Distributed Control of Hybrid Motor Drives," IEEE Trans. Power Electron., vol. 21, pp. 1374-1384, 2006.

[19] S. Chowdhury, P. Wheeler, C. Gerada, and C. Patel, "A dual two level inverter with a single source for open end winding induction motor drive application," Euro. Conf. on Power Electron. and App. EPE-ECCE-Europe, pp. 1-9, 2015.

ISSN (Online) 2395-2717

International Journal of Engineering Research in Electrical and Electronic Engineering (IJEREEE)
Vol 3, Issue 9, September 2017

[20] M. Darijevic, M. Jones, and E. Levi, "An Open-end Winding Four level Five-phase Drive," IEEE Trans. Ind. Electron., vol. PP, pp. 11, 2015.

AUTHOR'S PROFILE:

A.Prathima was born in AP, India in1993. Currently she is studying her Post graduate degree in Annamacharya institute of Technology & Science (AITS) affiliated to Jawaharlal Nehru Technological University Anantapur in Electrical and Electronics Engineering with specialization in Power Electronics. Her areas of interest include Power electronics and Drives, FACTS, Electrical measurements and Control systems. Email Id:amaravathiprathima@gmail.com.

P.Suneetha currently working as an Assistant professor in the department of EEE, Annamacharya institute of Technology & Science(AITS).Email Id:sreesuni30@gmail.com