OPEN SWITCH FAULT DETECTION IN CASCADED H-BRIDGE MULTILEVEL INVERTER USING NORMALIZED MEAN VOLTAGES

[1]Deepak Jyoti, [2]Prof. Balram Yadav
[1]Research Scholar, [2]Assistant Professor
SCOPE College of Engineering, Bhopal (M.P.)

Abstract: - Approximately 75 percentage of carbon monoxide emission is owing to vehicles and emission from automobiles denotes around 50 to 90 percentage of air pollution in urban areas. Electric vehicles are feasible answer to reduce the pollution from automobiles composing high quantity of air pollution. Electric vehicles make use of electric motors to drive the wheels of electric vehicle. Motors are supplied with electric supply and convert the supplied energy to mechanical energy with no carbon or other greenhouse gas emission. CHB topology of inverter is controlled with PWM technique. Many PWM techniques are explained and out of which sinusoidal PWM technique is employed for proposed work due to its simplicity. Many types of carrier based sinusoidal PWM techniques are there and explained but in-phase disposition (IPD or PD) PWM technique was used to trigger switches of CHB inverter. CHB topology of multi-level inverter under healthy conditions using IPD PWM technique for 5-level, 7-level and 9-level inverters was explained.

Mitigation is very important as fault persistence can severely damage the complete system and badly affect the induction motor performance. Prior knowledge of fault analysis, initiates the process of mitigation to restore the actual performance of induction motor drive load. A novel algorithms being studied for inverter fed induction motor drive system to identify and mitigate the inverter faults.

1. INTRODUCTION

Growth in power electronics lead to many developments in the area of electrical engineering. To achieve high output voltage from an inverter with low total harmonic distortion before the filter, multi-level inverter concept was developed. Achieving low total harmonic distortion before filter can eventually reduce the size of the filter, thus reducing the overall cost. If THD is more before filter, the sizing of filter might affect the overall cost of the system subjected to availability of large sized filters. With multi-level inverters, better output can be obtained with less cost than compared to conventional square wave inverter.

Use of number of switching cells and their control is main drawback in employing multi-level topology. As the number of levels at the output increases, the usage of switching cells will also be increased. Reliability of the components is very important for better performance of the system. In multi-level inverters driving induction motor drive, the failure in any of the switching cell can badly affect the performance of the induction motor drive. Failure in switching cells should be diagnosed very quickly to restore the actual performance of the motor drive when fed from inverters.

"Fault is an unusual behaviour of a component which results in malfunctioning of the system where device which is in failure condition was connected".

2. INVERTERS

Inverter is an electrical circuit which converts DC to AC. Inverter does not generate any power but just transforms the supplied DC type of power to AC type. Inverter basically consists of power switches and the output power and frequency can be controlled by controlling the switches. Wherever, variation in output frequency is required with variation in voltage, inverters are a viable option.

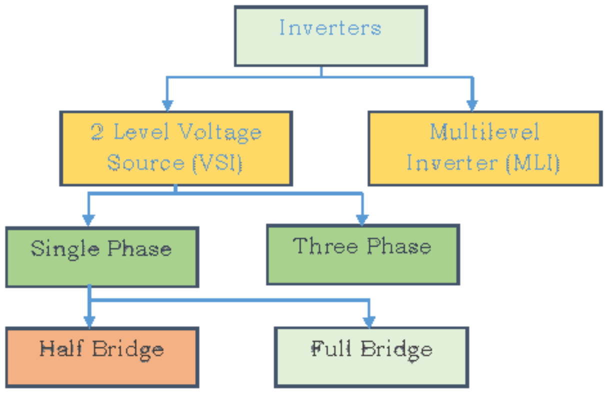

Figure 1, Types of Inverters

Different types of inverters are shown in figure 2.1. Inverters are broadly classified as basic conventional 2-level voltage source inverters (VSI) and multi-level inverters (MLIs). Conventional 2-level inverters are again classified to single-phase and three-phase inverters. Single phase inverters are further classified to half-bridge and full-bridge inverters.

The output of basic conventional 2-level inverter is a square wave and thus they can also be called as square wave inverters. Square wave output from conventional inverter consists of infinite harmonics and insists for harmonic mitigation. To reduce infinite harmonics sizing of filter will be more and not so cost effective. Thus to reduce the amount of harmonics at the output waveform, the level in output wave form is increased so that the harmonic distortion at the output wave is reduced compared to conventional square wave inverter. This concept of increasing the output level can eventually reduce the size of filters and are termed as multi-level inverters (MLI).

3. MULTI-LEVEL INVERTERS

High power usage has made a way for multi-level inverters in these days in electrical applications in power sector. Multi-level inverters became part of almost many applications replacing conventional two-level inverters. Multi-level inverters are best suited for high power high voltage applications [1 - 2]. Conventional twolevel inverters suffers from setback of high output distortions due to presence of harmonics. To reduce the amount of harmonic distortions, filters can be used. But to minimize the effect of lower order harmonics, large filter size may be required which increases the overall cost of the system while higher order harmonics can be easily nullified with low sized filters [3-4]. Harmonic distortions at the output of inverter driving an electric motor drive can cause excessive heating of motor coils, electromagnetic interference and increased torque distortions. Reduction in total harmonic distortion is to obtain the output of the inverter nearer to sinusoidal waveform. This can be obtained by increasing the levels of output wave retaining the power quality and thus obtained by using multi-level inverters.
3.1 ADVANTAGES OF MULTI-LEVEL INVERTERS
Multi-level inverters have exceptional features when compared to conventional type of inverters and some of them are mentioned below. Due to the listed features, multi-level inverters are widely used to achieve high power output.

- Requires low input current Produces high output voltage.
- Delivers output with exceptionally low distortions.
- Produce small common mode voltage (CMV) which sophisticates ease of motor bearing operation.
- Can operate at low and higher switching frequencies

4. FAULTS IN MULTI-LEVEL INVERTERS

Multi-level inverter consists of many components and faults are very common to occur in inverter circuits. Faults produce unwanted disturbance in the system and affects the performance of the loads to which inverter is fed from. Mostly inverters are used in motor drives, active filters, power factor compensators, interfacing with renewable energy source and many more. A simple fault can affect the complete load performance which is connected to faulty inverter [5]. Multi-level stepped output employs mostly IGBT as its main switching device for its operation. Also multi-level inverters consist of diodes connected anti-parallel to switching device. A fault in any of components in multi-level inverter can hardly affect the system performance. Some of the notified faults in multi-level inverter topology are:

1. Switch (IGBT) open fault
2. Switch (IGBT) short fault
3. Diode open fault
4. Diode short fault
5. Gate open fault
6. Gate short fault

5. LITERATURE REVIEW

This Section outlines the major research works reported so far in the multilevel inverter topologies and modulation techniques. Performance analysis of various multilevel inverters reported in the literature is given.

Debaprasad Kastha[6] et al., orderly depicts the consequences of various faults in PWM inverter fed induction motor drive employing V/F speed control technique. Internal faults of the machine are not considered in this study. Different type of possible faults are mentioned but only faults like input supply line to ground fault, diode short circuit fault, transistor base drive open fault and transistor short circuit fault were only considered for study. Simulation study was carried out for the said four types of fault conditions and the voltage and current stress on switching device was determined qualitatively so that the qualitative data for different faults will be helpful in diagnosing the fault and also to study motor drive performance after fault.

M. S. Mendes[7] et al., illustrates the use of Park's vector method for mitigating different faults like short and open faults of inverter. Prototype was built for inverter and the author validated the faults and diagnosis method with Park's vector approach.

K. Rothenhagen[8] et al., views that the faults in inverter are very common in occurrence and diagnosis of fault is important in restoring the performance of the system. Author reviews the fault analysis for open type of fault in inverters and author overview different strategies and algorithms to localize fault. Author starts with the survey of fault location in mains side rectifier with different strategies and he extends his work by evaluating the fault analysis in inverter connected to induction machine with variable voltage and frequency.

D. Diallo[9] et al., studies the viability of fault detection and mitigation in three-phase inverter connected to induction motor. Local patterns with seven parts are made where one is meant for healthy mode and remaining six are for six switches of inverter. A simple algorithm compares the patterns and locates the faulty switch. The proposed work is approached with sensor-based method by measuring the mains current and the patterns were built with stator mean current vector method.

B. A. Welchco[10] et al., compares fault tolerant topologies of 3- phase inverter driven AC motor for Open fault, short fault, phase leg faults. The author reviews the control strategies of faulty inverters including two phase and uni-polar control. The phase voltage and current were measured during faulty condition and are compared with no fault condition.

S. Khomfoi[11] et al., proposed genetic-algorithm-based selective principal component neural network method for fault diagnosis system in a multilevel inverter. Multilayer perceptron (MLP) networks are used to identify the type and location of occurring faults from inverter output voltage measurement. Principal component analysis (PCA) is utilized to reduce the neural network input size.

S. Khomfoi[12] et al., introduces fault diagnostic and reconfiguration method for a cascaded H-bridge multilevel inverter drive (MLID) using artificial-intelligence-based techniques. Output phase voltages of the MLID are used as diagnostic signals to detect faults and their locations. A neural network (NN) classification is applied to the fault diagnosis of an MLID system. Multilayer perceptron networks are used to identify the type and location of occurring faults. The principal component analysis is utilized in the feature extraction process to reduce the NN input size. A lower dimensional input space will also usually reduce the time necessary to train a NN, and the reduced noise can improve the mapping performance.

6. CONCLUSION

Faults are very common in occurrence and different types of faults in inverter circuits were presented in detail, out of which switch open and switch short are very often and constitutes more in occurrence. Fault mitigation topology was developed to by-pass the faulty CHB cell using thyristor based switch placed across each CHB cell in multi-level inverter. A simple algorithm was developed to identify the faulty cell and to activate the thyristor switch across faulty cell so that the fault in particular cell will not create any outage in supplying induction motor drive. Different work related to Fault mitigation is also discussed.

REFERENCES

1. T. H. Liu, J. R. Fu, and T. A. Lipo, “A strategy for improving reliability of field oriented controlled induction motor drives,” IEEE Trans. Ind. Appl., vol. 29, no. 5, pp. 910– 918, Sep./Oct. 1993.
2. Amarendra Edpuganti and Akshay K. Rathore "Optimal LowSwitching Frequency Pulsewidth Modulation of Medium Voltage Seven-Level Cascade- 5/3H Inverter", IEEE Transactions on Power Electronics, vol.30, No.1, January 2015.
3. Nashiren Farzilah Mailah et.al, "Harmonics Reduction of Three Phase Five-Level Neutral-Point-Clamped Multilevel Inverter", 2012 IEEE Conference on Power and Energy (PECon), Dec 2012.
4. Dr. P.V.V. Rama Rao , P. Devi Kiran, A. Phani Kumar, "Hybrid 5- level inverter fed induction motor drive", World Journal of Modelling and Simulation, Vol. 10 (2014) No. 3, pp. 224-230
5.] I. Jlassi; J. O. Estima; S. Khojet El Khil; N. M. Bellaaj; A. J. M. Cardoso, "A Robust Observer-Based Method for IGBTs and Current Sensors Fault Diagnosis in Voltage-Source Inverters of PMSM Drives," in IEEE Transactions on Industry Applications , vol.PP, no.99, 2016.
6. Zambra, DAB, Rech, C & Pinheiro, JR 2007, ‘A comparative analysis between the symmetric and the hybrid asymmetric nine-level series connected H-bridge cells inverter’, in Proceedings twelfth European Conference on Power Electronics Applications, pp. 1-10.
7. The Development of the Electric Motor," Early Electric Motors, Spark Museum, Retrieved 12 February 2013.
8. Md. Abdus Salam, Electromagnetic Field Theories for Engineering, Springer; Soft-cover reprint of the original 1st ed. 2014 edition (September 2016).
9. Molla Shahadat Hossain Lipu, “Energy Efficiency Opportunities and Savings Potential for Electric Motor and Its Impact on GHG Emissions Reduction”, International Journal of Electrical and Computer Engineering (IJECE) Vol. 3, No. 4, August 2013, pp. 533~542.
10. Andres Fernando Lizcano Villamizar et.al, "The Application of Genetic Algorithms in Electrical Drives to Optimize the PWM Modulation ANDRS", Recent Researches in Automatic Control, Systems Science and Communications.
11. H. Schwab, A. Kl¨onne, S. Reck, and I. Ramesohl, “Reliability evaluation of a permanent magnet synchronous motor drive for an automotive application,” in Proc. Conf. Rec. Eur. Power Electron. Appl., Toulouse, France, 2003.

