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Fault Detection in cascade H-Bridge Multilevel Inverter Using ANN based on Wavelet Decomposition

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ABSTRACT: Multilevel Inverter has becoming extremely popular in modern power system. Rapid expansion of the renewable energy sectors, transformer has less grid synchronization and demand for the harmonic free power quality is such igniting factors for its popularity. Multilevel inverters have acquired a great attention of modern power electronic systems. It will offers less distortion and electro-magnetic interference and hence, it can be used in medium voltage and high power applications. As power electronic devices are the prone to various faults, hence to ensure the stability and reliability of system operation, this project presents an intelligent fault detection method for open switch failure in a five level cascaded inverter. Cascaded H-Bridge converter has been recently utilized in different high-power applications due to its modular and simple structure. In order to have a balanced operation after a fault occurrence in this converter, it is necessary to detect the switch fault. In this Project, a fast power switch fault detection method will presented to identify the fault Wavelet decomposition is used to extract the valuable features from output voltage signals of the inverter. Artificial neural networks (ANNs) are a family of models inspired by biological neural networks which will used to estimate or approximate functions that can depend on a large number of inputs. Artificial Neural Network will employed at last for the switch fault detection purpose. Short circuit faults will converted to open circuit faults by incorporating a fuse before each switch inside it. Simulation results will be confirm the efficacy of the fault diagnostic approach with utmost of 99% classification accuracy with the output model.

KEYWORDS: Artificial Neural Network, Wavelet Decomposition, Multilevel Inverter, H-bridge

I. INTRODUCTION

Modernization of industries demands more power and an existing solution of uninterrupted high power supply is multilevel inverters. Here Inverter is a device which converts dc to ac and with the increase in power demand it plays a key role in renewable energy resource exploitation. For high power drives or large traction drives and also in hybrid vehicle applications multilevel inverter is one of the most auspicious solutions. Cascaded H-bridge multilevel inverter system is easier to fabricate with almost twice of output voltage level than input and reduced harmonics which increases its prospects of application. Multilevel inverter can also reduce the switching voltage stress and the corresponding switching frequency that makes it suitable for application in the direct drives involved in wind power system. Power converters are very much susceptible to switch failures. Statistical studies shows that about thirty-eight precent of the failures in case of industrial variable speed drives happen due to failure of power equipment and fifty-three per cent in the control circuits [1].

Power devices, capacitors and gate control circuits are the most vulnerable components [5]. On the other hand semiconductor, soldering and printed circuit board failures may results in 60% of converter system failures [8]. To make any system efficient and stable it is very important to sense any fault that arises during operation in minimum time. An intelligent fault detection approach is presented] for open and short circuit fault detection of power switches in inverter fed induction motor where an average of 99.9% classification accuracy will achieved. In order to maintain continuous operation for a multilevel inverter system, knowledge of fault behaviours, fault prediction, and fault diagnosis are necessary. There should be different Faults are observed and this should be detected as soon as possible

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after they occur, because if a motor drive runs continuously under abnormal conditions, the drive or motor may quickly fail. Research on fault diagnosis of the inverters initially focused on the voltage source inverters in which some of the fault modes will be discussed in this project [3]. These switching devices faults can be classified into open switch fault and short switch fault. A short switch fault not only generates an abnormal overcurrent in the power conversion system and generator but also causes some secondary problems like the demagnetization of synchronous generator. In this case, entire system should be shut down immediately for safety purpose, whereas an open switch fault does not require halting operation.

In multilevel converters, higher power is achieved with the use of series of power semiconductor switches with several lower voltage dc sources to perform the power conversion by synthesizing a staircase voltage waveform. Capacitors, batteries, and renewable energy voltage sources can be used as the multiple dc voltage source [1]. A multilevel converter has several advantages over a conventional two-level converter that uses high switching frequency pulse width modulation (PWM). With the increase in levels, the synthesized output waveform approaches the sinusoidal wave with minimum harmonic distortion. But, the numbers of achievable voltage level are limited due to voltage unbalance problems. Also, number of power semiconductor switches is required. Although lower voltage rated switches can be utilized in a multilevel converter, each switch requires a related gate drive circuit

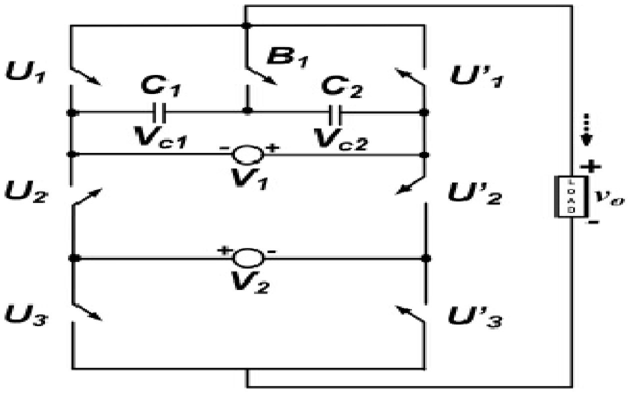

Fig 1 Fundamental unit of proposed MLI (U, unidirectional switches; B1, bidirectional switch)

II. INVERTER DESIGN

Here we are considering the basic inverter setup used in every electrical circuitry. H-Bridge multilevel inverter encompasses number of H-Bridge cells and every cell comprises of four switches which can be different power electronics devices such as IGBT, MOSFET etc. the circuit is very simple which contains the two Cell of MOSFETS In the fig 1(a) a two cell MOSFET based H-Bridge inverter is shown. Cell 1 is made up of MOSFETs M11, M12, M13, M14 having input voltageVin1. Similarly for cell 2 they are named as M21, M22, M23,M24 having input voltageVin2 . For simplification it is considered that both the inputs are equal i.e. Vin1= Vin2= Vin. The output level of inverter (M) and number of sources(S) are related by M=2S+1. It is also noted that a multilevel carrier based sinusoidal PWM is used for controlling gate drive signals for the cascaded multilevel inverter system. For a two cell inverter number of output levels are five i.e. Vin, 2Vin, 0, -Vin, -2Vin and they can be. It is observed that these setup of inverter shows the uniform sinusoidal waveform which is five level. In this five level inverter Setup, in normal condition the Sine wave is normal and if we consider the faulty conditions like if we take switch off the anyone MOSFET the it is occur that there is distortion in the waveform and also change in the amplitudes of the sine wave.

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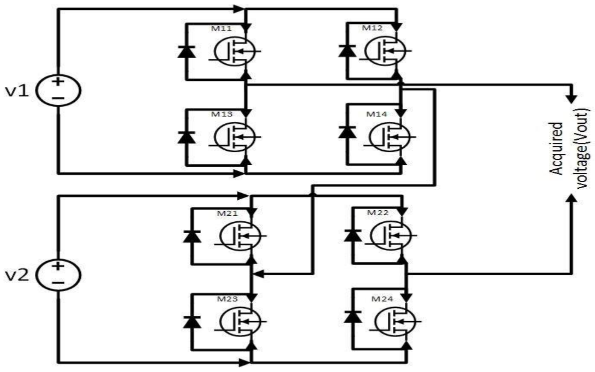

Fig 2 Single phase multilevel inverter system

For a single phase cascaded H-Bridge multilevel inverter two H-Bridges are needed. This two H-Bridge cells are connected in series which are fed by DC voltage sources[9]. To synthesize output voltage waveform, the output of two H-Bridges are connected in series in such a way that the total output is the sum of all individual H-Bridge cell output [1]. That is the output voltage is,

III. WAVELET DECOMPOSTION

There are various transformation techniques present that can be used to identify faults take place in various engineering and technological fields such as, Fast Fourier Transform (FFT), S Transform (ST), and Continuous Wavelet Transform (CWT) etc. which are mentioned in literature. In this paper Discrete Wavelet Transform (DWT) technique is used in which Wavelets are sampled discretely to demonstrate the significant and different features extracted. . DWT can be further categorized in Mallet, Transversal Filter, Lifting Scheme, Codec. The main advantage of Wavelet transformation is that with frequency its window size varies along with resulting optimal time frequency resolution. Starting from a signal s, two sets of coefficients are computed: approximation coefficients CA1, and detail coefficients CD1. These vectors are obtained by convolving s with the low-pass filter Lo_D for approximation and with the high-pass filter Hi_D for detail, followed by dyadic decimation. More precisely, the first step is The length of each filter is equal to 2N. If n = length(s), the signals F and G are of length n + 2N − 1, and then the coefficients CA1 and CD1 are of length To deal with signal-end effects involved by a convolution-based algorithm, a global variable managed by dwtmode is used. This variable defines the kind of signal extension mode used. The possible options include zero-padding (used in the previous example) and symmetric extension, which is the default mode

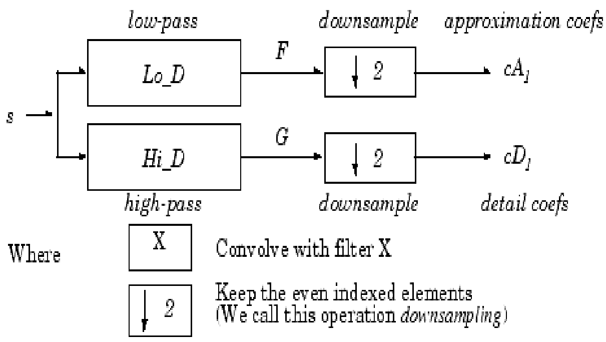

Fig 3 Wavelet Decomposition

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A mother Wavelet is required for decomposition of fault signal while DWT method is used. Among all the mother wavelets "dB10" is used here which belongs to "daubechies wavelets", a family of orthogonal wavelets. It has been observed that with the increase in level of decomposition the classification becomes more accurate which is essential to take precautionary measurements[13]. In this paper the fault signal is putrefied in twelve different levels and energy is extracted from each of them. In this wavelet decomposition works on the filtration process it takes the several samples and it get decomposes into to different samples like one is usable and other is temporary

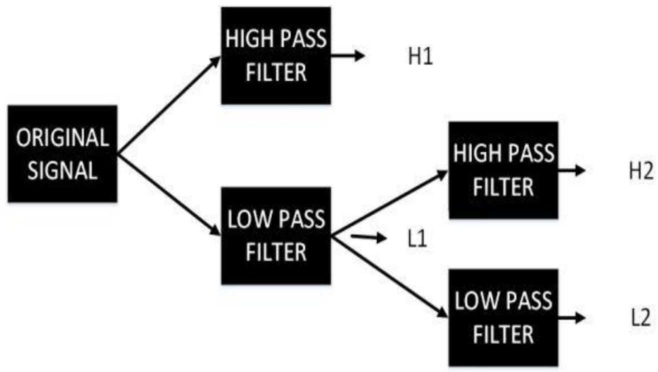

Fig 4 filtration in Wavelet Decomposition

IV. ARTIFICIAL NEURAL NETWORK

Numerous advances have been made in developing intelligent systems, some inspired by biological neural networks. Researchers from many scientific disciplines are designing artificial neural networks (A"s) to solve a variety of problems in pattern recognition, prediction, optimization, associative memory, and control Conventional approaches have been proposed for solving these problems. Although successful applications can be found in certain well-constrained environments, none is flexible enough to perform well outside its domain[17]. ANNs provide exciting alternatives, and many applications could benefit from using them.' This article is for those readers with little or no knowledge of ANNs to help them understand the other articles in this issue of Computer. We discuss the motivations behind the development of A " s , describe the basic biological neuron and the artificial computational model, outline network architectures and learning processes, and present some of the most commonly used ANN models. We conclude with character recognition, a successful ANN application [6].

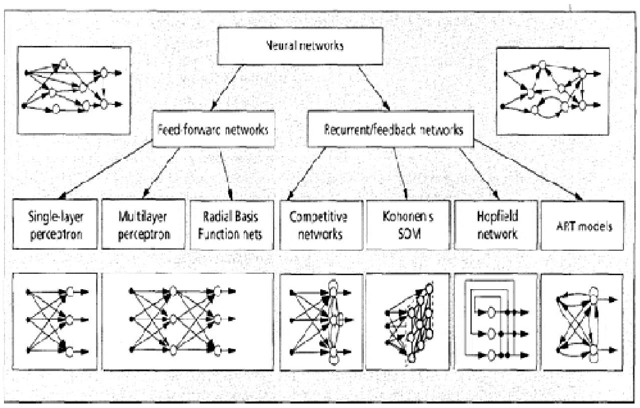

Fig 5 A taxonomy of feed-forward and recurrent feedback network architectures

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It considers a network with N mobile unlicensed nodes that move in an environment according to some stochastic mobility models. It also assumes that entire spectrum is divided into number of M non-overlapping orthogonal channels having different bandwidth. The access to each licensed channel is regulated by fixed duration time slots. Slot timing is assumed to be broadcast by the primary system. Before transmitting its message, each transmitter node, which is a node with the message, first selects a path node and a frequency channel to copy the message. After the path and channel selection, the transmitter node negotiates and handshakes with its path node and declares the selected channel frequency to the path.

The communication needed for this coordination is assumed to be accomplished by a fixed length frequency hopping sequence (FHS) that is composed of K distinct licensed channels. In each time slot, each node consecutively hops on FHS within a given order to transmit and receive a coordination packet. The aim of coordination packet that is generated by a node with message is to inform its path about the frequency channel decided for the message copying. Furthermore, the coordination packet is assumed to be small enough to be transmitted within slot duration. Instead of a common control channel, FHS provides a diversity to be able to find a vacant channel that can be used to transmit and receive the coordination packet. If a hop of FHS, i.e., a channel, is used by the primary system, the other hops of FHS can be tried to be used to coordinate. This can allow the nodes to use K channels to coordinate with each other rather than a single control channel. Whenever any two nodes are within their communication radius, they are assumed to meet with each other and they are called as contacted. In order to announce its existence, each node periodically broadcasts a beacon message to its contacts using FHS. Whenever a hop of FHS, i.e., a channel, is vacant, each node is assumed to receive the beacon messages from their contacts that are transiently in its communication radius.

V. RESULT AND DISCUSSION

The H-Bridge multilevel inverter circuit is simulated and tested in MATLAB Simulink environment to interpret the fault detection technique. Counting one healthy signal, total of nine signals are considered for open circuit faults arises in the circuit under test (CUT). The circuit is realized using power MOSFET having D.C. voltage source varying in the range of 80V to 120V with base value of 100V. An Artificial Neural Network (ANN) taking training to testing ratio sixty to forty that is 60 percent signals are used to train whereas 40 present is used to test, is used to recognize the fault signals. Here we basically create the faulty conditions like real time such that for ex. Switch 1 one MOSFET one is not working so in that case we come to know that fault at MOSFET 1 is occur after complete running of procedure. energy is extracted from each to feed to the ANN network. The algorithm is coded in MATLAB software to obtain the result summarized in the table 3

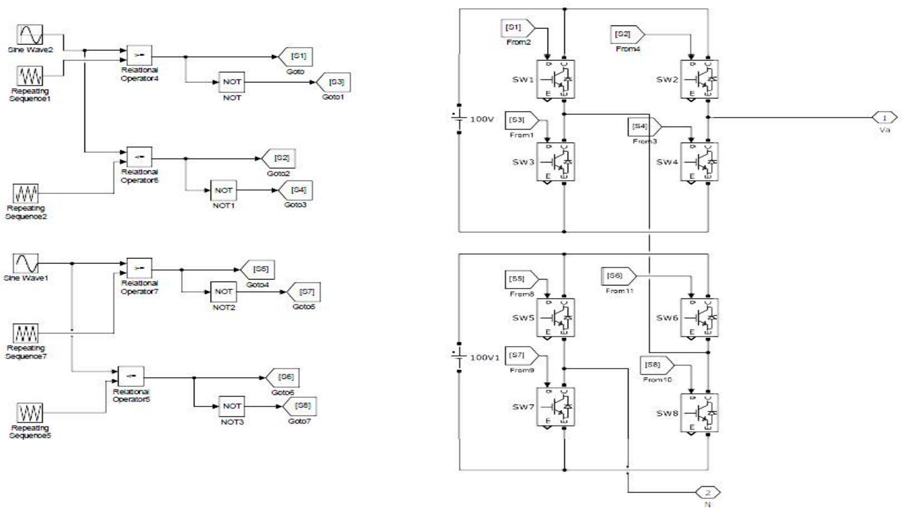

Fig 6 MATLAB Simulink Diagram

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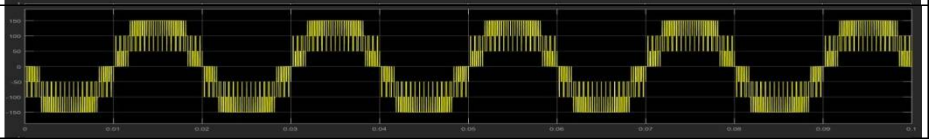
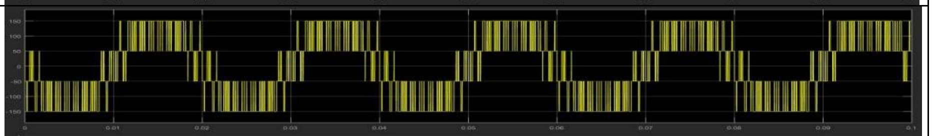
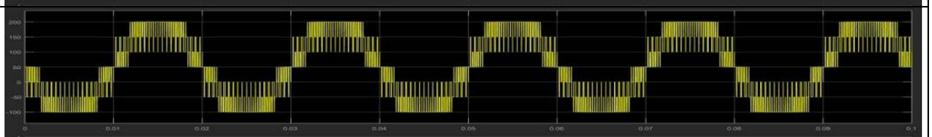
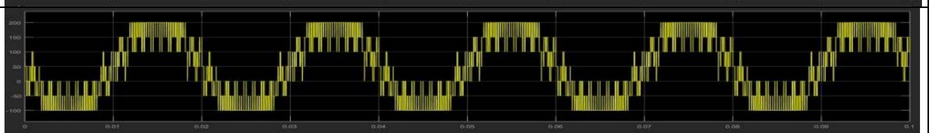
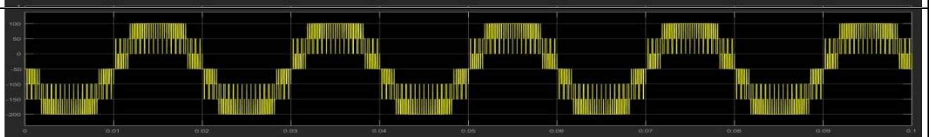
Sr. No	Faulty Conditions	Waveform
1	S1 off remaining on	
2	s1 s2 off remaning on	
3	s1 s2 s3 off remaining on	
4	s1 s3 off remainig on	
5	s1 s3 s5 off remaining on	
6	s1 s4 on remaining off	
7	s1 s5 off remaning on	
8	s2 off remanaing	
9	s2 s3 off remaining on	
10	s2 s7 off remaing on	

Table 1 waveforms of voltages at different fault conditions

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In above table the different waveforms of voltages at different faulty conditions are given. Where s1 s2 etc. are the switches connected with the MOSFETs. This waveforms are occurs by creating faulty conditions at different faults after that we observe the actual value and obtained values where some errors has been occur

VI. CONCLUSION

As the importance of multilevel inverter is increasing in medium and high power applications, many newer-topologies with reduced number of power elements and DC sources are proposed. The proposed work is simulated in MATLAB SIMULINK environment. Simulation results validate the effectiveness of the proposed method for discriminating faulty component that leads to the future progress of hardware based real time fault detection in cascaded H-Bridge inverter. This project proposed a fault detection method cascaded H-bridge multilevel inverter It is possible to detect the fault cell and identify the location of the fault switch under both the open-fault and short-fault by using the proposed detection method. In future multilevel inverter plays an important role because in futures AI will exist only and manual work will be decrease.

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