ABSTRACT

In recent times, cascaded multilevel inverters are mostly preferred for large electric drives used in industries and hybrid electric vehicles because of its advantages such as low harmonics, flexibility to use a set of batteries or fuel cells or any renewable energy sources in any intermediate stage of inverter and ability to reach desired high voltages. Since multilevel inverters are used in high power and expensive applications, considering the investment cost and safety aspects, it is necessary to maintain the reliability of the system. In the case of multilevel inverters, reliability is mainly affected by the electronic components, mainly because of increase in number of power electronic switches such as Insulated Gate Bipolar Transistor (IGBT) and Metal Oxide Semiconductor Field Effect Transistor (MOSFET) which are considered as the weakest part of the system.

Once a fault in the switch occurs, it should be detected at the earliest in order to avoid the operation of drive and motor under abnormal conditions, which may lead to the failure of motor or drive and major economic losses. Fault diagnosis of multilevel inverters is a hot research topic and has created lot of interest among many researchers in the development of better fault diagnostic techniques and protection system. Open circuit and short circuit faults are the most common failures in semiconductor switches and leads to failure of battery or load connected to the inverter. Several techniques have been proposed to identify the faulty switches of inverters based on current measurement and analysis. Since the output current of inverter is dependent on nature of load, accurate fault detection is difficult under low current values. Many researchers developed the fault diagnostic

system from the inverter output voltage measurement, because it is independent of load variations. However, reports on the high performance fault diagnostic system of cascaded H-bridge multilevel inverter is scanty.

Hence, in this research work, development of a high performance fault diagnostic system using advanced signal processing and soft computing techniques has been proposed. Inverter output voltage signal is considered as an important parameter for identification of faulty switches in inverter. This research work deals with the development of better diagnostic tool to identify the failure of power electronic switches due to both open circuit and short circuit faults from the output voltage time-frequency characteristics of multilevel inverters.

Simulation and experimental studies are carried out on five level cascaded H-Bridge multilevel inverter at both open circuit and short circuit fault conditions of IGBT components. Output voltage signals are measured at all possible switch fault cases at different modulation index values. Frequency domain characteristics of output voltage signals are studied using Fast Fourier Transform (FFT) technique. Important features such as Total Harmonic Distortion (THD), 3^{rd} harmonic/fundamental ratio, 5^{th} harmonic/fundamental ratio and Root Mean Square (RMS) voltage are extracted from the FFT technique. Voltage ratio analysis of output voltage signal at different fault conditions was also carried out in time domain. Similarly, time-frequency domain characteristics of the output voltage signals are extracted using Discrete Wavelet Transform (DWT) technique. Db4 wavelet is used as a mother wavelet in the present research work. Energy content of the signal is considered as an important feature and it is extracted from the DWT Multi Resolution Analysis (MRA) at different fault cases.

The process of identification of faulty switch of the multilevel inverter is automated using Artificial Neural Network (ANN) with Back

Propagation Training Algorithm. Performance of the neural network at different number of hidden layer neurons is evaluated. In addition, Adaptive Neuro Fuzzy Inference System (ANFIS) network algorithm is also used to diagnose the faulty switch of the multilevel inverter.

Results of FFT-ANFIS, DWT-ANN and DWT-ANFIS approach are compared. Reported results show that the open circuit and short circuit failure of power electronic switches of multilevel inverters could be accurately identified using the DWT-ANFIS based approach. Proposed methodology accurately identifies the individual faulty switch and hence this method can be implemented with any reconfiguration technique in order to improve the reliability of the multilevel inverter drive system.