

Abstract

This thesis presents a comprehensive analysis of the reliability evaluation and fault diagnosis of inverter. The converter and inverter form important part of electrical power system. Fault detection can increase the reliability and efficiency of power electronic converters employed in the power systems. The inverters are also used to drive electric motors and Electric Vehicles (EVs). Due to high pressure and complex work in this environment, the inverters are prone to breakdowns and faults. That is why providing a way to recognize faults in the inverters is very important. The Open Circuit (OC) faults may occur because of a short circuit between two legs, OC fault in triggering pulse, and OC fault in supply connection. This thesis studies the OC fault of IGBTs of three-phase inverters. The three-phase currents are used to identify the state of the system and extracting the features using different feature extracting algorithms for fault localization. This thesis first focuses on the literature survey made for understanding the importance of inverter and its applications in Electrical power system and EVs. The Reliability and Availability (RA) evaluation have become the critical area of interest for researchers. In this thesis, the Reliability Block Diagram (RBD) with exponential probability distribution function is used for the RA analysis of seven practical grid connected solar Photo-Voltaic (PV) systems. It aims to identify the weakest subsystem of a system in order to enhance system reliability. Elaborate analysis is presented for these systems beginning from the sub-assemblies to the subsystems and then to the overall system. In addition, the subsystems are ranked based on their impact on the overall system availability using availability importance measures. It is observed that inverter forms the weakest subsystem in the solar system. Types of faults that occur in the inverter are divided into two categories: OC fault and Short-Circuit (SC) fault. In case of occurring SC fault, system current increases up to 4 or 5 times its nominal amount which makes the detection easy but the OC fault is not like SC fault and current changes are very low. That is why identifying the OC fault is very important. After coming to these conclusions, the further study and analysis have been carried out taking the OC fault diagnosis and condition monitoring of

inverter as main focus. Therefore, the overall work done in this thesis is Reliability, Availability, and Condition Monitoring (RACM) of inverters. Along with the RBD method, the Principal Component Analysis (PCA) technique is used to monitor the health status of the inverter. The technique used for condition monitoring in second chapter is an unsupervised type machine learning technique which is also a well know dimensional reduction technique. This method is also used for features extraction from data set. There are various supervised type machine learning techniques also available in the literature such as Support Vector Machine (SVM), k-Nearest Neighbor (KNN), and Artificial Neural Network (ANN) based deep learning techniques which claim better results than unsupervised machine learning techniques. These supervised machine learning techniques need strong features which can be good predictors for monitoring. The features can be obtained either from time-domain or frequency-domain analysis of the signals of the equipment to be monitored. The signal processing techniques have been observed to be good for extracting the features from the signal. Therefore, the third chapter of this thesis is focused on the role of signal processing and machine learning based algorithms for the proper condition monitoring and fault diagnosis system of inverters. The two samples based signal processing technique for fault detection is proposed and validated. For fault localization, SVM method is used which uses the Entropy of Wavelet Packet (EWP) and mean of current signals as features. The results were found satisfactory and EWP is found to be better feature than mean as the prediction results using mean as feature show misclassification of faults. For further increasing the accuracy and decreasing the time of OC fault detection, the PCA-based machine learning technique is proposed in chapter four for fault detection and Wavelet Entropy (WE) feature based SVM technique is used for the localization of fault, which gives results better than the two-samples based technique. The research is further carried out to find a best feature extraction technique which involves simple addition and subtraction operations rather than involving complicated mathematical calculus. A KNN technique involving Walsh Function (WF) based feature has been proposed in chapter five, which is found faster than the previous two techniques and giving better results (accuracy of 98-100% and detection time of lesser than 10% cycle) because the feature includes simple mathematical addition and subtraction operations. The motive of this thesis is accomplished by proposing the various techniques, which can help to increase the accuracy and enhance the RACM of inverters.