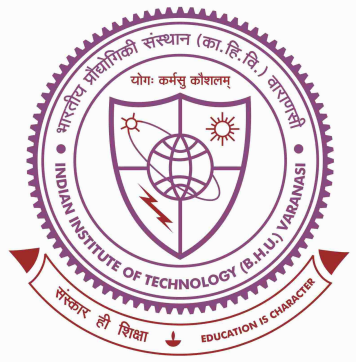
Reliability Assessment of Power Electronics Converters



Thesis submitted in partial fulfillment
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by

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Chapter 6

Conclusions and Scopes for the Future Work

6.1 Conclusions

- In the second chapter of this thesis, RBD with exponential probability distribution function is used for the RA analysis of seven practical grid connected solar 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.

- The third chapter focuses the role of signal processing and machine learning based algorithms for the proper condition monitoring and fault diagnosis system for inverters. The proposed two-samples based OC fault detection technique is found to be fast and accurate. The OC faults are detected in less than 0.33 ms. The chapter has discussed the EWP-SVM technique, which can diagnose the fault in a single IGBT, multiple IGBTs, and OC fault in the supply terminals. For feature extraction, the EWP technique is more accurate and simple with a less computational burden as compared with the other observer and PCA based features extraction techniques. The SVM algorithm gives accurate fault diagnosis results using the three-phase currents using the EWP feature because only one feature of currents is used, which is entropy. The proposed EWP-SVM technique is fit for implementing a fault diagnosis system to get reliable and faster fault detection schemes.

The results show that SVM with simple entropy and energy resulted in the wrong classification in fault diagnosis, which has been avoided by implementing the EWP-SVM technique. The mean value of the signal under a fault condition is also different from its value under normal conditions. Thus mean value alone cannot be used as a feature in fault classification algorithm because of the similarity of signals under different fault conditions. Therefore, it is used along with the EWP feature for better performance of the proposed algorithm.

- The work in chapter four has discussed the PCA-WE-SVM technique, which can detect the OC faults in a single IGBT and multiple IGBTs of inverters. For feature extraction, the WE technique is more accurate and simpler with a less computational burden. The SVM algorithm gives accurate fault diagnosis results using the WE feature of three-phase currents of the inverter. The fault detection and localization time with the proposed technique are found in lesser execution time than the other techniques available in the literature. The proposed PCA-WE-SVM technique is fit for implementing a fault diagnosis system to get reliable and faster fault detection schemes. In this work, results show that SVM with simple entropy and energy resulted in false-classification of the fault, which has been avoided by implementing the WE-SVM technique.

- The work in chapter five has discussed the WFC-SVM and WFC-KNN techniques, which can detect the OC faults in a single IGBT and multiple IGBTs of inverters. For feature extraction, the WF is found more accurate and simpler with a less computational burden. KNN-based algorithm gives more accurate fault diagnosis results using the WFC feature of three-phase currents of the inverter as compared with SVM-based algorithm. The fault detection and localization time with the proposed technique are found in lesser execution time than the other techniques available in the literature. The proposed WFC-KNN technique is fit for implementing a fault diagnosis system to get reliable and faster fault detection schemes.

- Along with the RBD method, the PCA, EWP-SVM, WFC-KNN techniques are used to monitor the health status of the inverter. So, the overall work done in this thesis is RACM of inverters. It has been found that entire system availability is mostly affected by the inverter subsystem. By using the availability importance measures, critical subsystems have been ranked based on their impact on the overall system availability. Regardless of the

costs, the most effective method to improve the system availability is to use redundancy method. The proposed method (RBD with OC detection methods) is helpful in giving the complete condition monitoring of the inverter and the results obtained outperform the existing methods such as FTA and RBD.

6.2 Benefits of the Proposed Work

The major advantages have been discovered as a result of this thesis study.

1. Movement of industries towards revolution 4.0
2. Automatic fault diagnosis system.
3. Reliable Electrical power system.
4. Dream of digital twin of equipment, system is possible.

6.3 Scopes for the Future Work

The Thesis explores the following future research scopes.

- The condition monitoring and reliability assessment of inverter which is the weakest component of PV system is presented in this thesis. The proposed condition monitoring algorithms are applicable in other sub-assemblies as well for improving the overall reliability and availability of the system which is future scope of this work.
- The detection time of the OC fault of IGBTs-based inverters can be further decreased, and accuracy can be improved with other supervised based machine learning techniques or by combining the KNN or SVM techniques with other feature extraction techniques. The level of signal to noise ratio and other transient effects that can be avoided by the proposed detection technique with different types of loads can be analyzed for checking the reach of the proposed technique.
- The RACM and predictive maintenance of inverters can be implemented by using digital twins of inverters using the proposed algorithms.