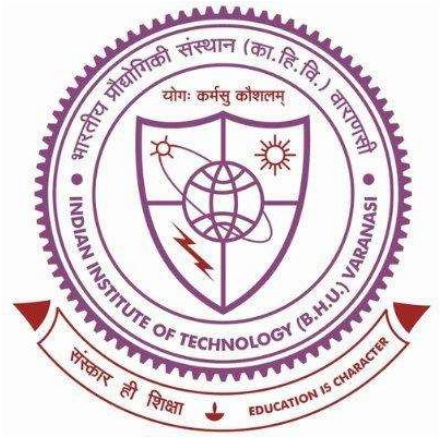
ISLANDING DETECTION AND POWER QUALITY DISTURBANCE DETECTION AND CLASSIFICATION IN ACTIVE DISTRIBUTION NETWORK USING SIGNAL PROCESSING



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by

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Chapter 6

CONCLUSION AND FUTURE SCOPE

This thesis work has been carried out to address two critical problems in the active distribution network using signal processing and voltage-driven features. These critical issues are; i) Islanding detection in ADN, emphasizing critical islanding events, and 2) classification and detection of PQD. The conclusions of the thesis and future scope of work are delineated below.

6.1 CONCLUSION

- A literature review has been carried out on two critical issues, islanding detection, and Power quality disturbance detection and classification. As presented in the existing literature, IDT and the large non-detection zone of conventional relays have also been presented. The importance and requirement of new islanding detection schemes and PQDs characterization methods are highlighted. Existing literature studies facilitate identifying the research gap addressed in this thesis.
- A new passive method involves VMD-based voltage decomposition and its mode/IMF energy-based index to detect islanding in an active distribution network. The developed approach uses IMF energy features extracted from the target DG end PCC voltage in ADN. This energy index variable shows distinguishable behavior for classifying the islanding and non-islanding events as presented through analytical expressions and simulations. The islanding events, considering all possible combinations of power mismatch scenarios with particular emphasis on the critical events associated with NDZ, are considered during the testing. It has been demonstrated that the developed IDT method

successfully categorizes islanding events with reduced NDZ through simulation results.

- A modal voltage-based islanding detection approach has been developed in which three-phase voltages are combined in a linear combination without canceling the transient information containing the voltage signal. It reduces the memory requirement and decreases the computational burden by decomposing the single signal instead of a three-phase voltage signal.
- The boundary limit of NDZ for rate-of-change-of-frequency (ROCOF) and vector surge (VS) relays is developed using the concept of critical active power imbalance inside the islanded segment. These analytic expressions are helpful for the performance study of ROCOF and VS relays for islanding detection. Moreover, a comparative study of VS and ROCOF relays with the proposed approach is conducted, considering the performance of NDZ, detection time, and DG type under different network contingencies. Test results demonstrate the superiority of the proposed IDT method over ROCOF and VS relays.
- The proposed IDT has been tested on critical switching events such as reactor, capacitor, induction machine starting, HIF, and LIF faults events.
- The developed IDT has been tested on all types of DG such as Inverter, Synchronous, and Wind (DFIG).
- Further, the proposed IDT has been validated on Real-Time Digital Simulator (RTDS)/ RSCAD and Microlab box. The simulator consists of NOVACOR chassis with four licensed cores and RSCAD 5.013 versions. The simulation is performed in Power system mode, having a solution time step of 50 microseconds. NovaCor chassis has 12×12 bit digital to analog channels

(GTAO) operating over a range of ±10 V peak. The PCC three-phase voltage has been sent from the front panel interface of RTDS (GTAO) to MicroLabBox (dSPACE1202) ADC pin, where the proposed algorithm has been implemented.

- The VMD-based method for the detection and classification of PQD has been developed. The PQDs are divided into five major classes, i.e., sag, swell, interruption, harmonic, and flicker. The Simulation study has been demonstrated in three stages of development. In the first stage, mathematical modeling of PQDs has been implemented using MATLAB coding environment, and PQD data were generated, and the four PQD index has been extracted from the decomposed voltage signal such as instantaneous RMS, standard deviation, total harmonic distortion, and center frequency from the decomposed voltage signal for classification and detection of PQD. In the 2nd stage, a test system was simulated in PSCAD/EMTDC environment, and different types of switching events such as capacitor switching, inductor switching, induction machine starting, and all types of faults were simulated for generating the PQD in the system, and voltage waveform is stored and validated the proposed VMD based PQD detection and classification approach.
- In the 3rd stage, the recorded voltage waveform data of PQD provided by the IEEE task force has been used to test the proposed approach to the classification of PQD.
- Further, the real-time co-simulation platform was developed using RTDS/RSCAD and MATLAB to validate the proposed approach.

Therefore, the proposed approach can be used as a real-time PQD monitoring tool and is suitable for online implementation.

6.2 FUTURE SCOPE

The presented thesis work can be further extended in the following direction:

- The IDT for islanding detection of distributed generation (DG), two types of DG, such as inverter and synchronous type, have been discussed. The proposed approach can be extended for asynchronous or induction generator type DG and PMSM.
- Increasing RER integration into the power system poses challenges for islanding protection issues for future micro-grid or smart-grid safety. Hence, the islanding detection method needs to provide reliability with the possibility of a limited number of maloperation. Hence, actual data collected from the practical network during islanding events can enhance the VMD-based method's reliability.
- Laboratory microgrid prototyping can be implemented to test the proposed IDT method.
- VMD-based PQD can be extended for Artificial Intelligence and Machine Learning approach for more complex classification of Power quality disturbances and IDT.
- The work can be extended for Highly RER penetrated Microgrid systems with Electric vehicle dynamics.