Chapter 7

CONCLUSION & FUTURE SCOPE

7.1 Conclusion

The ongoing transformations in the transmission system with the induction of emerging energy resources and electronic devices comprehensively increase the intricacy of the modern electric grid. The modern power utility requires secured and reliable operation of the power system in all aspects such as generation, transmission and power distribution. The functioning and performance of the transmission grid is frequently hampered by shunt fault events in the transmission lines. The loss of series compensated transmission lines creates more burden on the Transco utilities as these lines have higher energy transfer competency. Hence the development of competent protective measures for modern grid structure needs to be properly addressed. The amelioration in the protection methodologies is inevitably needed according to ongoing changes in the structure of the transmission network. The major problem involved in the power network protection is to detect, identify the category and precise location of the fault events in the transmission lines. Varying transient parameters like fault resistance, inception angles, types, location, and CT's saturation etc. comprehensively influences the performance of the fault events ascertaining schemes.

The present research work addresses the detection, categorization and distance estimation of the normal shunt fault events and transforming fault events in a series compensated power transmission network. An intelligent protection methodology has been

developed through combined application of signal processing mechanism and machine learning based classifier models. The principal idea applied in the present work, is to extract the dominant fault feature vectors form the retrieved post-fault 3-phase current samples in the transmission network and later on those extracted feature sets are fed to the designed intelligent technique based classifier and distance estimator models for categorizing and ascertaining the fault positions in the transmission network.

Chapter 1describes the relaying challenges due to series compensation and brief review of various reported protection methodologies. It also outlines the objectives of the proposed research work. Chapter 2 thoroughly discusses the fundamentals of signal pre-processing mechanism that have been applied in the present work for acquiring the fault feature vectors.

In chapter 3, a DWT and non-parametric ML techniques based scheme has been described for ascertaining the fault events in compensated transmission network. It has been seen that the applied K-NN, SVM, and PNN based classifier models provides 99.55 %, 99.39 %, and 99.65 % events classification accuracy respectively during validation of first simulated test network. Likewise on the second test network the events classification accuracy obtained by the classifier models is 100 %, 99.17 %, and 99.83 %. In addition, the proposed scheme is also effectual in identifying the transforming fault events in the network and is capable of ascertaining the fault events even during CTs saturation.

In chapter 4, EMD based extracted fault features are utilized for ascertaining the fault events in the transmission network. During application of this scheme the classifier models i.e. K-NN, SVM, and PNN gives 99.39 %, 99.34 %, 99.57 % events categorization accuracy while testing on first test network and 99.24 %, 99.04 %, and 99.75 % on second

test network. Moreover, functioning of this scheme is also abide undisturbed during fault conditions variations.

In chapter 5, ensemble learning and deep neural network based events classification schemes have been described. The ensemble learning based scheme provides 99.34 %, 99.29 %, and 99.27 % events classification accuracy during efficacy assessment on first, second and third test network respectively. The DNN based scheme gives 99.31 %, 99.25 %, and 99.28 % events classification accuracy on different test network.

In chapter 6, the issue of localization of fault events in the compensated power transmission network has been addressed. Four distinct neural network models i.e. feed-forward neural network, linear neural network, cascaded-forward neural network and generalized regression neural network have been utilized for estimating the position of fault events in the transmission network. The maximum distance assessment error percentage observed for normal shunt events is within 0.9 % for FFNN, 1.8 % for LNN, and 1.0 % for GRNN and CFNN models respectively. For transforming fault events, the maximum distance estimation error percentage is within 0.4 %.

In general, it has been concluded that the proposed integrated signal processing and machine learning based protection methodology is well competent for providing accurate location and classification of normal shunt and transforming fault events in the compensated power transmission networks irrespective of varying conditions such as types of fault, variable fault resistances, fault inception angles, location of events, multi-location faults, evolving fault events, the position and level of line compensation percentage. The non-parametric ML based classifier models provide better events classification accuracy than that of parametric ML based classifier models. The acquired accuracy by EMD based

scheme is slightly lower than DWT based scheme but, it does not requires extensive analysis regarding electing the pertinent mother wavelet and level of signal decomposition. The ensemble classifier models are more robust due to its majority voting weighing attribute. Application of deep learning mechanism efficiently allows multi-layer feature representation and has superior generalization capability. The time response of the deep learning based fault events ascertaining mechanism is faster than ensemble, K-NN, and PNN based mechanism. Application of ensemble and DNN classifier models are more efficient if the training dataset is very large.

7.2 Future Scope

The proposed research work is mainly focused on identification, categorization, and localization of different fault events in series capacitor compensated transmission network. It can be extended for designing of intelligent protective relaying mechanism for series compensated power network in hardware-in the loop system. The competency of the proposed approach can be analyzed in some FACTS compensated power transmission network. The impact of shunt compensation on the performance of proposed fault events ascertaining methodology is to be studied. The proposed research work can also be extended for ascertaining the fault events in distribution power network.