# Fault Detection and Classification in Double-Circuit Transmission Line in Presence of TCSC Using Hybrid Intelligent Method

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**Extended Abstract**

**Introduction:** In this paper, a new method is used to detect and classify faults in a double-circuit transmission line in the presence of a Thyristor-Controlled Series Capacitor (TCSC). The TCSC-based double-circuit system changes the parameters of the transmission line, and, thus, the identification and classification of faults become a challenging issue. One of the most effective methods for detecting and classifying faults in compensated lines is the application of intelligent classification algorithms. Prerequisites for the optimal use of these algorithms are the extraction and selection of appropriate input data to feed the classifier. In this paper, the best mother-wavelet is identified using a new method, which can be used to extract the features to train classifier models. In the classification step, decision tree, supporting vector machine, and k-nearest neighbor algorithms are trained. Accordingly, their accuracy is evaluated against different simulation scenarios to select the best classifiers.

**Materials and Methods:** In this paper, the sample system is simulated in MATLAB software, and the best mother-wavelet is identified using a new search method based on the energy of the signal. The wavelet is used to extract features from the faulty signal to train classifier models. In the classification step, three types of classifier models-- i.e., decision tree, supporting vector machine, and k-nearest neighbor algorithms-- are trained. In the proposed method, the search of an optimal mother wavelet in the two-circuit transmission system, including TCSC on each of the circuits, is done separately. Finally, in order to extract the feature vector, the mother wavelet db1 has been selected as the most suitable mother wavelet. Moreover, the energy of detail coefficients of the fourth level of decomposition extracted from the current signals are provided as the input feature vector.

**Results:** Based on changing fault parameters, training and testing data were simulated. Three types of classifiers were trained using the training feature vector. Then, the trained models were tested using the test and unseen data set. The accuracy of the proposed method was evaluated against different simulation scenarios to select the best classifiers. Among three classifiers-- decision tree, supporting vector machine, and k-nearest neighbor algorithms-- the support vector machine had the best performance with an average of 94.78% of classification accuracy. The average classification accuracy obtained from decision tree and k-nearest neighbor classifiers were 94.76% and 91.79% respectively. Moreover, the performance of the proposed method was evaluated against two levels of signal-to-noise-ratio, 30 dB and 40 dB. To evaluate the noisy condition, the trained model was kept without noisy condition, whereas the test data set contained

noisy data. The results confirmed the performance of support vector machine-based classifier under noisy condition. In the proposed method, the time duration of feature extraction was about 1.1±0.1 ms, and the time duration of supeprot vector machine to classify a new test data was about 0.7±0.1 ms. Considering 20% marginal time, the response time of the proposed method was about 2.4 ms.

**Discussion and Conclusion:** In this paper, to extract and select suitable input data, 85 mother wavelets have first been examined by the proposed method, and the best mother wavelet was selected at last. Then, using different classification algorithms, the tasks of fault detection and classification in a sample system with a two-circuit transmission line and TCSC has been addressed. The wide investigation of mother wavelets confirmed the efficacy of the search algorithm. The effect of variation in fault resistance, fault location, fault types, mutual induction in parallel lines, and fault inception angle has also been considered in the double-circuit compensated transmission line. Moreover, in parallel transmission lines, the effect of inter-circuit faults has been evaluated as well. Since the TCSC and mutual effect in a double-circuit system changes the signals measured at the relay location, it is required to provide an accurate method to identify and classify faults. One of the most effective methods for detecting and classifying faults in compensated lines is the use of intelligent classification algorithms. Prerequisites for the optimal use of these algorithms are the extraction and selection of appropriate input data to feed the classifier. In this paper, using one-cycle of data measured at one-end of transmission line, high-classification accuracy, based on three classifiers, has been achieved.

**Keywords:** double-circuit transmission lines, fault classification, compensated transmission line.

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