ABSTRACT

The development in global urbanization has increased the quantity of electrical power consumed by end users in recent years. Human life has evolved into a complex series of daily modifications aimed at attaining a sophisticated lifestyle. In this regard, there is a strong demand for electrical energy, prompting electrical energy producing businesses to create more electricity to match the demand. This may be accomplished through the use of renewable energy based power generation resources. This encourages the distributed generating sector to use solar, wind, and other renewable energy sources to create electricity. These distributed generating systems are linked to the existing electrical grid for additional processing in order to satisfy the growth in electrical demand. The most popular approach in distributed generating systems is solar and wind-based power generation. Wind energy has a higher efficiency in electric power generation than solar energy, and its power quality may be increased by utilizing power electronic equipment. As a result, wind energy conversion systems (WECS) may be used in tandem with the electric grid to fulfil the increased demand for electricity. Certain requirements in grid code have been devised to ensure proper functioning of grid tethered WECS, and they must be followed throughout during the operation of WECS under grid connected mode.

There are several elements that influence the risk of a smart grid system malfunctioning due to faults. The short circuit fault is arguably the most devastating to many problems that may occur in smart grid system. Hence, the incorporation of WECS into the grid has an impact on transmission line protection strategies under various short circuit faults.

These faults must be detected as soon as possible in a grid-tied WECS, and the fault current must be limited to protect the entire grid-tied WECS. As a result, various mathematical transformation techniques are used to detect the different types of short circuit faults that can occur in a grid-tied WECS. Several classifiers are used in this context, along with transformation techniques, to improve classification accuracy. The S-Transformation (ST) technique is used in this work to detect the type of short circuit faults that occur in a grid-tied WECS, and a Probabilistic Neural Network (PNN) is used as a classifier to improve fault type classification accuracy. The S-Transform (ST) can analyze the electrical signal under noisy condition and produce multi resolution time-frequency analysis with phase corrected signals as its output. It also combines the property of Wavelet Transform (WT) and Short Time Fourier Transform (STFT) which can be known as phase corrected Wavelet Transform. The features extracted from amplitude matrix of ST are evidently visible and can be highly helpful for visual inspection of fault signal occurring in a SG system. The advantages of PNN classifier are it is much faster, accurate and generates precise predicted target probability scores. Based on the above mentioned advantages, the ST is preferred over other Wavelet Transforms for fault detection and PNN for fault classification.

The endorsed research work investigates fault analysis, such as fault detection, identification, and classification, as well as their Fault Ride Through (FRT) technique in a grid-tied WECS using the Stockwell Transform (ST) and Solid State Fault Current Limiter (SSFCL). When ST is applied to symmetrical and asymmetrical faults in a grid-tied WECS for detection and identification, it produces a ST amplitude matrix (STA). The features extracted from ST are used to determine the nature of the fault in a grid-tied WECS. STA with probabilistic neural network (PNN) classifier aids in classification of fault types using extracted features from fault signal. In a grid-tied WECS, the results of PNN help to classify the nature of faults such as single phase, two phase, and three phase faults individually and with respect to ground fault.

Further, the fault current generated by a short circuit fault might be more than ten times the maximum nominal current. This leads to a low voltage problem and the control of a WECS system operating in grid connected mode is disrupted. In this period the WECS is removed from the grid for self-protection and the protection circuits may disrupt normal power flow in less severe instances, resulting in loss of power service in grid tied system. This mandates the fault ride through (FRT) technique as one of the grid code requirements in WECS. The fundamental challenge for improving the FRT capacity of grid connected WECS is to stay connected to the grid under the various fault situations. There will be some adverse effect in the grid which is created due to more integration of WECS in terms of fault situations. Under any abnormal operating time, the amplitude of fault current flowing through the grid will be enormously higher in nature and leads to insulation failure in the generating units, transmission units and distribution units. Hence, to overcome the above said issue, fault current limiters are incorporated in the electrical grid to reduce the amplitude of fault current flowing over the grid. The presented research work analyses the technical gap in the selection of FCL to overcome FRT issues in a grid tied WECS and explains the detailed literature review about the FRT techniques to be adopted for grid tied WECS using the FCL. One possibility for increasing the FRT capabilities of grid-connected WECS is to use a fault current limiter (FCL). FCL restricts the amplitude of current passing over the system and ensures continued, uninterrupted operation of the electrical system. As a result, the FRT approach in a grid tied WECS is enhanced using Solid State

Fault Current Limiter (SSFCL). Furthermore, limiting the fault current ensures that grid-tied WECS continues to operate and are reliable even when there is a fault. SSFCL is also used to prevent the wind turbine system from being disconnected from the grid and to overcome the block out problem. It improves the FRT capability of a grid-tied WECS system by keeping the fault current within the specified limit and keeping the wind turbine system connected to the grid.

The proposed scheme is modelled and validated using MATLAB time domain simulation. In this connection, MATLAB simulations are used to investigate the enhancement of FRT in a grid tied WECS using Solid State Fault Current Limiter (SSFCL) and their performance is compared with recommended Factional Order PI controller. Finally, real time hardware prototype model of three phase SSFCL is implemented in the three phase power system to verify their performance of reduction of fault current during fault situation and maintain voltage profile within the limit and thus improved the FRT capability of the power system using SSFCL.