

## **A novel hybrid machine learning classifier-based digital differential protection scheme for intertie zone of large-scale centralized DFIG-based wind farms**

### **ABSTRACT**

The protection of intertie zone between wind farm and grid line is critical for stable and safe operation of both the grid line and wind farm in the event of fault within or outside the intertie zone. As a reliable source of renewable energy doubly fed induction generator (DFIG)-based wind farms have been increasingly integrated to the power grid over the last two decades. Nowadays with the enormous penetration of large-scale DFIG wind farms, the commonly used distance relays are no longer reliable due to their incapability of providing accurate impedance measurement during internal and external faults. Thus, it results in maloperation, false tripping, and/or delayed operation. Therefore, in this article a digital differential-based protective relay (DBPR) scheme is designed and developed to provide reliable protection for wind farm intertie zone. Additionally, a new Bayesian-based optimized support vector machine (SVM), as a supervised machine learning classifier approach, is developed to take into account both the dynamic behaviors of wind speed and the current measured by the current transformers. Thus, the proposed hybrid SVM-DBPR scheme can distinguish among the normal operation, internal and external faults correctly that helps to avoid any false tripping. In a laboratory environment the proposed DBPR is implemented in realtime using FPGA DE2-115 board equipped with Cyclone IV-E device (EP4CE115F29C7). It is found from both simulation and experimental results that the proposed hybrid SVM-DBPR is able to provide reliable, efficient, and robust protection for the intertie zone of wind farms with 97.5% accuracy rate.

**Keyword:** Differential relay; Intertie zone; Machine learning (ML); Optimized support vector machine (SVM); Wind farm protection