Abstract

From the early days of electrical power systems to today's systems, many infrastructural developments and policy-related rules and regulations have come into play. Accordingly, its operation, planning, monitoring and protection scheme have also been updated to meet the system requirements.

From manual to semi-automated, from semi-automated to fully automated system configuration has evolved and it took more than 140 years to get to its present state.

All three major sections in the power system– generation, transmission, and distribution—are advancing rapidly towards the smart digitized system. This helps power engineers monitor, control and protect the whole network very efficiently. Recently, researchers in the power system field have been very much concerned about different sensing devices that reliably fetch required signals to analyze in a better way using different computational and analysing tools. Different intelligent algorithms have been proposed in the past with the aim of controlling the whole system smoothly. Researchers are changing and revising these existing algorithms as a result of the increased complexity of the system due to the inclusion of various entities. Better controlling, monitoring, and protection of the system require a clear understanding of all feasible power system abnormalities. The deviation of any quantity, such as current, voltage, power, etc., from its normal operating condition is termed a power system disturbance. The immediate effect due to these disturbances is faced by all electrical equipment and appliances connected to the system. Anything from maloperation to permanent damage may happen. Consequently, voltage and current quantities get distorted. These abnormalities may persist for a few microseconds to a few cycles and even for hours. In this work, voltage and current during

all possible disturbances have been investigated. The causes of disturbance creation, termed as events, have also been studied. Even these disturbances may be of a cumulative type due to the occurrences of two or more events. Two or more events may occur simultaneously or one after another. These probabilities have also been considered. Finally, the identification of events has been studied. Fast and accurate identification is essential for adopting suitable measures to restore the system quickly.

An experimental setup with all feasible disturbance-creating event arrangements and sensing devices has been fabricated for producing power system events. Instrument transformers have been used to sense line currents and node voltages, and a data acquisition system has been arranged to record those sensed signals. These acquired signals have been filtered to eliminate noise using mathematical tools and unsupervised machine learning techniques before the data have been normalized. These normalized filtered data have been processed using different signal-processing techniques to extract their particular features. Processed data have been represented in different formats to make them compatible with the various machine learning techniques. At different stages of this work, various advanced machine-learning techniques were used to classify the events.

Throughout the work, the number of events and their types were revised and modified by including new investigated events, and subsequently, different classifiers were modelled. These models have been equipped with a laboratory-based system to observe their working in case of any real-time event.

Chapter 1 of this thesis provides an overall concept of system disturbances and the origin of the disturbance. Some adverse situations arising due to these disturbances have also been illustrated to realize their effects. A few research works in this area have also been highlighted.

Chapter 2 has been organized to illustrate the laboratory-based experimental arrangements for conducting some tests on power system events. Their original photographs have shown each part of this experimental setup.

Chapter 3 deals with a few very commonly occurring single event-based disturbances and a few classifiers for their classification.

In Chapter 4, a few multi-event-based disturbances were considered along with the single-event disturbances. Finally, a few deep learning-based classifiers have been proposed depending on the number and type of cases considered. In addition to these, a special type of classifier has been proposed to visually classify all disturbance categories using 2D plotting of data.

In Chapter 5, an overall conclusion has been drawn, and a few future scopes in accordance with the power system advancement in the field of system monitoring and protection have been proposed.