DETECTION AND LOCALIZATION OF ELECTRIC DISCHARGES IN INDOOR SUBSTATION FOR FAULT MONITORING

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RESEARCH HIGHLIGHTS

Power Substation is the most important unit in the power system, therefore, the monitoring process must be carried out effectively to detect the operation status of the equipment, and the maintenance is necessary for safe operation. Substation faulty such as Dielectric breakdowns, originating from the insulation degradation is still a major issue in the power system (1–3). Many methods and techniques with intelligence approaches have been developed to provide a better way of fault detection in a substation. However, not many are willing to adopt those techniques by reasoning the high cost of installation and more sensors required to improve localization accuracy (4). Therefore, to reduce cost and increase the speed of detection, this paper presents a 2-element array antenna to perform as a sensor to detect and localize the electric discharges (ED) produced by abnormal radiated electromagnetic activities in substation based on the direction of arriving angle (DOA) received by elements in the array antenna. The radiation patterns obtained were then visualized using software of signal processing based on the normalized Array Factor (AFN). This sensor has shown its efficiency in eliminating the interferer signals at random DOA of 40° and 60° and maximizing the desired signal at DOA of 45° ; the identified angle direction from the substation power apparatus. This sensor has the ability to be steered isotopically and terminate or maximize signals which differ by 5° or 0.0873 radians of DOAs, simultaneously. Having these abilities allowed this sensor to be a cohesive unit in detecting and localizing the abnormal radiated electromagnetic activities in substation based on the identified DOA thus, make it as a promising preventive approach for substation breakdown and improve the performance in Substation Fault Monitoring.

Keywords: Sensor, Substation Fault Monitoring, Electric Discharges

RESEARCH OBJECTIVES

The aim of this research is to improve the efficiency and performance of fault monitoring system in substation by designing a cohesive unit of sensor which has the abilities to detect and localize the abnormal radiated electromagnetic activities produced by the power apparatus in substation thus make it a reliable preventive technique for Substation Fault Monitoring.

MATERIALS AND METHODS

In this research, the design of the monitoring system consisted of a 2-element Array Antenna as the cohesive sensor. The Normalized Array Factors (AFN) were derived and simulated using MATLAB software for different value of phase-shifted angle to fulfill two conditions of signals detection to be run simultaneously. The first condition was to eliminate the interferer signals which were randomly set at DOAs of 40° and 60° and the second condition was to maximize the desired signal at identified DOA of 45° . In this simulation work, the detecting and localizing of the ED were focussed on the desired location of a transformer unit in the indoor substation which the DOA was to be identified. Some initial parameters and mathematical equations (5) to represent the ideal condition of the indoor substation were set the simulation program so that the scanning process was done continuously. Software implemented signal processor was used in the process of ED signals elimination and maximization by varying the weight (w) as the multipliers to the input source (ED) and the final radiation patterns were obtained based on the AFN.

RESULTS

The radiation patterns of AFN for the interferer signals which were taken at two undesired points of $\theta_i = \frac{2\pi}{9} \text{ rad}$ (40°) and $\frac{\pi}{3} \text{ rad}$ (60°). From the results, it can be seen that whenever the interferer signals arrived at angle θ_i , the elimination were made relative to the DOA angle, θ_i . The simultaneous decision was successfully made for the second condition. Once the signal was detected from the desired DOA, the signal was maximized relative to the identified angle. It can be observed that the maximum radiation pattern of Total Electric field (E) was similar to the radiation pattern of AFN at DOA= 45° . Observing the simulation results, it was obvious that these two conditions (i.e. simultaneously maximizing and zeroing the beam in two different directions can be run simultaneously and applied to this 2-element Sensor provided the desired angle (DOA) of the source needed to be identified first. In addition, the E -Field can be determined where $E_\theta = 200V/m$ thus, allowing the Radiated Power Density to be obtained where $P = 53.1W/m^2$.

FINDINGS

In this work, a cohesive unit of 2-element array antenna acted as the sensor was tested for indoor substation fault monitoring where the beamform was steered directly towards the power apparatus for abnormal ED electromagnetic radiation detected and the signal was being localized based on the location of the transmitting source DOA. The beamform can be rorted towards each apparatus one by one makes the monitoring process more efficient and reliable. This unit can be adapted to substations as a preventative approach for substation breakdown and to improve the efficiency and the performance of fault detection technique in future Substation.

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