Online Partial Discharge Testing of Power Cables in High Noise Environment

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ABSTRACT

Condition monitoring of power equipment is a key tool to ensure their reliability and safe operation. Partial discharge (PD) detection of underground power cable has been proven as one of the reliable techniques of condition monitoring for the purpose of condition based maintenance of power cables. Online PD monitoring is a valuable tool to assess the condition of power cables while in service. This paper will present the case studies conducted in different substations with high noise. Detecting partial discharges (PD) is simple when low background noise or interference is present. However, measurements become practically difficult to extract PD signals from noise. Sometimes, PD signals are much lesser in magnitude than the noise or superimposed onto the noise or interference signals making it difficult for simple pulse location algorithms to extract PD signals. Acquiring data at high sampling rate (greater than100MS/s) and taking the advantage of signal processing techniques, it makes possible to extract PD signals in high noise conditions. Different de-noising techniques are being discussed in literature, this paper will present the techniques that serve the purpose for successful PD testing of power cables along with their implementation in real substation environment.

KEYWORDS

Partial Discharge, Cable PD, Portable System, Condition Monitoring, Diagnostic Testing.

INTRODUCTION

In power cables system, terminations and joints are the most vulnerable accessories that face failures and lead to the unplanned outage in the power network. This results in the huge costs and penalties due to unplanned shutdown of the system. The high percentage of failures in accessories (terminations, joints) is because of bad workmanship and in-experience personnel responsible for the installation, repair and maintenance of these accessories. It is important to monitor these accessories regularly in order to identify and detect incipient defects in such accessories. One way to monitor PD in cables is to implement continuous monitoring of cable system. This would require a huge investment but at the same time a peace of mind to cable owners. Other way is to use a portable system and use it at different locations on cables terminations, joints etc. regularly. Obviously, this would require trained personal to operate and analyze the recorded data out of the system.

Online PD measurement techniques have been in application by many cable owners. It is commonly accepted that PD measurement becomes challenging in high noise environment where either the magnitude of PD signals is lower than noise signals or PD signals are superimposed onto noise signals. In such situations, simple pulse separation tools and algorithms fail as PD signals will be lower than the noise threshold level or PD signals are '*hidden*' within the noise.

In the market, there is a huge list of companies that manufacture condition monitoring tools. These systems are offered at high prices due to the availability of sophisticated analysis tools that can help the user to perform online PD measurement [1].

Commercial companies, researchers and graduates, all are focused towards the implementation of novel and efficient de-noising and filtering techniques that can remove noise and interference signals in order to make further analysis easier. In their efforts to design an efficient de-noising tool, following techniques have been emerged [1- 4].

1. Wavelet based filtering
2. FFT filtering (band pass filtering)
3. Filtering based on pulse characteristics
    a. Frequency component
    b. Rise time
    c. Fall time
    d. Pulse width
    e. Pulse duration
    f. Pulse amplitude

Researchers have used one or combination of more than one of the above techniques along with fuzzy logic (FL), genetic algorithm (GA) and artificial neural network (ANN) techniques to efficiently de-noise and characterize different activities in the recorded data. There is a huge number of techniques or combination of techniques not limited to only above mentioned, which have been developed, tested in laboratory and tested (successfully or with limited success) in field.

Rest of the paper will present the methodology of Online PD measurement in power cables using one of the commercially available tool and will present three case studies (one laboratory testing, two field testing) where background noise and interference were present and PD activities were extracted successfully.

ONLINE PD MEASUREMENT METHODOLOGY

In order to perform online PD measurement on power cables without the need to de-energize power cables, inductive type, split core, high frequency current transformers (HFCT) are used. Transient earth voltage (TEV) sensors are also used to detect external discharges happening at the termination point. Simultaneous application of HFCT and TEV enables the user to differentiate between internal and external discharges and PD source location along the length of cable can be detected by using HFCT.