A NOVEL ANTI-INTERFERENCE METHOD FOR PARTIAL DISCHARGES ON-LINE MEASUREMENT OF HV POWER CABLES

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ABSTRACT

In order to extract the millivolt range partial discharge(PD) signals drown in the harsh electromagnetic interference for HV power cables, this paper presents a novel anti-interference method, based on fast fourier transform auto-thresholding method, 1-D discrete wavelet thresholding method and three phase amplitude and arrive-time difference method. This method is examined and proved to be effective on the power cable with actual interference. Moreover, the insulation condition assessment application of a 7.1km 220kV XLPE power cable line shows that the anti-interference effect is outstanding to eliminate field harsh interference, laying a good foundation for further PD pattern analysis and diagnosis.

KEYWORDS

HV power cable; Partial discharge; anti-interference; condition assessment

INTRODUCTION

With the development of power grid, more and more HV&EHV cross-linking polyethylene (XLPE) power cables are utilized in China, with a more than 20% average annual growth rate during the past decade. Since it is well-acknowledged that partial discharge (PD) is one of the symptoms of local defect and insulation deterioration of XLPE cable system, on-line measurement and diagnosis of PD activities have been widely adopted as a means for insulation condition monitoring to provide information on both the type and severity of defects or potential failures, which is further expected to give advice on repair or replacement of components.

For on-line partial discharge measurement in field, Since PD signals are extremely small, in the millivolt range, serious electrical interference and noise, such as narrow-band broadcast signal, white noise and interference from other equipments, can “drown out” the PD signals. The suppression of interference and noise is crucial prior to any PD data analysis. Lots of current on-line partial discharge equipments are based on trigging mode to capture small PD signal. However, If the main energy of the PD signal are located in the same bandwidth with interference, some of them will fail to extract the targeted PD signals.

In this paper, a novel anti-interference method, based on fast Fourier transform (FFT) auto-thresholding method, 1-D discrete wavelet thresholding method and three phase amplitude and arrive-time difference method, is presented.

DEFINATION OF WAVEFORM RETAINING EVALUATION AND SIMULATED PD SIGNAL

Signal to noise ratio (SNR), Mean Square Error (MSE) and Amplitude error (AE) are used to indicate the de-noising effect, which are defined as:

$$SNR(dB) = 10\log_{10}\frac{W_s}{W_n} \quad [1]$$

where W_s and W_n are the energy of PD pulses and noise, respectively.

$$MSE = \frac{1}{n}\sum_{i=1}^{n}[f(i) - r(i)]^2 \quad [2]$$

where f represents the original PD pulses sets while r stands for the de-noised PD data, and n is the length of the PD signal.

$$AE = \frac{A_f - A_r}{A_f}\times 100\% \quad [3]$$

where A_f stands for the amplitude of original PD signal whereas A_r represents the de-noised PD data.

Simulated PD signal can be expressed as double exponential attenuation oscillation mathematics model which is more similar to real detected PD pulses:

$$f(t) = A[e^{-1.3(t-t_0)/\tau} - e^{-2.2(t-t_0)/\tau}]\sin[2\pi f_c(t-t_0)] \quad [4]$$

Here, A is the amplitude of the PD pulse; t_0 is the time of PD occurrence; τ is the damping factor; f_c is the damping frequency of PD pulse.

FFT AUTO-THRESHOLDING METHOD

To suppress narrow band broadcast signal, the sampled data are firstly fed through FFT to get its spectrum distribution. The sum of mean & standard deviation of amplitude spectrum are calculated as threshold. The ones larger than this threshold in amplitude spectrum is replaced by the threshold, while the smaller ones than threshold is unchanged. After inverse fast Fourier transform, most narrow band broadcast signals are eliminated but the PD pulses are retained. Meanwhile, the time occurrence of PD signal is unchanged, and the amplitude and polarity features of PD pulses can also be reserved satisfactorily.

Fig.1 shows a simulated PD signal with $\tau = 0.8\mu s$, $f_c = 1MHz$ and maximum value 1mV. Fig.2 shows a series of narrow band broadcast signals with frequency of 140、520、680、830、1120kHz. When the SNR=1, after FFT auto-thresholding method, the MSE=9.31e-7, while the AE=-0.018% (Fig.4). When the SNR=0.01, after FFT auto-thresholding method, the MSE=9.26e-3, while the