HIGHEST MEASUREMENT FREQUENCY SELECTION OF FDR BASED ON SHORT-TIME FOURIER TRANSFORM

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ABSTRACT

Generally, the performance of the Frequency domain reflection(FDR) can be enhanced by increasing the highest measurement frequency of the signal. However, with the increment of the signal frequency, misdiagnosing is introduced due to the attenuation of the signal and noise. Thus, in this paper, the highest measurement frequency selection method is proposed to improve the performance of cable defect location. First, three dimensional location spectrum of the cable is obtained under higher sweeping frequency based on Short-time Fourier transform. Second, the reasonable highest measurement frequency is selected through the energy change of the cable end. Then, the optimal localization result of the cable defect is calculated by FDR. At last, a case of single defect through YJV-8.7/10kV XLPE power cable is used in the experiment to verify the effective of the proposed method.

KEYWORDS

Power cable; Highest measurement frequency; FDR, Short-time Fourier transform.

INTRODUCTION

Traveling wave reflection method is widely used for nondestructive detection and location of cable faults. Generally, it can be divided into Time Domain Reflectometry (TDR) [1], Frequency Domain Reflectometry (Frequency Domain Reflectometry), FDR) [2] and Time-Frequency Domain Reflectometry (TFDR) [3] according to the incident signal.

Recently, FDR has been attracted more attention because of high sensitivity to weak defects in the power cable [4]. The incident signal of FDR is linear sweep signal with limited frequency band. When the signal is transmitted in the cable, it will reflect and refract encountering the cable defect, and then Reflection Coefficient Spectrum (RCS) and Broadband Impedance Spectroscopy (BIS) are generated at the cable test end. The idea of FDR method is to analyze RCS or BIS through Fourier transform to detect and locate cable defects [5-6]. However, due to the attenuation of high-frequency signals, the performance of cable defects location is often affected by the highest measurement frequency of sweep signals using by FDR method [7]. Too lower highest measurement frequency will cause insufficient resolution and lead to large positioning error of cable defects. Too higher highest measurement frequency will have bad impact on the location result. Because the signal will be distorted after long distance attenuation and dispersion, and become noise directly in serious cases, resulting in bad performance of cable defects. In addition, the calculation cost of the test equipment will increase because the number of samples increases as the signal frequency increases. Therefore, there should be a reasonable highest measurement frequency in theoretical to improve the location performance of cable defects using FDR under existing test conditions. Although the performance can be improved under reasonable highest measurement frequency selected by multiple times under different upper limit frequency of sweeping signal[6-7]. However, it is not applicable to the actual field site based on experience for many times.

This paper proposes a method of highest measurement frequency selection based on Short-time Fourier Transform (STFT) to improve the performance of FDR cable defect location. First, the influence of highest measurement frequency is analyzed. Secondly, STFT can be used to simultaneously characterize the time-frequency characteristics of RCS, so as to select the reasonable highest measurement frequency through the energy attenuation at the end of the cable. Then, the defect can be localized by FDR under the reasonable highest measurement frequency with good performance. Finally, the effectiveness of the proposed method is verified by simulation and experiment.

BACKGROUND

1.1 Distributed parameter model of defective cable

According to the transmission line theory [1], the cable model needs to be equivalent with the distributed parameter model under high frequency signals, and the model with impedance discontinuity as shown in Fig. 1. Where R_0, L_0, G_0 and C_0 are the resistance, inductance, conductance, and capacitance of each unit length of cable, and *R'*, *L'*, *G'* and *C'* are the resistance, inductance, conductance, and capacitance of each unit length of defect respectively. Z_L is the load impedance.

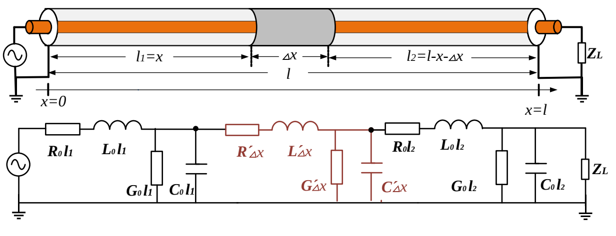

Fig.1 Distributed parameter model of power cable with single defect

Ascribing to transmission line theory, the reflection coefficient $\Gamma(\omega)$ of the healthy cable with a length of *l* can be represented as following [6].