Research and experiments of electromagnetic wave transmission rate in different kinds of cable.

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ABSTRACT

Because of the importance of UHF signals in the measurement of partial discharge increasingly prominent, this paper based on the theory of electromagnetic wave, analyzed the wave transmission rate in different voltage classes, different cross sectional area. By the experiments, it is found that many factors influence transmission speed. Without considering the waveguide effect of electromagnetic wave in semi conducting and conductor, large error will be produced in practical applications. A lot of transmission experiments had been done in 10kV (120mm^2, 150mm^2) and 35kV (150mm^2, 185mm^2) cable. After statistics, analysis, fitting of the experimental data, a nonlinear correction term had been gotten. By this correction, the calculation error in the original equation was reduced to 2.98%.

KEYWORDS

XPLE cables; Transmission characteristics;
Electromagnetic wave; Signal attenuation

INTRODUCTION

Electromagnetic measurement method has become the mainstream of on-line partial discharge tests.

In each PD the positive charge neutralizes negative charge within the cable, accompanied by a very steep pulse of current and the pulse signal has a very short rise time. By the discharge it can produce electromagnetic disturbance, and generate electromagnetic wave with the changes of time in space. At present, it proves that the cable internal PD can really inspire a high frequency electromagnetic wave, on the maximum of GHz.

UHF electromagnetic wave need to go through a variety of different medium when spreading in the cable accessories or in the body, and electromagnetic wave will happen reflection and refraction at medium interface. The main insulation dielectric properties of XLPE cable basically remain unchanged and the electromagnetic wave energy will produce a severe loss after refraction and reflection in insulating medium of semi-conducting layer [1-2]. Literature which shows that PD signal propagation characteristics on cable is studied and it indicates that the causes of high frequency signal attenuation and distortion of PD is mainly caused by the semi-conductive layer of the cable. Because of the PD signals' diverse elements and complexity of transmission principle, transmission rate of electromagnetic wave in cable is not simply the same as that in vacuum.

Transmission rate of electromagnetic wave plays an important role in localization of cable defect. Now electromagnetic measurement has widely used in GIS PD measurement. The technology is not immature for its localization of the defects. However, the typical localization method is to put lots of the same sensors to different position of GIS. By calculating the distance of each sensor from the GIS, the location of defect could be confirmed. The distances are related to wave transmission rate in GIS. In the same way, the method could be applied to the localization of cable defect [3]. So it is important to be aware of wave transmission rate in cable.

This paper first introduces the existing model of propagation velocity in the cable and gives out the theoretical transmission rate. Then the experiments have been done to verify the authenticity of theoretical model and margin of error is obtained. The reason for error is put forward.

THEORETICAL WAVE TRANSMISSION RATE

There isn't an appropriate model for the propagation velocity of electromagnetic wave when spreading in the cable. The transmission properties of electromagnetic waves are often the subject which radio communications technician studies. What's more, the propagation velocity is not the research focus in the study of PD. So the model of electromagnetic wave in communication is applied to the cable, which is connected with the capacitance and inductance of the cables' body. And the speed of electromagnetic wave in cable is said to be 172m/us [4-5].

EXPERIMENTS

A lot of experiments have been done to test and verify the theory data. The one for velocity of electromagnetic wave in 10kV XLPE cable is introduced below, see Fig. 1.

The experiment takes use of the PD detector we have developed for 4 years. It could realize the synchronization of the two high-speed DAQ cards in less than 200ps. So when two sensors are put to different positions of the cable, wave forms could be got in nearly same time. Signals travel form one side to the end of cable. The distance between the two sensors is measured to calculate the wave transmission rate.