PULSE SIGNAL PROPAGATION CHARACTERISTICS ON THE AGED XLPE CABLE

Toshihiro **TAKAHASHI**, Takashi **KURAISHI**, Tsuguhiro **TAKAHASHI**, Hiroshi **SUZUKI**, Tatsuki **OKAMOTO**, CRIEPI, (JAPAN), tosihiro@criepi.denken.or.jp, kuraishi@criepi.denken.or.jp, shodai@criepi.denken.or.jp, ksuzuki@criepi.denken.or.jp, tatsuki@criepi.denken.or.jp

ABSTRACT

Partial discharge (PD) measurement is a most effective technique for the soundness evaluation of the power apparatus as well as the XLPE power cable system. Thus, the PD measurement can also be effective for the aged XLPE cable system, which may contains something deterioration in its electrical insulating property. Here, aged XLPE cable system may have degraded metallic shielding layer due to water immersion through sheath without water barrier layer. This paper shows empirical investigations on the pulse signal propagation in the aged 60 kV class XLPE cable and some model cables simulating the aged XLPE cable. As a result, the attenuation rate of frequency components higher than 150 MHz is much larger than those lower than 150 MHz for aged XLPE cable. Moreover, higher frequency components higher than 150 MHz have larger attenuation rate than those lower than 150 MHz for model cables simulating aged XLPE cable.

KEYWORDS

XLPE cables, Aging, Partial discharge, High frequency pulse signal, Propagation characteristics.

INTRODUCTION

Partial discharge (PD) is a well-known phenomenon as the precursor of breakdown. Thus, its detection and diagnosis are considered to be a promising technique for insulation diagnosis and breakdown prediction. As for the XLPE cable system, PD source can be foreign substances such as a mote and a small fiber, as well as a water tree in a XLPE cable [1-3]. PD source can also be come up at aged joints, such as an interface between XLPE and rubber part, due to solid deposits of deoiled grease, etc. [4]

Here, PD signal initiated in the XLPE cable system propagates in the XLPE cable [5], so PD signal can be measured at the plural measuring points such as some terminations and joints. Therefore, propagation characteristics of PD signals in the XLPE cable system have to be investigated for the accurate location of the PD source as well as limitation of the PD detection, because the PD signal attenuates in its propagation in XLPE cable. A new XLPE cable system can be a coaxial structure [5, 6], however, an aged XLPE cable may not be considered to be a coaxial structure, because the metallic shielding layer such as copper tapes would get oxidized by means of water penetrated through the cable sheath, if the cable has no water barrier layer. The oxidized copper is insulating material, so the oxidized copper tapes may have insulating thin films on their surfaces. Indeed, some copper shielding tapes sampled from the aged and removed XLPE cable operated for around 30 years in underground cable ducts turn black and sometimes have verdigris in their surface. Therefore, the propagation characteristics of PD signal having very short rise time such as several nano-seconds may be changed due to the condition change of the metallic shielding layer.

This paper empirically shows the propagation characteristics of a pulse signal with short rise time considering with PD signal using some models and actual aged XLPE cable. Then the limitation of PD measurement for the aged XLPE cable system is discussed from viewpoint of the propagation characteristics.

PROPAGATION CHARACTERISTICS OF PD SIGNAL IN AGED XLPE CABLES

The pulse propagation characteristics were measured as schematically shown in Fig. 1. The cable specimen was a removed 60 kV class XLPE cable of around 30-year operation, whose specifications are shown in Table 1 and the surface condition of the copper tapes consisting of the shielding layer is shown in Fig. 2. A pulse generator that can generate a pulse with short rise time of several nano-seconds was connected to the cable specimen through a coaxial cable 5D-FB as a delay line to separate the incident pulse and reflected one. The pulse waveforms were obtained at the output (point A) of the pulse generator, the connecting point (point B) of the delay line and the XLPE cable specimen, and the far end (point C) of the XLPE cable specimen. The pulse waveform was measured by a digital oscilloscope with its analogue bandwidth of 1 GHz and its sampling rate of 5 GS/s. In order to reduce influences of the measurement to the pulse propagation, the input impedance of the oscilloscope was 1 MΩ mode for point A and an active probe with its frequency range of up to 1.5 GHz and a high input impedance of more than 1 MΩ was used for points B and C.

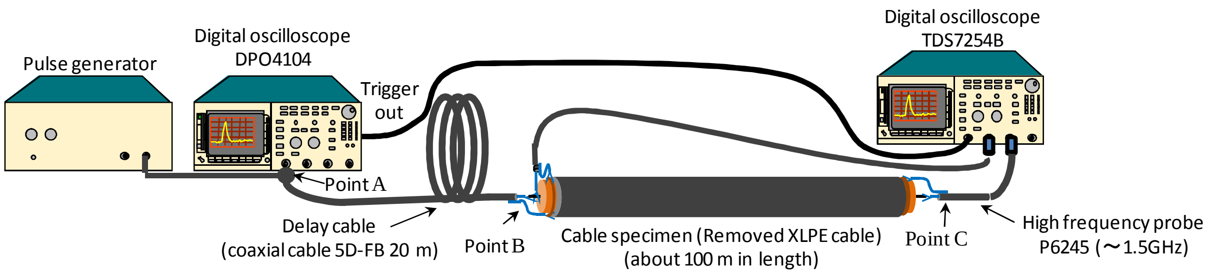

Fig. 1: Measuring setup of the pulse propagation characteristics for the removed XLPE cable