Development of Advanced Partial Discharge Measuring Method for XLPE Cable System

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ABSTRACT

Partial discharge (PD) is considered to be a precursor phenomenon to the dielectric breakdown. Thus, PD measurement is one of strong candidates of the degradation diagnosis for power apparatus such as XLPE cables including terminations and joints. PD measurement also becomes one of the important testing items in its commissioning. Here, to locate PD source and to distinguish PD signal from noises are very important especially for on-site PD measurement to improve the measurement reliability. This paper describes an improved PD measuring technique with UHF techniques which has an ability to locate the PD source with high precision. This technique has been applied to the location of PD source in the pre-breakdown discharge detection test and proved that its accuracy is several tens of centimeters at most.

KEYWORDS

XLPE cable system, Partial discharge measurement, Ultra high frequency, Time resolved measurement, Location, Time-difference-of-arrival method

INTRODUCTION

XLPE insulated power cable is so widely used in the electric power transmission and distribution system that its role becomes quite important to keep high reliability of electric power supply. Therefore, its deterioration diagnosis becomes very important in these days. The partial discharge (PD) phenomenon is a precursor to the breakdown, so its detection and analysis are one of strong candidates of the deterioration diagnosis for the aged XLPE cable system, and are the important items at the commissioning test of the XLPE cable system [1], as well as its type test and pre-qualification tests [2]. From these viewpoints, PD measuring techniques are required to be more accurate. Here, the location of the PD source is strongly required in the deterioration diagnosis for the aged XLPE cable system, to avoid the redundant maintenance and increase the maintenance efficiency.

This paper reports the fundamental development of PD measuring technique applied with UHF technology, in order to locate the PD source in several tens of centimeters for the XLPE cable system. A PD detecting circuit using UHF amplifiers is developed and applied to the improved foil electrodes attached on the cable and / or joint surface. Then detected signal is measured with a digital oscilloscope with the sampling rate of more than 1 G samples per second to achieve the signal with sub nanosecond accuracy, because of the application of the time-difference-of-arrival method for the location. The developed technique is applied to the pre-breakdown discharge detection test for clarification of the degradation cause such as a water tree, etc.

PD DETECTING CIRCUIT

The requirements for the PD detecting circuit to be developed are:

- Amplification enough to detect a weak PD signal.
- Wide frequency range with high upper-limit enough to measure PD signal in sub nanosecond for precise location of PD source by the time-difference-of-arrival method.
- External power supply in order to extend the measuring time as long as possible.

In order to fulfill the requirement above mentioned, and to apply to the foil-electrode type PD detecting system taking into account an application to the PD detection in the pre-breakdown discharge detection test, a PD detecting circuit was developed with application of wideband operational amplifiers and UHF techniques. Its block diagram is shown in Fig. 1. Both of the foil electrodes were connected to the nonolithic wideband amplifiers [2]. The outputs of the amplifies are led to an operational amplifier as differential amplifier to gain the differential signal between two foil electrodes. Here, two inputs of the differential amplifier have polarities, positive one and negative one. Thus, the input of the detecting circuit on the positive side of the differential amplifier is determined as “positive input” and that on the negative side as “negative input.” The output of the differential amplifier is led to another operational amplifier to amplify the signal and match the output impedance [3] to that of the coaxial cable, connecting to the oscilloscope. Fig. 2 shows the circuit diagram of the developed PD detecting circuit [3, 4]. Whole circuit is configured on a circuit board made of fiberglass immersed with epoxy resin to sustain the frequency characteristics in UHF region. Fig. 3 shows the outer view of the circuit. The operational amplifiers used in the developed circuit require dual polarity dc power, although the external power supply should be 5 V dc, single positive polarity to reduce the complexity in power connection. Thus a power regulation circuit with an charge-pump technology is configured on the circuit board opposite side of the amplifiers to generate dual polarity dc power from 5 V dc of single positive polarity [5].

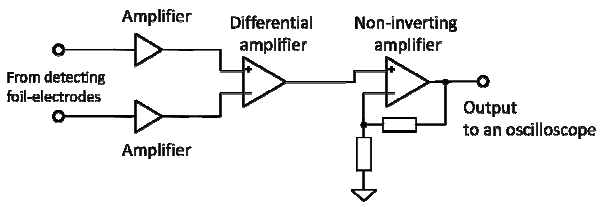

Fig. 1: Block diagram of developed PD detecting circuit.