ON-LINE LOCATION OF PARTIAL DISCHARGES IN AN ELECTRICAL ACCESSORY OF AN UNDERGROUND POWER DISTRIBUTION NETWORK

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ABSTRACT

Many of the power failures occurring at cable joints in Hydro-Québec's underground distribution network are due to partial discharges inside the joints. The network consists mainly of XLPE cable with rubber-moulded accessories. After five years of R&D, a new on-line detection device for locating partial discharges (PD) in the harsh radiofrequency environment of a city is about to be deployed. We have modified a known design by adding an electrostatic shield, an embedded filter and a variable-gain amplifier. Two sensors are clamped around the helical-strand shield of the cable on each side of the electrical accessory. A third sensor, clamped on the semiconductor shield, is used to confirm the presence of high voltage and to measure the line phase angle. Hundreds of underground measurements downtown and in the suburbs demonstrate the diagnostic accuracy. This paper presents the new detection concept, the applied signal processing and some of the field results.

KEYWORDS

Partial discharge, XPLE cable, underground distribution network, time domain reflectometry, spectrogram, line phase sensor.

INTRODUCTION

Hydro-Québec began to deploy mobile infrared (IR) thermography units on its underground system at the end of the 1980s. IR thermography is used to locate resistive contacts and dielectric hotspots on-line in the network. Nevertheless, some of these hotspots remain hidden from view and cannot be detected by thermography. To combine good preventive maintenance with guaranteed safety for its workers, in 1993 the Québec power utility therefore started to use a commercial device for the on-line detection of electromagnetic (EM) radiation associated with partial discharges (PDs) present in the network. The EM emission from PDs is therefore measured after the thermography. Inspired by patent No. CA 2013552 [1], this device performs a double-conversion AM (superheterodyne detection) in a narrow band of several kilohertz on a 6.9-MHz carrier. The EM activity in this narrow-band is displayed on a decibel scale. The device has a number of drawbacks however:

1) It does not have the required sensitivity to be able to detect sites with a low rate of discharges.

2) It does not differentiate between a wideband (>100 MHz) very short discharge with a high amplitude and a time-dispersed transient signal with a lower frequency and smaller amplitude.

3) Attenuating an EM wave propagating in the cable to 6.9 MHz is not enough to eliminate signals coming from other manholes.

4) The EMI causes faulty detection. Sometimes, operators can hear music or conversations from the device's loudspeaker.

5) The detection principle is based on the use of a floating capacitive coupling, not ground-referenced, so that the instrument's response appears sensitive to the way it is maintained.

Points 2) and 3) imply that a discharge in adjacent equipment gives a diagnosis indicating the presence of PDs, even if they are located several hundreds of meters from the source [2].

With no ready access to many of its underground installations, Hydro-Québec launched a research program earlier this century in an aim to develop a reliable device for detecting, locating and characterizing discharge sites on-line. There are now some 30 units of a second generation of this new device in operation in the Québec underground network. The PD analyzer (PDA), as it is known, is based on time-domain reflectometry (TDR) and calls for three sensors to be installed on the accessory or the portion of cable to be instrumented; these sensors are connected by a 13-m cable to the device, which is installed outside the manhole. Although the PDA is more complicated to use than the earlier commercial device, we have not found any error in its diagnostics, after more than 1000 field measurements.

HARDWARE DESCRIPTION

After multiple tests in the laboratory and on the underground network, we chose the magnetic sensor proposed by E. F. Steennis at KEMA [3,4]. This sensor comprises a single conducting loop which responds to the longitudinal magnetic field generated by the helical-stranded shield of the cable. However, as this sensor is not very practical to install and responds to noise in a wide band, we made a few improvements (see Fig. 1), namely:

- Addition of a hinge with a connection on the opposite side so as to convert the sensor into a clamp and therefore easy to position.
- Electronics (including a filter and a commutable gain amplifier) built into the sensor.
- Electrostatic shield enveloping the sensor and its electronics.

Since the PD signals observed with this sensor have a bandwidth exceeding 350 MHz, the sensor is attached to a 1