NEW TECHNIQUE FOR FAULT LOCATION ON UNDERGROUND MEDIUM-VOLTAGE CABLES

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ABSTRACT

This paper presents the development of a new method of cable fault location used on the Hydro-Québec underground distribution system. The method helps prelocate faults on de-energized medium-voltage cables for lines from a few hundred metres to several kilometres long. The method is based on a comparison between simulated thumping on a software model of the line and thumping measurements taken on the line itself. The results obtained are presented and show that the method is effective even when there are branch lines of varying length off the line being tested.

KEYWORDS

Fault location, reflectometry, medium-voltage cables

INTRODUCTION

Hydro-Québec Distribution has over 4,000 underground distribution lines with 10,300 km of 12-kV and 25-kV medium-voltage underground cables. More than 200 lines are over 10 km long and most have branch lines. The system is almost entirely comprised of duct banks containing bare concentric neutral cable with 28-kV XLPE or TR-XLPE insulation.

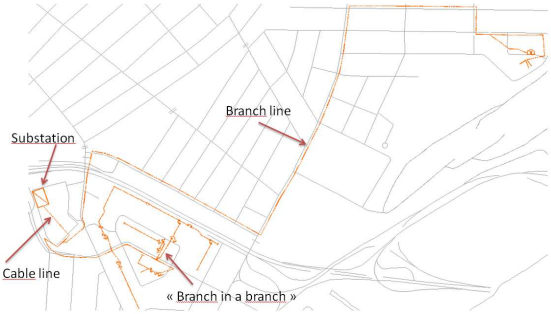

Figure 1. Example of an underground line with branch lines

Fault location on underground lines of the medium-voltage distribution system consists in identifying where on a cable run or at a splice a fault is located. Faults may occur in service or during off-line dielectric tests. Fault location is thus performed on de-energized lines. Various location techniques available are reviewed in [1] and [2].

Most faults are of one of the following types:

- Insulation damage represented by a resistive-capacitive circuit between the core and ground, modelled as a spark gap
- An open circuit (neutral and/or conductor severed, or poorly installed splice)
- A direct short circuit (neutral touching conductor of the cable, external conductor piercing the cable or poorly installed splice)

Prelocating consists in determining as precisely as possible the location of, or distance to, a fault from a measurement point at the end of the line using various measurement techniques. Until recently, the most commonly used prelocating technique was reflectometry where a pulse reflectometer is used with a pulse generator or "thumper".

In 2002, Hydro-Québec Distribution gave its research institute, IREQ, the mandate to develop a more effective fault location technique, i.e., to reduce average fault location time and the training workers required to perform the task.

The challenge was to locate faults on long lines with many branch lines. The purpose was also to reduce the number and amplitude of pulses on the cable.

METHOD

The method developed by IREQ is based on the following principles:

- The fault is considered as a type of spark gap.
- Thumping a fault produces a voltage waveform that travels down a conductor and reflects off its terminations until completely attenuated.
- The electric arc lasts much longer than the time it takes for the shock wave to travel back and forth several times.
- From the pulse generator, the electric arc is seen as a low-impedance circuit of a few ohms.
- A breakdown at a given location on a line section produces a unique signal that can be modelled and simulated.

Based on these principles, the new method consists in performing the following three steps (see figures 2 and 3):

1. **Simulate** thumps at regular distances along the line, checking the signal from the point where the pulse generator is to be installed.
2. Measure an actual thump on the line at the point where the pulse generator is installed.
3. Compare simulations with the measurement and identify the best match, which corresponds to a unique point on the line and indicates the location of the fault.