Close and Return

PARTIAL DISCHARGE DETECTION IN POWER CABLES: PRACTICAL LIMITS AS A FUNCTION OF CABLE LENGTH

Andrea CAVALLINI, DIE University of Bologna (Italy) andrea.cavallini@mail.ing.unibo.it
Chandrasekar SUBRAMANIAM, DEEE, Sona College of Technology, (India), chandrukvt@gmail.com
Gian Carlo MONTANARI, DIE University of Bologna, (Italy), giancarlo.montanari@mail.ing.unibo.it

ABSTRACT

Power cables behave as transmission lines as regards partial discharge (PD) pulse propagation. Attenuation and dispersion phenomena have, therefore, great influence on the detectability of PD pulses, particularly when long cable routes and detection from terminals are considered. This paper presents an approximate model to infer PD pulse waveform as a function of the distance travelled along the cable and shows results that can provide practical limits for PD detection in cable routes when using IEC 60270-compliant and/or ultra wideband detectors. Considerations on the effect of calibrator characteristics on sensitivity check procedures are, eventually, reported.

KEYWORDS

Partial discharge, bandwidth, detection sensitivity.

INTRODUCTION

Partial discharge (PD) pulses traveling along power cables undergo frequency-dependent attenuation and dispersion phenomena. Since attenuation increases with frequency, traveling pulses lose frequency content, as more as the distance between the PD source and the detection point (traveled distance) increases. As a consequence, depending on the spectral characteristics of background noise and interference, detection effectiveness decrease up to a point where detection can be practically unfeasible.

Modeling frequency-dependent losses (and, therefore, attenuation and dispersion constants) in power cables is, therefore, a key point for establishing (a) the optimum detection bandwidth to detect pulses coming from a given distance and (b) the maximum distance at which PD pulses can still be observed. In [1], a model based on the Advanced Transient Program (ATP) has been proposed and experimentally validated. Here, the model will be recalled shortly, being the focus of the paper on practical implications for PD testing.

CABLE MODEL

Propagation phenomena in cable systems are very difficult to model accurately. As a matter of fact, models that are commonly encountered in power system simulation packages (e.g., the ATP) take into account only skin effect losses. However, at frequencies larger than 1 MHz, those that generally are interesting for PD propagation issues, semicon losses become the predominant factor [2].

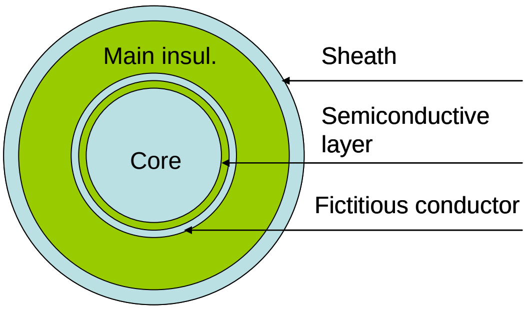

Figure 1. Structure of the cable model used simulation purposes.

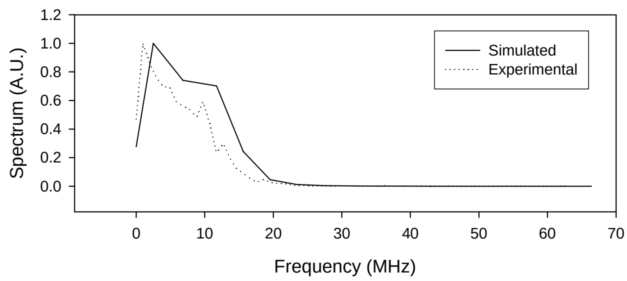

Figure 2. Comparison between experimental measurements and simulation results in the frequency domain. The distance between sending end and detection point is 360 m. Receiving end: open-circuited.

Modelling semicon characteristics is fairly complicated, as one needs to perform measurements through network analyzers and, moreover, the complex permittivity of semicon materials is subjected to change with frequency, pressure and temperature [3].

In order to obtain an approximate propagation model, tests were performed in the lab by injecting calibrator pulses into two MV cable rolls and by looking at the characteristics in the time and frequency domain of the propagating pulses. It was found that, with some approximation, the model reported in Figure 1 could be used properly. In particular, semiconductive layers were simulated through a layer having a relative permittivity equal to 1 and resistivity of 3 Ω·m (value obtained through DC measurements performed on the tested cable, neglecting the dependence of resistivity on frequency). A fictitious conductor around the semiconductive layer had to be considered due to the constraints of the ATP routine that evaluates transmission line parameters (i.e., RLGC parameters) as a function of frequency starting from the geometric characteristics of the cable. As shown in Figure 2, discrepancies between