# CONTINUOUS ON-LINE MONITORING OF PARTIAL DICHARGES IN HV DISTRIBUTION CABLES

Hao ZHANG, Transgrid, (Australia), hao.zhang@transgrid.com.au
Zhao LIU, University of NSW, (Australia), z.liu@unsw.edu.au
Toan PHUNG, University of NSW, (Australia), toan.phung@unsw.edu.au
Trevor BLACKBURN, University of NSW, (Australia), t.blackburn@unsw.edu.au

## *ABSTRACT*

*The most effective method of monitoring insulation condition in high voltage distribution cables is by continuous on-line partial discharge monitoring. However, on-site partial discharge measurement sensitivity can be limited by high levels of interference which can make it difficult to obtain and interpret adequate PD data for insulation assessment purposes. Differential circuit methods can be used to reject common mode interference but for high frequency non-conventional PD methods the standard balanced circuit will not produce satisfactory noise-free results, especially for medium or longer length power cables. A software based differential technique has been developed and has proved effective for on-line PD monitoring of power cables. The method gives good interference rejection and the sensitivity is suitable for assessment of both extruded and paper insulated cables. The monitor has been applied successfully to a number of various on-site cable systems in Australia.*

## *KEYWORDS*

Cables, Monitoring, On-line partial discharges, Insulation assessment.

## INTRODUCTION

The high voltage cable distribution infrastructure in a power system is arguably the most important part of the power infrastructure. Because of the time and cost required for repairs of cable failures it is a necessary requirement that cables be reliable. The reliability is significantly determined by the presence of any defects in the insulation. Thus insulation assessment is a key factor, as in almost all high voltage plant. In most insulation materials the dielectric deterioration is normally accompanied by partial discharge (PD) activity and thus PD monitoring is the most effective and sensitive assessment method available. PD measurement is thus now very widely used for insulation condition monitoring in all items of high voltage equipment.

However in the case of XLPE cables the application of partial discharge methods for insulation assessment is not as apparently useful as in impregnated paper insulated cables. While paper insulation is relatively tolerant of some PD activity, XLPE (and EPR) insulated cables are not able to tolerate any significant PD activity for prolonged periods.

Different classes of HV equipment and their insulation systems can differ greatly in their capability to withstand PD activities [1]. Typically, paper insulated cables are able to withstand PD levels of several hundred or more pico-coulombs without significant effect on insulation life. However for XLPE cables the permissible (withstandable) PD levels are only some tens of pC.

In many substation environments the equivalent background electrical noise level may be one or two thousand pC. Thus the measured PD signals have to be extracted from this high level noise. For paper insulated cables it is possible to monitor PD levels with a sensitivity that is adequate for detecting PD levels that will cause damage to the paper (thousands of pC). However in the case of XLPE, damaging levels of PD activity fall some orders of magnitude below the typical PD sensitivity detection levels with such background noise levels. Even low levels of PD activity can cause breakdown in XLPE [2]. It is thus necessary to use noise reduction techniques for application with extruded cable PD monitoring. As XLPE is almost the universal choice of new distribution cable the assessment requirements for such cable necessitate the development of new and more sensitive PD monitors.

The problem is further compounded by the fact that although water tree growth in XLPE insulation, which is the most common form of degradation in XLPE, takes a very long time to develop, once the water tree changes to the electrical tree phase, the time taken for the dielectric to progress to full breakdown is quite short. Electrical trees will generate PDs, while water trees will not. As a result, while regular routine monitoring of PD activity may be adequate to provide sufficient forewarning of potential failure in paper insulated cables, in XLPE cables the water tree - electrical tree transition may progress to full breakdown in a time shorter than the intervals between regular routine PD testing. This rapid development to breakdown of electrical tree degradation requires the new PD monitors to be continuous and on-line.

As a result of this rapid deterioration of the XLPE and the general resistance of asset managers to providing more facilities for more frequent offline monitoring, the only option available is to use continuous online PD monitoring of cables. The additional constraint of the low PD tolerance of XLPE means that PD detection sensitivities have to be improved to allow detection of levels of at least 100 pC against possible background levels of the equivalent of some thousands of pC.