Electrical Power and Energy Systems 94 (2018) 374–384

Contents lists available at ScienceDirect

Electrical Power and Energy Systems

journal homepage: www.elsevier.com/locate/ijepes

# A new design of a test platform for testing multiple partial discharge sources

A. Rodrigo Mor [a], L.C. Castro Heredia [a,*], D.A. Harmsen [a], F.A. Muñoz [b]

[a] Delft University of Technology, Electrical Sustainable Energy Department, Delft, The Netherlands
[b] Universidad del Valle, Escuela de Ingeniería Eléctrica y Electrónica, Cali, Colombia

ARTICLE INFO

*Article history:*
Received 25 January 2017
Received in revised form 13 June 2017
Accepted 17 July 2017
Available online 8 August 2017

*Keywords:*
Clustering techniques
Partial discharges
Phase resolved partial discharge pattern

ABSTRACT

Partial discharge (PD) measurements are an effective tool for insulation assessment of high-voltage (HV) equipment widely used in both HV laboratories and in field tests. This paper presents the design of a test platform for electrical detection of partial discharges that contribute to the understanding of the phenomena. The test set-up comprises a collection of electrodes for the production of artificial PD sources frequently found in HV equipment, such as positive corona, negative corona, surface discharges, internal discharges, floating component and free moving particle. The test set-up has been designed in such a way that the gaps and clearances can be adjusted to modify the discharge characteristics, e.g. the discharge inception voltage, amplitude, repetition rate, etc. Besides, the platform has a symmetrical and radial arrangement of the PD sources around the coupling capacitor of the PD measuring systems with contribute to reduce the effect of the measuring circuit on the measurements.

Relevant characteristics of the presented design is that the sensing of the PD signals is done by a high frequency current transformer (HFCT) with a wide bandwidth and the acquisition of the signals by a digital oscilloscope. A software tool was designed for the purpose of processing of the digitalized signals which proved to be an excellent workbench for studying the performance of clustering techniques.



## 1. Introduction

Partial discharge (PD) measurement is a well-known diagnostic test for the dielectric insulation of HV equipment. Electrical detection of PD pulses is the most important and by far the most used method both in industrial and in laboratory tests. In addition to the conventional electrical methods as defined by standard IEC270 [1], currently the unconventional methods, understood as those with bandwidths lying on hundreds of MHz capable of resolve the waveform of the pulses, are becoming more and more predominant for testing cables, gas insulated systems and rotating machines [2–5]. One of challenges with the electrical detection is that a PD event itself cannot be measured directly but only the response of a measuring circuit after the PD event. In unconventional PD measuring systems, this response, i.e. the PD pulse waveform, is affected not only by the physics of the discharge but also by the interaction among the test object, the measuring circuit and the PD event. Consequently, PD parameters computed from the pulse waveform by different users and instruments might be incomparable.

As pointed out in [6], if properly measured, a PD pulse should be unipolar and non-oscillatory. However, If the test object has inductance as well as capacitance (e.g. a stator winding), then the PD pulse will create an oscillating response. Commonly, literature omits very deep details of the measuring circuit and readers are then prone to not to notice that even the connections and cables of measuring circuit affects the results. For instance, long lengths of cables in the circuit can add large ground inductances which produce an oscillatory response that affects the sensitivity [7] and the charge estimation [8] of the pulses.

In this paper, we present a design for an unconventional partial discharge test platform that contributes to minimize the aforementioned effects of the measuring circuit. This platform comprises several electrodes and a software tool to study different artificial PD sources representative of the most relevant insulation defects. It will be highlighted that the characteristics of the set-up contribute to control the circuit parameters, thus contributing to the repeatability and consistency of the measurements. Dimensions and details of the easy-to-build electrodes, a collection of phase-resolved PD patters (PRPD) as well as an introduction to the performance of clustering techniques to separate and recognize PD sources are provided to the user as a reference guide, that joins others efforts for a better learning of the PD phenomena [9,10].

* Corresponding author.
*E-mail address:* l.c.castroheredia@tudelft.nl (L.C. Castro Heredia).

http://dx.doi.org/10.1016/j.ijepes.2017.07.013
0142-0615/

## 2. Set-up description

A detailed scheme of the PD test platform is depicted in Fig. 1. The set-up comprises a high-voltage transformer, a blocking inductor, an arrangement of electrodes for different types of PD sources, a high frequency current transformer HFCT-type PD sensor, a high-voltage divider, a synchronization unit and an oscilloscope Tektronix DPO7354C.

### 2.1. High-voltage transformer supply

This set-up has been designed in such a way that the discharge inception voltage (DIV) is below 10 kV for any of the PD sources. In this way, a HV supply with proper ratings can be found in most cases. Due to the small currents, medium voltage instrument transformers can be used to energize the set-up. The high-voltage transformer is supplied from a regulating autotransformer via a safety box that includes a fence interlock, voltage and current trips. This transformer is located within a faraday cage (see square area D in Fig. 1a).

A blocking inductor is placed between the high-voltage transformer and the electrode arrangement to block possible discharges from the transformer and to increase the sensitivity of the set-up. The blocking inductor is a ten turns coil with a TDK N30 magnetic core.

### 2.2. Artificial PD sources

Several electrodes were built to create artificial PD sources such as positive corona, negative corona, surface discharges, internal

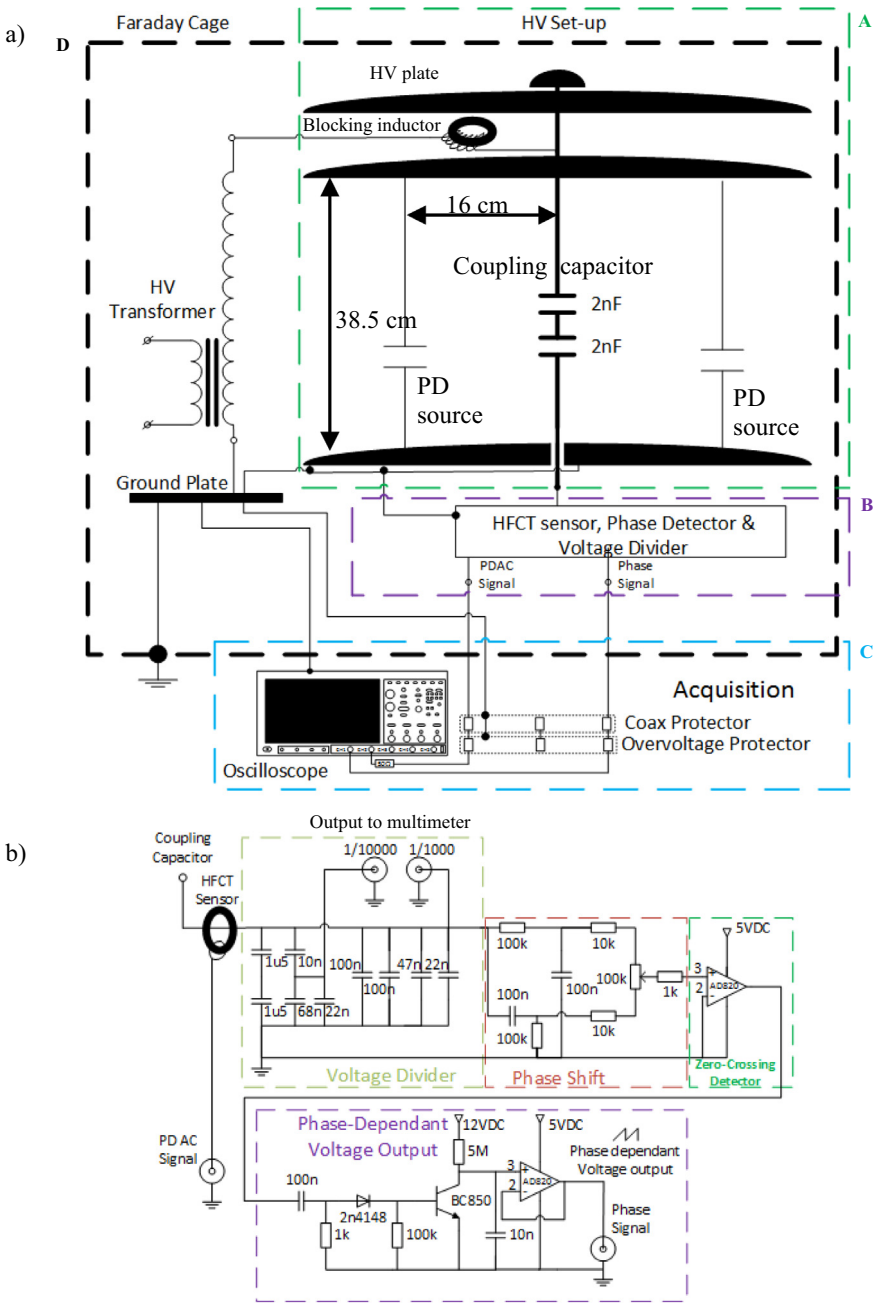


**Fig. 1.** (a) Scheme of the partial discharge test platform, (b) Circuitry of the synchronization unit, PD signals and voltage dividers arranged within the square area B. The square area A is the test set-up itself formed by the ground and high-voltage plates, the blocking inductor, the coupling capacitor and the PD sources.