A Technique for Evaluating Electrical Insulation in High Frequency/High Voltage Applications

Clayborne D. Taylor, Jr.
Electrical and Computer Engineering
Mississippi State University
Mississippi State, MS, USA
cdt4@ece.msstate.edu

Clayborne D. Taylor, Sr.
Professor Emeritus
Electrical and Computer Engineering
Mississippi State University
Mississippi State, MS, USA

Abstract— **During fabrication electrical insulation, imperfections that lower the insulation quality cause non-linear responses when energized at high voltages. The non-linear response, generally known as partial discharge (PD) and described by patterns of current pulses, is seen at a broad band of frequencies. The PD pulse shape is approximated by a Gaussian distribution and is directly measured revealing a pulse width less than 1 ns. Patterns of the PD current pulses can help in evaluating the quality of electrical insulation systems. Due to the nature of insulation systems designed to withstand the forces of high power systems, measurement of Gaussian current pulses is quickly degraded at higher frequencies. Traditional methods of low-bandwidth PD measurement do not apply where high bandwidth, high power sources are required. A novel approach is presented that uses a wavelets-based estimator with lower bandwidth multi-channel measurement.**

Keywords: partial discharge, high frequency pulse patterns, wavelet decomposition

I. INTRODUCTION

Precise measurement of partial discharge (PD) is a difficult problem for high bandwidth power sources. PD pulses for gas voids have a steep rise (sub-nanosecond) and short width (typically <10 ns). This shape and bandwidth is based on the size and density of the charge trap, and the electrical properties of the material that the discharge energy must propagate through. Finally, the PD energy may be very close to the electrical noise level of the physical environment.

II. MEASUREMENT SYSTEM

Measurement of current pulse signals shown in Fig. 1 is performed using a 1 GS/s Digital Storage Oscilloscope to capture a pulse train of 10 total square pulses.

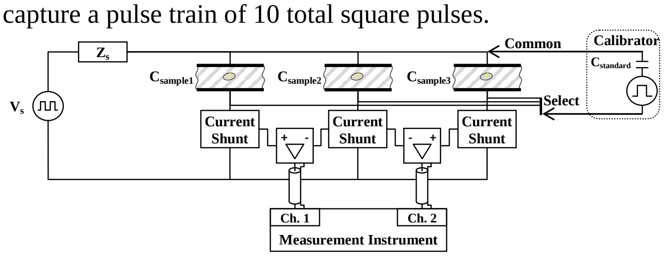

Figure 1. Multi-channel PD measurement system.

III. METHOD OF ESTIMATION

A. Wavelet Transformation

Decomposition of signal data is performed using the Daubechies 4 coefficients with 3 levels of decomposition of a signal that is down-sampled to 300 MHz. Signal estimation threshold for wavelet coefficients was selected at 300% of the coefficient noise level.

B. Algorithm of Estimator

Two channels from the measurement system are transformed with wavelets for proper estimation of pulse patterns. For the estimator, the channel voltage is determined from the first order wavelet detail and the PD coefficients in (1). These PD coefficients are directly correlated to the physical PD phase location and magnitude.

$$\tilde{v}_{ch}[n] = v_{c\pm}^{d1}[n] * PD_{\pm}[n] + v_{cx}^{d1}[n] * PD_x[n]. \quad (1)$$

IV. RESULTS

Current pulse patterns were recorded when pulse train magnitude reached 750 V for 50 ns rise-time and fall-time and total cycle time of 100 µs, 50% duty cycle. At room temperature, the recorded pulse patterns presented in Fig. 3 show results in good agreement with other similar studies at

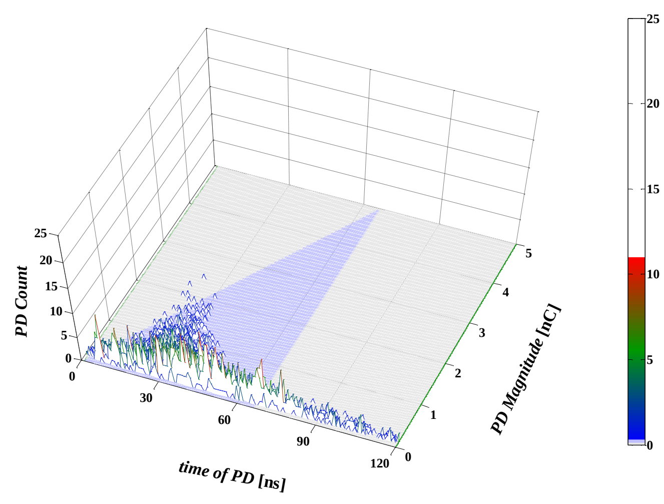

Figure 3. PD Pattern for 750V Magnitude, 10 kHz Square Pulse Train, 20°C.

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