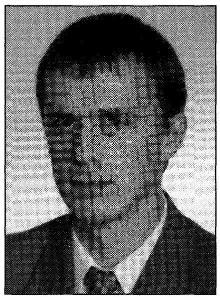
Kazimierz GOHRA, Marek OLESZ, Adam KONKEL
GDAŃSK UNIVERSITY OF TECHNOLOGY, FACULTY OF ELECTRICAL AND CONTROL ENGINEERING, DEPARTMENT OF HIGH VOLTAGE TECHNOLOGY AND POWER ELECTRICAL APPARATUS

Computer-aided registration of current pulses in polyethylene insulation during the first stage of electrical treeing

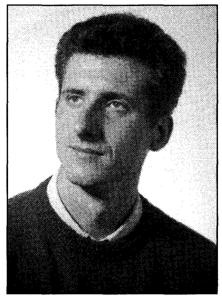
Mgr inż. Kazimierz GOHRA



He was born in 1972 in Puck, Poland. He received MSc. degree from the Gdansk University of Technology in 1998. At present, he is researcher at the Gdansk University of Technology. His field of interest are partial discharge and electrical treeing.

kgohra@ely.pg.gda.pl

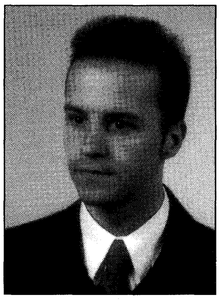
Dr inż. Marek OLESZ



He was born in 1966 in Gdynia, Poland. He received MSc. and PhD degrees in 1990 and 1998, respectively, both from the Gdansk University of Technology. At present, he is lecturer at the Gdansk University of Technology. His current research interests include electrical treeing phenomena and power quality.

molesz@ely.pg.gda.pl

Mgr inż. Adam KONKEL



He was born in 1976 in Tczew, Poland. He received BSc degree from the Gdansk University of Technology, faculty of Electrical Engineering in 2002. He works at the Electrical Engineering in Gdansk. His fields of interest are computer science and data acquisition systems.

adam.konkel@eg.pl

Abstract

The paper presents Labview program for automatic measurements of current pulses in polyethylene insulation during the first stage of electrical treeing. The pulses have a very short duration (ns) and a small level of current, so to make the measurements possible, the differential method was applied. This method allows to compensate the residual dissipative and capacitive current of the control sample by the same current in the standard sample.

Streszczenie

Proponowany referat przedstawia aplikację opracowaną na bazie programu LabView współpracującą z oscyloskopem cyfrowym za pośrednictwem karty GPiB. Program ma na celu ciągłą (on-line) rejestrację impulsów prądowych mających charakter niepowtarzalny o krótkich czasach trwania (ns). Rejestrowane impulsy związane są z ruchem ładunku elektrycznego w obszarze przyelektrodowym (układ ostrze-płyta uziemiona), w początkowej fazie drzewienia elektrycznego. Aby mierzyć składową prądu związaną tylko z ruchem ładunku zastosowano metodę wykorzystującą układ wzmacniacza różnicowego. Sygnał pomiarowy w układzie uzyskuje się mierząc spadki napięć na dwóch rezystorach bezindukcyjnych włączonych szeregowo w obwody obu próbek - badanej i wzorcowej. Napięcie z wyjścia wzmacniacza różnicowego rejestrowano oscyloskopem cyfrowym i przesyłano do komputera za pomocą karty GPIB. Aplikacja napisana w Labview umożliwia rejestrację i akwizycję wybranych parametrów kolejnych impulsów prądowych, zapisywanych w standardowym formacie pliku tekstowego (spreadsheet).

Keywords: electrical treeing, partial discharge, polyethylene
Słowa kluczowe: drzewienie elektryczne, wyładowania niezupełne, polietylen

1. Introduction

The detection, location and recognition of partial discharges at an early stage of possible insulation failure in medium voltage are of great importance for maintenance purposes [1]. The information connected with ageing insulation material can help to improve the reliability of the insulated system. Under the rated voltage, polyethylene cable insulation is submitted to an electrical field up to 10 kV/mm. Excluding water and oxygen influence, the main processes leading to electrical tree initiation is the existence of defects like cavities, contaminants and protrusions. Electrical treeing in polyethylene is still a poorly understood phenomenon. Some papers [2, 3] allowed for proving the thesis that partial discharges initiated by switching impulse could be supported by ac voltage. This is probably caused by a space charge injected into the polymer insulation by the voltage impulse. The charge remains in the insulation and co-operates with the ac voltage. Theoretically discharges initiated during short overvoltage could continue at comparably lower ac voltage, leading to polymer degradation.

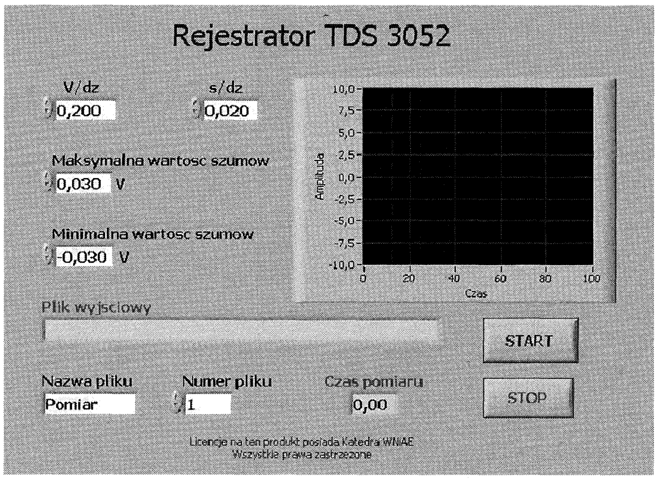


Fig. 1. The user interface
Rys. 1. Interfejs użytkownika

The measurement of current impulses is important to understand the mechanisms of electrical treeing - induced by partial discharge. The main purpose of this work was to make a system for automatic measurements of level and phase impulses under ac voltage. To carry out this work, we chose Labview, which is a graphical environment for signal acquisition, measurement analysis, and data presentation (fig. 1). This language provides an easy means to quickly design and implement measurement applications. It provides seamless integration with measurement hardware to facilitate rapid development of data acquisition and analysis, instrument control, and data presentation solutions [4, 5]. Among other things The Labview system is fully integrated with GPIB hardware - a standard for digital oscilloscopes. It will be possible to take the full advantage of this system in applying switching impulses supported by ac voltage and this will be done later.

2. Experimental implementation

The program is implemented for automatic measurements of current pulses in polyethylene sample, when an electrical tree starts to grow. The whole setup is presented in fig. 2. The circuit is supplied by a HV transformer. Two polyethylene samples in a needle - plate arrangement are immersed in silicone oil. The residual dissipative and capacitive current of the control sample is compensated by the same current in the standard sample. The output voltages from 50 ohm, non inductive resistors are subtracted by a very sensitive differential amplifier (DA 1850A - Lecroy, frequency limit - 100 MHz). The output voltage is proportional to the current impulses connected with charge transfer between needle and polymer [6]. The charge transfer is connected with injection and extraction of charges during electrical treeing. The area near needle electrode was observed by optical microscope and recorded by digital camera. The differential voltage proportional to charge transfer is recorded on one input of oscilloscope. The second input is used to record ac waveform from voltage probe (P6015A). The results are transmitted from oscilloscope to computer via GPiB card.

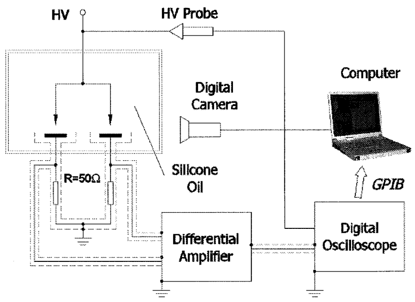


Fig. 2. Complete setup with optical microscope
Rys. 2. Układ pomiarowy z mikroskopem optycznym

The program which controls the measurements and writes some results to the file in spreadsheet format, was prepared with integrated Labview programming environment (fig. 3).

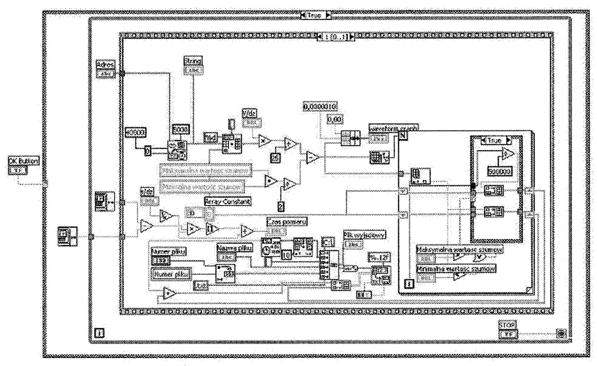


Fig. 3. The diagram of the program (virtual instrument)
Rys. 3. Układ blokowy programu (przyrząd wirtualny)

With the virtual instrument panel (fig. 1), the following functions can be performed:
- setting the time base and vertical sensitivity,
- setting the level of disturbances of both polarities,
- setting the name of output file,
- setting the time of measurement,
- starting and stopping the program.

After pressing the start button, the program runs in a loop until the time of the monitoring waveforms is exceeded (fig. 4). The loop involves 2 steps. The first step controls the amplitude of current impulses. The program rejects all points of partial discharge waveform which are below a defined threshold. The input value of threshold allows to reject some noises connected with electromagnetic disturbances. The second step records all remaining points to output file (text file in spreadsheet format). The format of file is the following: two columns, the first column - time of current impulse, second - level of current impulse. After every transfer of data from oscilloscope, the program adds the next events (time and level) of current of partial discharges.

The program gives a possibility of long-standing acquisition with frequency of 3 measurements per one second. In measurement intervals, the computer takes waveforms from oscilloscope (first and second channel). The time base of waveforms depends on frequency of sinusoidal voltage (for example for 50 Hz the time base is set up at 2 ms).

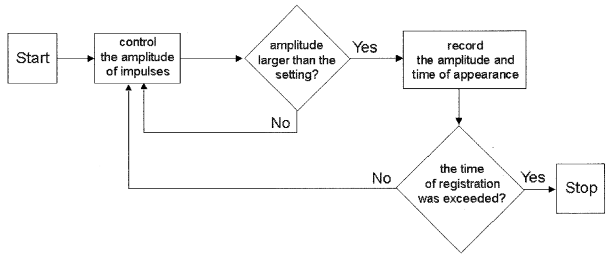


Fig. 4. Impulse detection algorithm
Rys. 4. Algorytm detekcji impulsów

After the experiment, the output file is analysed in a spreadsheet. The statistical calculation gives some information about process of tree growing:
- intensity of impulses versus time
- the total number of current pulses
- the mean level of impulses
- the impulse distribution (phase angle - magnitude - number),

which are important for diagnosis of electrical treeing degradation.

Preliminary experimental results obtained on polyethylene sample prepared from XLPE cable give some information about the activity of partial discharges during treeing. For example, the intensity of impulses is variable in time. At the beginning (first 15 minutes of treeing) the level of impulses is very high, and then the level decreases with time (fig. 5).

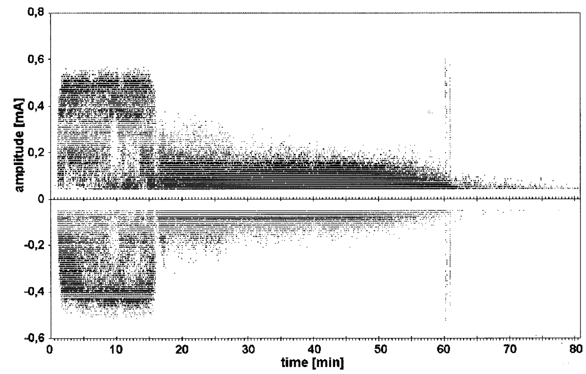


Fig. 5. Intensity of impulses during experiment
Rys. 5. Amplitudy impulsów w czasie trwania eksperymentu

Fig. 6 and 7 show the typical phase - magnitude - number pattern of electrical treeing - induced by partial discharges under sinusoidal voltage of 6 kV and 50 Hz. During the experiments, the final tree was like a bush - tree approximately 1 mm in length. The phase - magnitude - number pattern (fig. 6) was obtained by summing the measurement result from 900 consecutive cycles at Δt=300 s interval (fig. 5). It is clear that current magnitude has the maximum activity for phase angle 0÷90° and 180÷270°. The number of positive impulses is a little larger than the negative due to back discharges from insulation to electrode initiated by space charge [2].

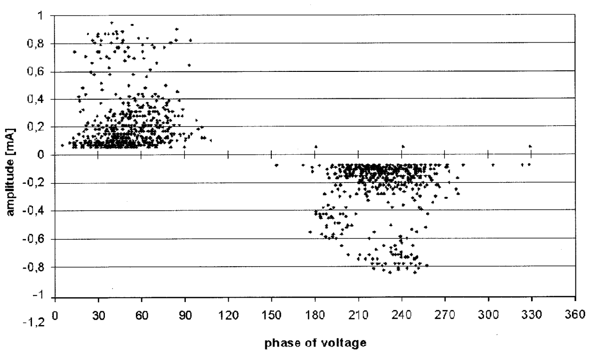


Fig. 6. Phase distribution of impulses
Rys. 6. Rozkład fazowy impulsów

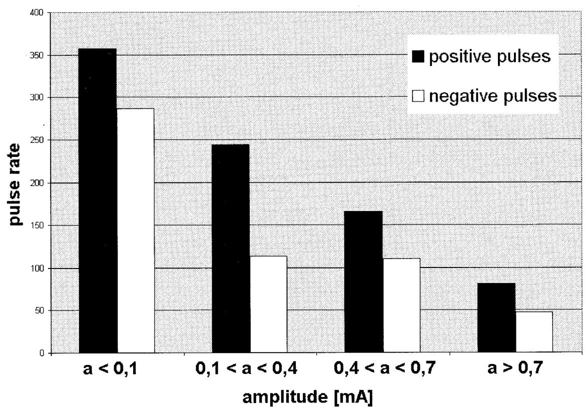


Fig. 7. The number of positive and negative impulses acquisition at Δt interval
Rys. 7. Liczba impulsów dodatnich i ujemnych zarejestrowana w czasie Δt

3. Conclusions

The presented application considerably improves the process of data acquisition from experiment. During many hours of tests, the program operates fully automatically, and the output file is ready for further processing, using any spreadsheet or mathematical analysis software. The graphic programming language applied, makes it possible to easily extend the application, to create additional libraries allowing to support other oscilloscopes or measuring devices. The small frequency of acquisition of samples from the oscilloscope is a disadvantage of the program. However, it is sufficient for the needs of the presented experiment. It does not cause a threat of incorrect interpretation of results.

References

[1] B. Florkowska, M. Florkowski, R. Włodek, P. Zydroń: Mechanizmy pomiary i analiza wyładowań niezupełnych w diagnostyce układów izolacyjnych wysokiego napiecia, Wyd. PAN, Warszawa 2001
[2] T. Tanaka: Charge Transfer and Tree Initiation in Polyethylene Subjected to ac Voltage Stress, IEEE Trans. on EI, vol. 27, No. 3, pp. 424-431, 1992
[3] Marek Olesz: Wpływ udarów nałożonych na napięcie przemienne na propagację drzewienia elektrycznego w polietylenie sieciowanym, Zeszyty Naukowe Politechniki Gdańskiej nr 583, Elektryka nr 86
[4] J Porcello: Using GPIB Instruments to Test Communication Systems, Montana, College of Mineral Science and Technology
[5] National Instruments Corp.: LabVIEW User Manual. Austin, 2001
[6] T. Himba, H. R. Zeller: Direct measurement of Space Charge Injection from a Needle Electrode into a Dielectric, J. Appl. Phys., Vol. 59, 1986
[7] W Winiecki: Virtual instruments - what does it really mean?, Proceedings of XIV IMEKO World Congress, vol. IVa, Tampere (Finland) 1-6.06.1997

Tytuł: Komputerowa rejestracja impulsów prądowych w izolacji polietylenowej w pierwszej fazie rozwoju drzewienia elektrycznego

Artykuł recenzowany