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## Using electro magnetic PD sensors for diagnostics of high voltage equipment

**Streszczenie.** (Elektromagnetyczne czujniki wnz dla diagnostyki urządzeń wysokonapięciowych). Pomiar wylądowań niepełnych (wnz) należą do szerokiego grona metod pomiarowych wykorzystywanych w diagnostyce układów izolacyjnych urządzeń wysokonapięciowych. Istnieje kilka sposobów wykrywania sygnału wylądowań niepełnych. Generalnie metody te można podzielić na bezpośrednie (off-line) oraz pośrednie (on-line). W artykule przedstawiono metodę pomiaru z wykorzystaniem elektromagnetycznych czujników wylądowań niepełnych. Przedstawiona bezpośrednia metoda (on-line) została porównana z klasyczną, pośrednią metodą elektryczną. Przykładowe pomiary zostały przeprowadzone na różnych modelach oraz na jedno- i trójfazowych transformatorach o izolacji żywicznej.

**Abstract.** Partial discharge (PD) measurement belongs to very prospective measuring methods that are used for diagnostics of insulating systems of high voltage equipment. There are several ways, how to detect partial discharge signal. In general, it is possible to divide partial discharge measurements into direct (off-line) and indirect (on-line). In the article, measurements with electro magnetic partial discharge sensors will be described. This indirect on-line method will be compared with classical direct electric method. Measurements were carried out both on various types of models and on real epoxy one- and three-phase transformers.

**Słowa kluczowe:** detektor wylądowań niepełnych, elektromagnetyczne wykrywanie wnz, modelowanie wnz, wylądowania ulotowe, wylądowania wewnętrzne.

**Keywords:** partial discharge detector, electromagnetic PD sensing, partial discharge modeling, corona discharge, cavity discharge.

### Introduction

The idea to detect discharges using electro magnetic PD sensors is not new. In sixties, a design of the first transistor receiver fastened on the insulating tube was published. Authors recommended it is a good tool for locating of PD sources (corona) on high voltage lines. Electro magnetically induced signals in ferrite antenna of the receiver were after amplifying transformed to acoustic signals by the loudspeaker. The acoustic signals were transmitted inside the tube to the microphone mounted on the other end of the tube. A similar detector with a simpler acoustic indication was used for locating of PD signal on distribution lines and substations [1]. Regarding the limiting parameters of both detectors, they could be used only for equipment up to several tens of kilovolts.

While frequency spectrum of a corona discharges is below 5 MHz, the frequency spectrum of gap discharges is up to 300 MHz. Gap discharges can be located with help of narrow band measuring receiver with antenna in a frequency range from 90 to 300 MHz. While disturbing sources on high voltage lines can be located exactly such a way, it is not easy to find out the sources in substations, where they can occur at many points situated closely each other. And what is more, the manipulation with antenna in substation is dangerous.

Electromagnetic PD detector made in High voltage laboratory of EGÚ Praha [2] was tested at measurement both on various types of partial discharge models and on real epoxy transformers.

### Description of PD detector

The insulated, potential free detector of electromagnetic pulses is mounted on the top of a very light insulating 6m long laminated tube. Metal cylindrical sheet protects internal circuits of detector from strong electric and magnetic fields occurring near high voltage conductors. Detector can be approached closely to high voltage parts up to 400 kV [2]. When a high voltage metal part is touched by accident, sparking between the high voltage part and the sheet of detector (or its antenna) does not damage circuits inside.

As a sensitive part of detector, rod antennas with the active length from 1mm to 10mm are used. Sensitivity of the indication is determined by the length of antenna. Two inputs enables pulse indication in two frequency ranges:

- 3 ÷ 50 MHz for detection of surface and corona discharges,
- 50 ÷ 250 MHz for detection of gap discharges.

The output optical signal is transmitted by fiber optic cable from the potential free detector into the indicator mounted on the lower end of the tube where the optical signal is transformed to an electrical and finally to an acoustic signal.

### Detection of partial discharges in transformer oil

Partial discharges occurring in transformer oil were modeled in glass tank filled with oil. High voltage and earth electrode were immersed into the oil, see fig. 1. Types of electrodes was possible to change, so we get needle-barrier, plane-barrier and sphere-barrier electrode systems.

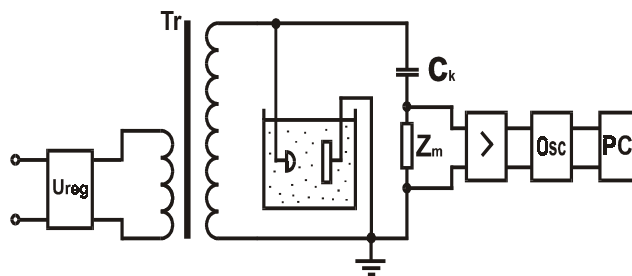


Fig.1. Partial discharges in transformer oil

The ultimate goal of experiment was to determine the ability of detector to sense electro magnetic PD signal. Measurements were carried out simultaneously with direct electrical PD detection to compare results.

The best results were obtained using sphere-barrier electrode system in transformer oil, when the inception voltage was from 6 to 12 kV in dependence on the distance

between electrode and barrier. The partial discharge magnitude was from 6000pC to 13000pC and partial discharge detector could detect discharge process very well.

The worst results were obtained using needle-barrier electrode system, when only very occasional discharges occur with magnitude of 200pC. In this case the PD detector was not very sensitive and it was very hard to locate the site of defect.

Good results were obtained when testing epoxy one phase 22kV instrument current transformer and epoxy three phase 6kV transformer. The localization of defect (cavity discharges) was very sensitive (from the discharge magnitude of 100pC) and precise. In fig. 2 there are located defect sites on one phase transformer.

Results from direct electrical measurement is shown in fig. 3. phase epoxy transformer-  $U_t=11kV$

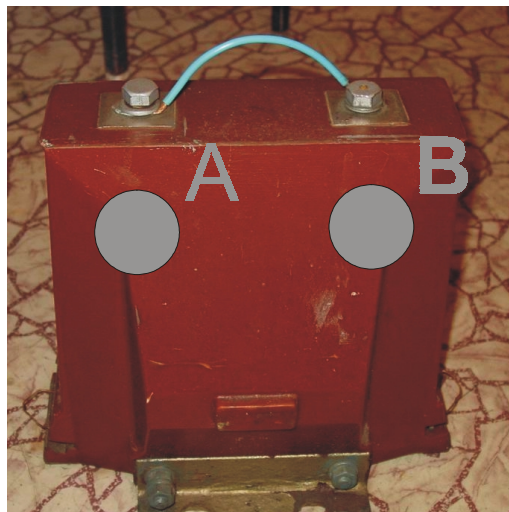


Fig. 2. PD localization on one phase epoxy transformer.

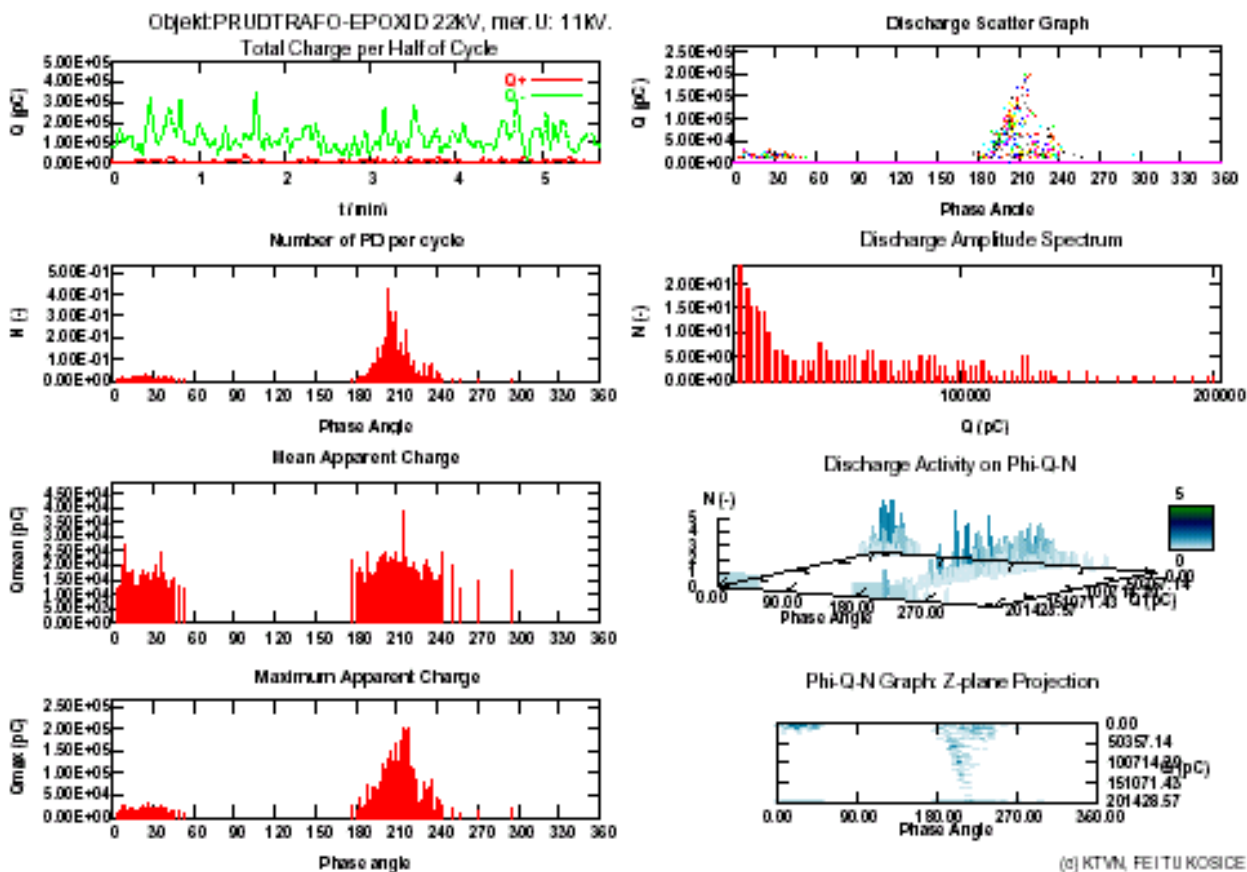


Fig. 3: Phase resolved partial discharge analysis – one

**Conclusion**

Laboratory measurements proved, that detection of electromagnetic PD pulses seems to be good tools for on-line diagnostics in electromagnetic open systems, as surge arresters, bushings, epoxy transformers. Farther measurements will be focused on field on line measurements. The results will be given in future.

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