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UHF 기술을 이용한 온라인 PD 모니터링

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On-line PD Monitoring Using UHF Technique

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Abstract : A field-oriented UHF system for on-line PD monitoring of transformers is designed, which has been installed inside the oil tank of a transformer by two ways: on-line installing mode through the oil-valve and pre-installing mode through the man hole/hand hole cover. This system has successfully captured long intermittent discharge signals that hadn't been detected through conventional techniques, and solved the problem successfully. The results demonstrate that UHF technique has great advantages for on-line PD monitoring of transformers. By adopting the peak detection technique, it becomes easy and effective for the transplantation of the phase-resolved pattern recognition technique from conventional method to UHF method, and then to realize continuous on-line monitoring, source characterization and trending analysis.

Key Words : UHF system, On-line PD monitoring, Long intermittent discharge signal

1. Introduction

The studies of UHF partial discharge detection technique mainly concentrate on the following aspects: sensor design、optimization and calibration [1-4], UHF radiation and propagation mechanism, PD source characterization [5] and fault location[6]. In addition, some researchers use UHF method as an anti-interference tool for the conventional technique. Of course, most of the researches are specially developed for GIS, but as a matter of fact, many of the above techniques can be used to transformers. In 1996, Rutgers firstly explored the feasibility of using UHF technique in transformers[7]. After that, many people made deep researches into this project, and good results is obtained both in laboratory and field practices [8-10].

As for practical use, phase-resolved pattern recognition and trending analysis are the most useful tools for UHF method, just as it is for traditional technique. But because the original UHF signal is very fast, only lasts for the magnitude of nano seconds, it is extremely hard to correlate it with power cycle. At present, people mostly fulfill this function by using the POW mode of the spectrum analyzer, but it's a rather luxury approach and inconvenient at the same time. The peak detection technique is very effective to condition the UHF signal and can accomplish the same function as SA quite easily. This paper adopts the peak detection technique in the field-oriented UHF on-line PD monitoring system of transformers, then the two practical

working instances are introduced in detail, the results indicate the effectiveness of the UHF technique and its superiority over conventional methods.

2. Design of UHF On-line PD Monitoring System

2.1 Configuration of System

The system includes two main parts: the stationary continuous-working equipment that deals with the UHF peak detection signals, and the movable instrument that analyzes the original UHF signals in time domain as well as frequency domain. The stationary equipment is a self-developed industrial PC system, which is made up of a fast DAQ card and real-time analyzing software. While the movable part is a high quality digital oscilloscope that works in "plug and play" mode. Figure 1 shows the diagram of the system configuration.

2.2 HardwareComponentsofSystem

Th hardware components mainly consist of UHF sensor、UWB amplifier with peak detection module 、RG142/U cables、high-speed DAQ card 、IPC and digital oscilloscope, the bandwidth ranges from 400 M~1500M Hz. UHF sensor is a self-compensative Archimedes antenna fed by a 50Ω coaxial cable, which is matched through a 4:1 wideband ferrite-core transformer. The gain of the amplifier is 40dB with the same working frequency band, and there're two channels output, one is the original UHF signal and the other is the UHF peak detection signal. The function of DAQ card is to sample the UHF peak detection and the reference phase signal with the max sampling rate 20MS/s per channel. The oscilloscope is LeCroy 574A model with 4GS/s single-shot sampling rate and 1GHz analog bandwidth, which is used to process the original UHF signal.

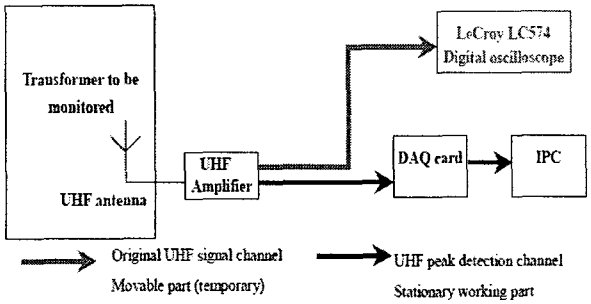


Fig. 1. Diagram of UHF PD on-line monitoring system.

2.3 UHF Peak Detection Technique

Usually in the practices of UHF, the phase information of the PD is obtained by using a SA that is set to POW mode. When considers the cost factors and the convenience reasons, the SA does not suitable to be used as a component of the stationary equipment, so the peak detection technique is adopted to condition the original UHF signals, which not only maintains the phase and magnitude info, but also lower the requirements for the digital sampling rate greatly. By doing this, the cost of the device is reduced to the maximum extent, and the traditional phase-resolved pattern recognition technique can then be transplanted to the UHF method.

3. Results and Discussion

3.1 Backgrounds

The background noises level inside the oil tank is very low (about 25mV), which is about two times lower than the outer environment (about 50mV). A stable and continual signal was found and recorded by the oscilloscope, see Figure 2. In order to find out its source, several layers of aluminum foil was wrapped onto the apertures at where the flange joints and all the signal lines were screened by a

soft spiral iron pipe, which intention is to ensure good screening of the whole measuring system. After convinced that the interferences could be totally removed by the screening, we found that the signal still exists, then the sensor was withdrawn out of the transformer, still the signal existed, so we concluded that the signals are interferences brought about by the switched power of the amplifier.

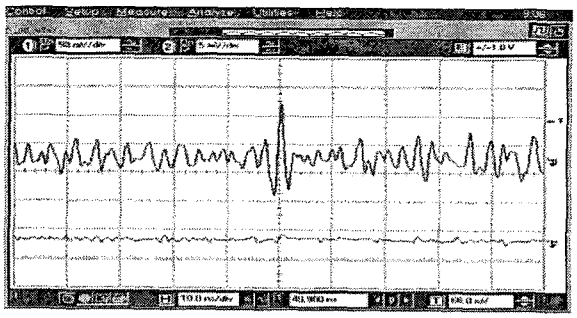


Fig. 2. Typical noise signal from the power system

During the period of monitoring, three intensive signals were captured by the measuring system. The amplitudes of the signals were about 400mV, which were much higher than that of the background noises (see Figure 3). When each signal was captured, the operations of the transformer tap changer could be excluded definitely. The time intervals between two signals were seven hours approximately. The time domain waveform of the signals indicated that they were much likely to be discharges, but it was kept uncertain whether they were generated inside the transformer' oil tank or other electrical equipments' operation coupled into the transformer from the power lines.

3.2 Site-test

As in the conventional PD test, the procedure is to apply 1.3 times of normal voltage for 30 minutes to each phase one by one. The conventional results are shown in Table 1. The typical UHF PD signals of the yellow phase are shown in Figure 4. It shows that the background of the manhole antenna is about 30mV, while the PD signal is approximately 150mV. Besides, each time the waveform of the signal almost keeps the same, which indicate that it is a monotype discharge. The case of the hand hole antenna is analogous as the manhole antenna, but the signals are much smaller. Because the signals become steady and low in a few minutes, we conclude that it is gas cavity discharge in oil or corona discharges on small conductor burrs which soon be melted down by the PD energy. The results demonstrate that the sensitivity of the UHF system is high enough to detect very small discharges in transformers.

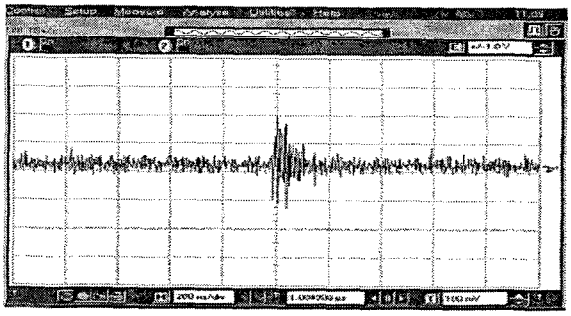


Fig. 3. Typical suspicious discharge signal

Table 1. Apparent discharges recorded with conventional method

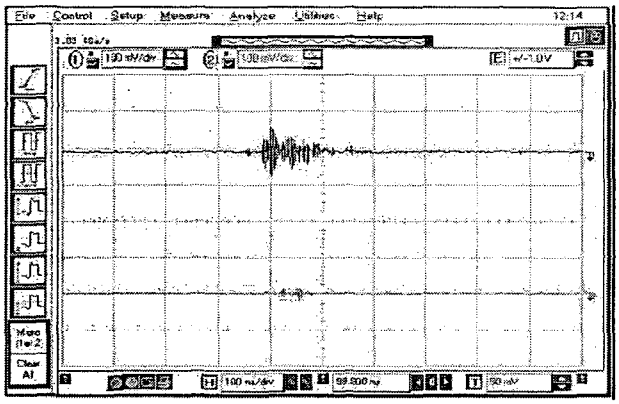
Apparent charge (pC)	Applied Voltage (kV)	Yellow phase	Blue phase	Red phase
Maximum	189	2,000	800	1,200
Steady	189	100	130	110

4. Conclusions

The practical applications in field demonstrate that the UHF technique is very effective for on-line monitoring and site testing. By putting the UHF sensor inside the

transformer tank, both high sensitivity and anti-interference characteristics can be achieved at the same time, which are the most advantages of UHF over conventional methods. Peak detection technique makes it easier and cheaper for UHF method to import conventional phase-resolved pattern recognition technique and trending analysis, which makes it more practicable for on-line utilization of UHF technique.

Fig. 4. Typical PD signals from Manhole and hand hole antenna when the yellow phase is energized



[Acknowledgement]

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