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UHF 기술을 응용한 전력용 변압기의 PD 모니터링

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PD Monitoring of Transformer Using UHF Technique

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Abstract - 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.

1. Introduction

The studies of UHF partial discharge detection technique mainly concentrate on the following aspects: sensor design、 optimization and calibration [1], UHF radiation and propagation mechanism, PD source characterization [2] and fault location[3]. 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[4]. After that, many people made deep researches into this project, and good results is obtained both in laboratory and field practices [5].

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. Experiment

The 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 400M～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.

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. Result and Discussion

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.

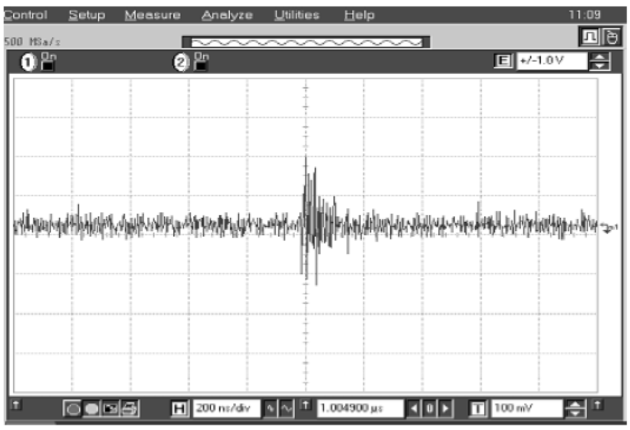

Fig. 1. Typical suspicious discharge signal.

The transformer had been inspected disassembly, and a $7\times7mm^2$ cavity defect was found in the yellow phase bushing's ceramic cone of the 110kV side, which is 250mm away to the equalizing ball at the bottom. There're black carbon trails in the vicinity of the cavity, which indicates that it's the possible discharging spot. After the inspection, the suspicious bushing was replaced, and the acetylene content is keeping low and steady for 3 months of services since then.

So we conclude that the discharging in yellow phase bushing of 110 kV is the right cause of high level of acetylene of the transformer. This application successfully detected the long intermittent discharges and avoided a potential accident, so it demonstrates the advantages of the UHF on-line monitoring technique.

In the inspection period of the transformer, a manhole sensor and a hand hole sensor are designed and pre-installed permanently onto the oil tank, and all the wires and cables are screened with metal pipe. In the on site PD test before the transformer was put into service, we did experiments with both the UHF system and conventional PD method at the same time, and the current pulse signals and UHF signals were recorded synchronously for comparison studies. During the experiments the maximum UHF signal was saved and set as the threshold of warning when the transformer was in the normal service state. The power spectrum of the UHF by FFT can be compared with those obtained in the laboratory, so as to get the source type information.

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 2. 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.

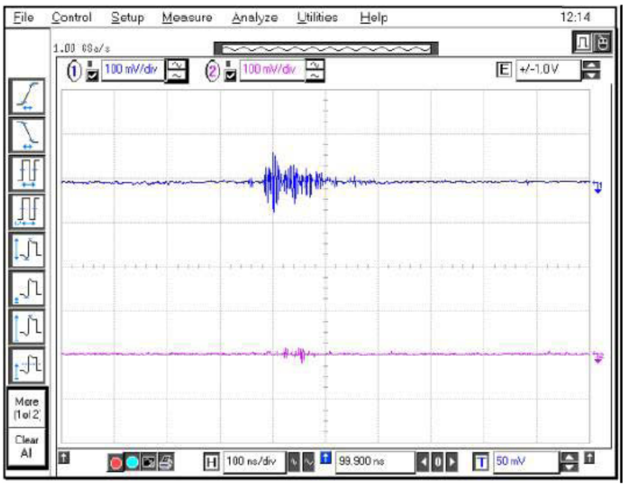

Fig. 2. Typical PD signals from Manhole and hand hole antenna when the yellow phase is energized.

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. Conclusion

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.

[Acknowledgement]

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