部分放電監視で観測された部分放電信号の持続特性

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The Sustained Property of Partial Discharge Signal Observed by Partial Discharge Monitoring

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キーワード：部分放電、監視、時間持続特性

1. Introduction

Conventional insulation diagnostics focus on the ageing condition of whole insulation system rather than the defects inside the material. Among diagnostics on insulation defects, on-line partial discharge measurement (PDM) is the most effective insulation diagnostics.

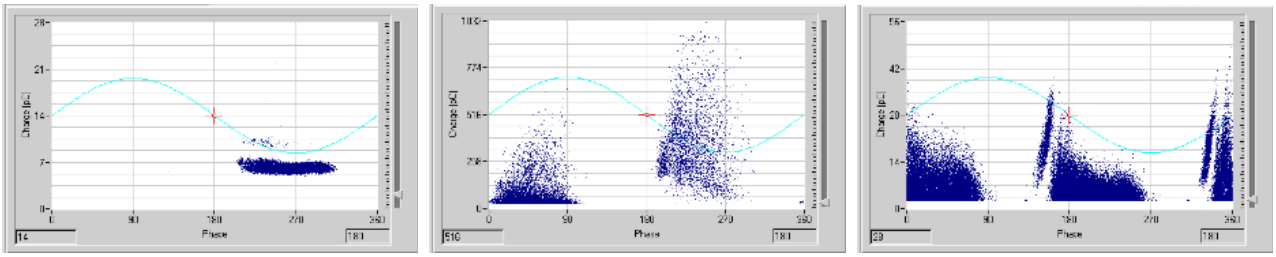
As interfered by background noise, de-noise algorithm is required to eliminate the interference of background noise for on-line PDM. Moreover, different defects will induce different types of partial discharge behaviors, and some background noise and external discharge phenomena have similar properties as internal discharge does. Therefore, the precise interpretation of measured results mainly relies on the understanding and experience of the experts. Hence, the interpretation of on-line PDM is inconvenient for the customers who don't familiar to partial discharge phenomenon.

According to the field observations, it is concluded that the "real" partial discharge signals, which is induced by the internal discharge, will sustained till the insulation breakdown or power outage, and the signal intensity will be relatively stable as time goes by. Oppositely, the "fake" partial discharge signals, which are caused by the external discharge or unknown noise, will appear intermittently and the signal intensity will varies dramatically. In other words, the "real" partial discharge signal shows time-independent property, and the "fake" partial discharge signal shows time-dependent property.

Therefore, a partial discharge monitoring system adopting the above-mentioned principle is designed, and is installed to the field. By the field examination, the partial discharge signals caused by the insulation defects show stable intensity and similar phase-resolved partial discharge (PRPD) pattern, and other signals don't have such properties. Hence, the sustained properties of partial discharge signals will make it easy to distinguish partial discharge signals from background noise.

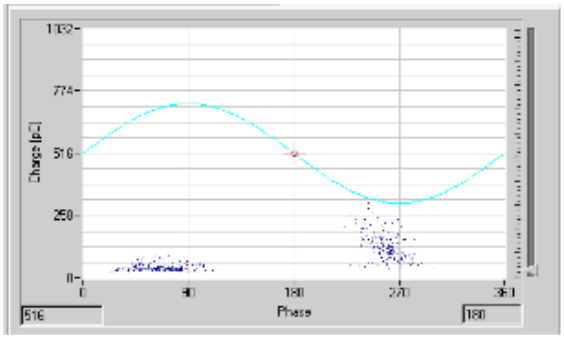
2. Field Observation of Periodic on-line PDM

Typical PRPD patterns of partial discharges are shown in Fig. 1. Corona discharge is a special case of partial discharge, and it is easy to be identified. However, surface discharge and internal discharge are not easy to be distinguished from each other. In laboratory, surface discharge and internal discharge can be recognized by varying test voltage. As shown in Fig. 2, the PRPD patterns of surface discharge will change at different test voltages, and the PRPD patterns of internal discharge won't charge at different test voltages. However, the system voltage is restricted to certain value, and the distinction between surface discharge and internal discharge can't be done by voltage property. Then, other partial discharge measurement instrument is necessary for the distinction between surface discharge and internal discharge, such as airborne ultrasound sensor.

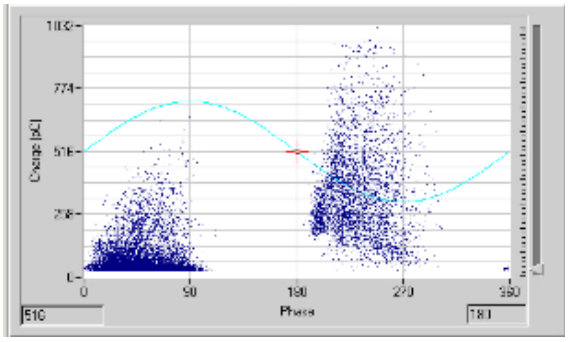


(a) Corona Discharge　　(b) Surface Discharge　　(c) Internal Discharge

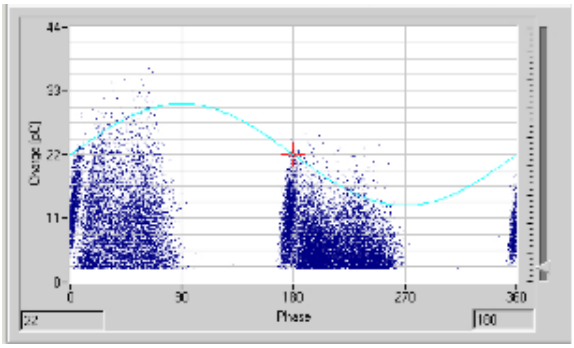
Fig. 1　Typical PRPD pattern



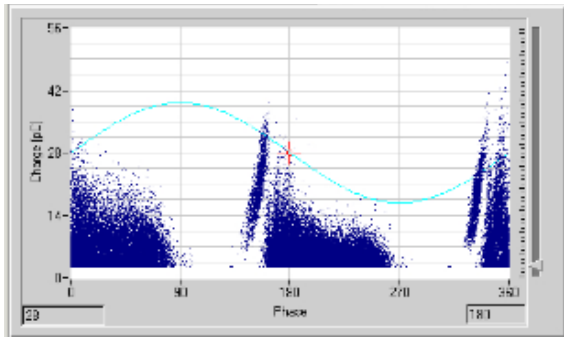
(a) Surface Discharge @ 3 kVRMS



(b) Surface Discharge @ 6 kVRMS



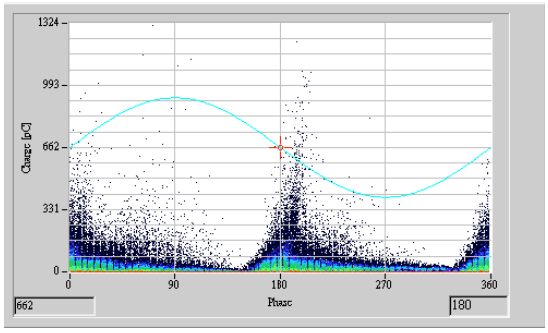
(c) Internal Discharge @ 3 kVRMS



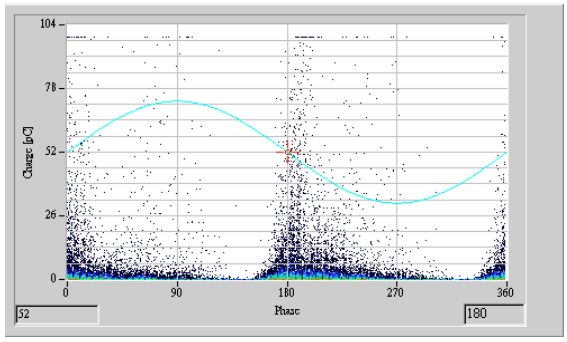
(d) Internal Discharge @ 6 kVRMS

Fig. 2 PRPD Pattern at Different Test Voltage

According to extensive field experience, the PRPD patterns of internal discharge at different dates would be similar and the signal levels of those would also be almost constant. As illustrated in Fig. 3, the 1st measurement and the 2nd measurement (6 months later) have similar PRPD patterns and signal levels. Contrary to internal discharge, the PRPD pattern and the signal levels of surface discharge and background noise will alter at different dates. As shown in Fig. 4, the PRPD pattern of 1st measurement indicated that it might be internal discharge, and the 2nd measurement (2 months later) showed that there was no partial discharge phenomenon.



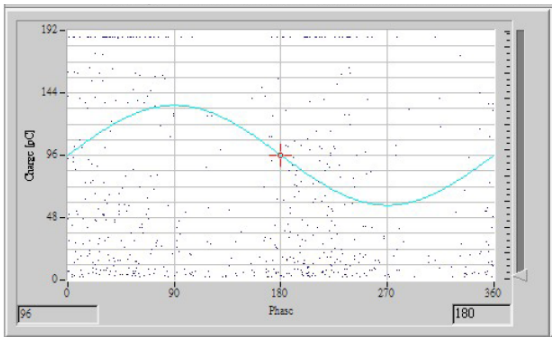
(a) 1st measurement



(b) 2nd measurement (6 months later)

(the reading of Y should x 10)

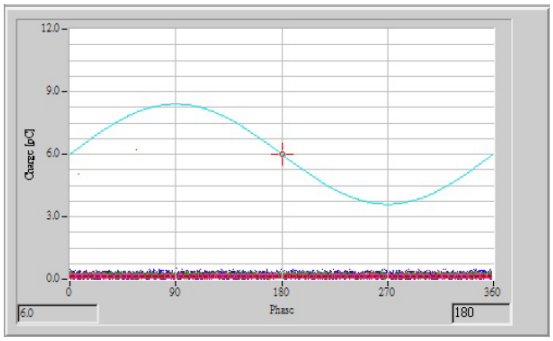
Fig. 3 PRPD patterns of internal discharge at different dates



(a) 1st measurement

Fig. 4 PRPD patterns of surface discharge at different dates

(to be continued)



(b) 2nd measurement (2 months later)

Fig. 4 PRPD patterns of surface discharge at different dates (continued)

3. Field Observation of PD Monitoring

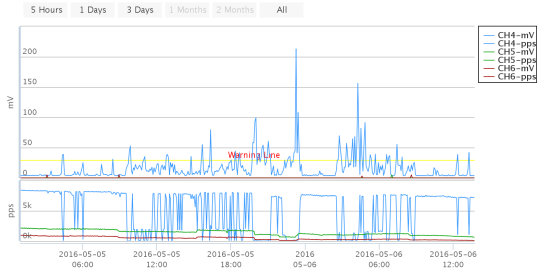
Based on the field observations, one simple partial discharge monitoring device is designed, named as PDSimply. PDSimply records the trend of signal level and the pulse number per second. The partial discharge monitoring system, called as PDCare, adopts PDSimply as the data acquisition device. Up to now, there are more than 6000 units monitored by PDCare, and the units types are transformer, switchgear, generator, gas-insulated switchgear, ant etc.. The measured data are compared with previous observations.

- Noise Interference

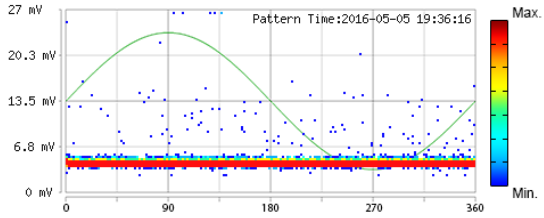
Fig. 5 shows the property of noise interference. From Fig. 5(a), once unknown signals appeared, the signal levels (mV) vary largely, and the amount of pulse number (PPS) is large and changes quickly. Based on field experience, the random signal level and pulse number is the main characteristic of noise. From Fig. 5(b), the phase-independent PRPD pattern confirms that the measured signal is noise.

- Corona Discharge

Fig. 6 shows the property of corona discharge. From Fig. 6(a), once corona discharge occurred, the signal levels (mV) vary with time, and the amount of pulse number (PPS) is large and changes quickly. Based on field experience, the unstable signal level and high pulse number is the main characteristic of corona discharge. From Fig. 6(b), the cloud-like PRPD pattern confirms that the measured signal is corona discharge.

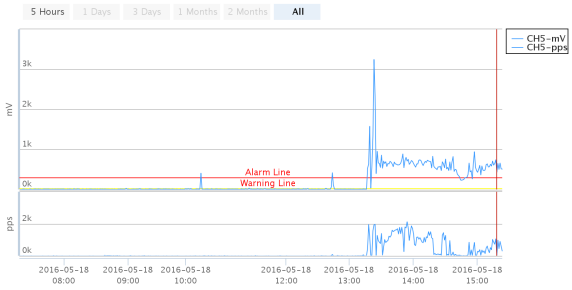


(a) Trend of Signal Level

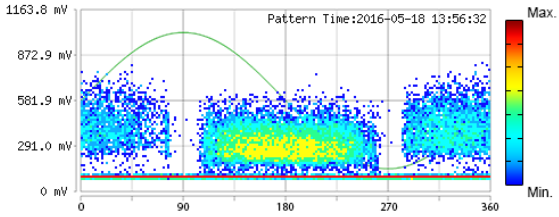


(b) PRPD Pattern

Fig. 5 Noise Interference



(a) Trend of Signal Level

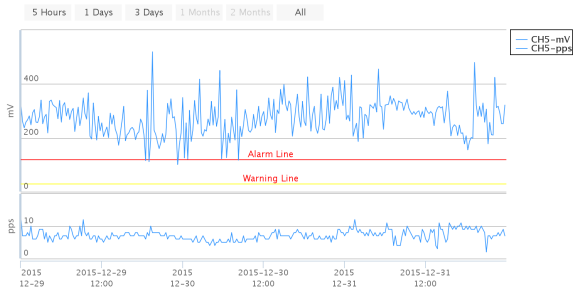


(b) PRPD Pattern

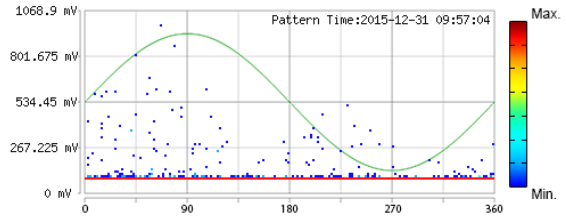
Fig. 6 Corona Discharge

- Surface Discharge

Fig. 7 shows the property of surface discharge. From Fig. 7(a), once surface discharge occurred, the signal levels (mV) oscillate, and the amount of pulse number (PPS) is small. Based on field experience, the unstable signal level and low pulse number is the main characteristic of surface discharge. If the interpretation is made only by PRPD pattern (shown in Fig. 7(b)), it could be concluded as surface discharge or internal discharge. In general, the recognition could be done by means of the airborne ultrasound instrument.



(a) Trend of Signal Level



(b) PRPD Pattern

Fig. 7 Surface Discharge

Actually, the signal level of surface discharge won't be sustained for long period, and this could be easily observed from the monitoring system as shown in Fig. 8. The signal only survived for one week, and the signal level is unstable in the view of long period. Therefore, the distinction between surface discharge and internal discharge would be done by analyzing the trend of the signal levels.

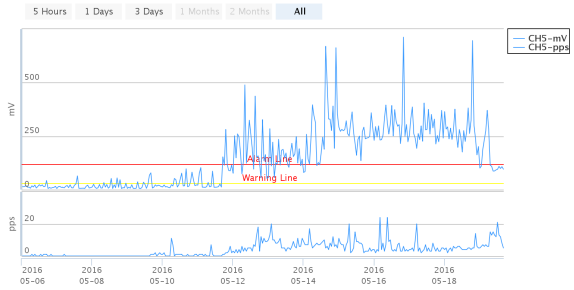
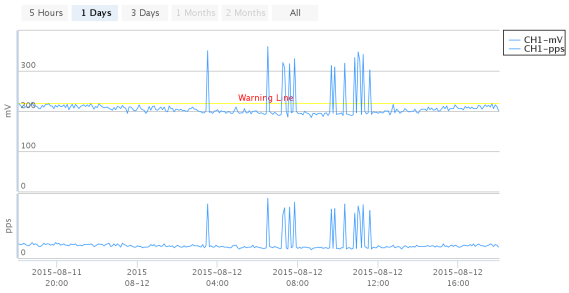


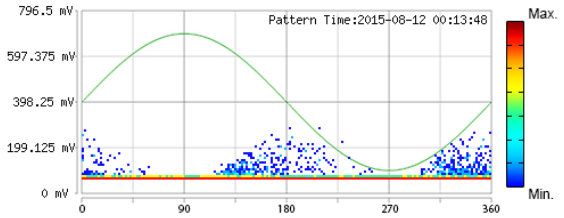
Fig. 8 Long time trend of signal level of Fig. 7

● Internal Discharge

Fig. 9 shows the property of internal discharge. From Fig. 9(a), once internal discharge occurred, the signal levels (mV) are almost constant, and the amount of pulse number (PPS) is usually in the range of several tens. Based on field experience, the stable signal level and medium pulse number is the main characteristic of internal discharge.



(a) Trend of Signal Level



(b) PRPD Pattern

Fig. 9 Internal Discharge

In field, if only PRPD pattern (shown in Fig. 9(b)) is measured, it could be classified as surface discharge or internal discharge, and other measurement should be done to identify the type of discharge. Actually, if the trend of signal level were measured, it would be easily separated from each other.

4. Conclusion

Up to now, on-line PDM is the most effective insulation diagnostic, and the necessary of extensive field experience and analysis skill restrains its application. Based on the field observation, the sustained property of partial discharge phenomenon is analyzed, and is summarized in table 1.

Above mentioned properties is used to be the main principle of partial discharge monitoring system (PDSimply and PDCare), and more then 6000 units are monitored by PDCare. Based on the field experience of PDCare, different types of partial discharges have different properties of signal level and pulse number, and it is coincided with the field observation of periodic on-line PDM.

Therefore, the sustained properties of partial discharge signals are confirmed, and it could be used for the interpretation of partial discharge measurement.

Table 1 Typical Sustained Properties of Partial Discharge Signals

	Noise Interference	Corona Discharge	Surface Discharge	Internal Discharge
Signal Level (mV)	Random	Unstable	Unstable	Constant
Pulse Number (PPS)	Random	High	Less Than Ten	Tens