Analysis of Anti-interference for HV Capacitor PD Measurement at DC

Liu Huachang, Yu Chenglong

HIMALAYAL - SHANGHAI - CHINA

Abstract: In order to reduce the effect of interference and improve the anti-interference performance in HV capacitor PD test at DC, the paper presents the analysis of interference existing in the test circuit from the aspects of generation mechanism, reason, source and category. After taking anti-interference measures including adding isolating transformer, filter and independent earth wire, the input voltage waveform gained by oscilloscope is more smooth. The Q/N curve also indicates that the number of discharge reduces and the noise amplitude becomes smaller.

Key words: Partial discharge (PD), interference, anti-interference, capacitor

Introduction

The PD signal in the HV capacitor PD measurement at DC is weak and the interference signal often affects test results.

1. Mechanism of PD and Interference Source

The PD is caused by uneven electric field and electric media, bubbles, impurities and corrosion, thermal cracking, moisture of insulation etc. The PD mechanism is based on the electron-collision ionization theory. In the electric field, the speeding free electrons collide with neutral molecules. The kinetic energy of electron is high enough to make neutral molecules stimulate electrons, forming new free electrons and ions. Thus, the electron avalanche generates. The model of air gap discharge in the medium is shown in Fig.1.

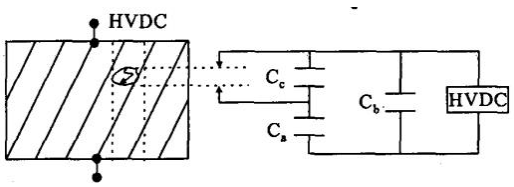

Fig.1. Model of air gap discharge in the medium

There are a variety of interference sources in the PD test. They can be classified into interference from electric grid or space according to the type; fixed or stray interference according to pattern of manifestation. According to whether to connect testing power supply, the interference can be divided into the following: ① interference which is not related to test equipment and circuit, such as weather, radio, electromagnetic radiation of HV test device,

interference generated by fluorescent lamp and air-conditioner, interference from motor and industrial equipment or generated by relay, contactor action and so on. ② interference related to test equipment and circuit, such as power supply line, corona discharge, transformer, coupling capacitor's PD, contact noise in the sample, poor grounding etc.

In fact, the first category of interference is called radiation interference. Its interference signal's frequency spectrum is generally broad and has a great impact on the PD measurement. The intensity of secondary one is uncertain and varies according to the test voltage. Hence, if the test equipment has partial discharge, it will reflect on the tester.

2. Test Circuit and Anti-interference Measures

The test is carried out in the HV shielding lab; the test circuit uses the oscilloscope and PD tester record PD signal's impulse waveform and statistic characteristics respectively. The digital oscilloscope can be connected with the computer via GPIB. The waveform can also be stored to the floppy disk. The test wiring is shown in Fig.2.

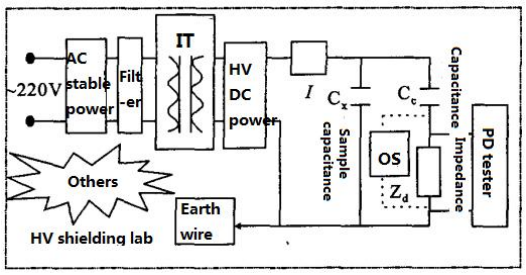

Fig.2 PD discharge circuit

The PD tester obtains the electric impulse from two ends of Z_d. The signal line should be as short as possible to reduce attenuation and distortion during the process of transmission. Fig.4 presents the discharge impulse waveform. It is found that the signal has the vibration. The reason may be that there is the inductance in the line coupled with stray capacitance. Therefore, selection of Cc and Z_d should be based on the capacity of Cx.

The test is conduced in the HV shielding lab and external electromagnetic interference is relatively small but the on-site interference is inevitable. In order to eliminate or restrain such interference and ensure the reliability and flexibility of measurement, the following measures are taken:

1) Effective measures are taken to eliminate the interference from measuring circuit: ① In the test, the maximum test voltage is 10kV and the 20kV no-corona HVDC power supply is selected as the test power supply; the wide margin remains to guarantee no discharge at the side of test power supply, and the same goes for the coupling capacitor. ② It is easier to cause electric field concentration at the joint between the wire and equipment or sample; if the connector can be used to connect, the wire is welded on the connector. ③ The test circuit grounding adopts independent earth wire and grounding resistance should be as low as possible to avoid interference. Although the earth wire is zero potential, improper treatment still causes the field strength to be strong, thus leading to discharge

interference; the test equipment is compactly connected with the circuit to reduce the dimension of test circuit as much as possible. The connection wire and element form the arc in order to reduce the corona discharge. ④ Other equipment and objects around the test site should be far away from the test site and reliably grounded to prevent the floating discharge interference. Through the above measures, the voltage is boosted to 2kV. The quantity measured from the PD tester changes a little compared with the one without the boosting of voltage. Within the range of voltage corresponding with more than 1.8pC, the discharge impulse is rarely seen at the oscilloscope, which indicates that dealing with the circuit meets the requirement of test.

Try your best to restrain the interference introduced from power supply, measuring instrument and the outside world and make the most of functions to reduce the level of interference: ① Add filter and isolating transformer between AC and HVDC power supply to reduce the power frequency interference and discharge pulse generated by AC stabilizer; after adding isolating transformer, the waveform output by AC power supply improves a lot. ② select the suitable resistance as the protection resistance. If the resistance value is too great, it is likely that the voltage on the sample is affected; if the value is too small, it cannot play the role of protection. It should meet the following requirement: $R \geq (U_{omax}-U_{imax})|Zd|/Uimax$ (U_{omax}: maximum test voltage; U_{imax}: the allowable maximum input voltage of oscilloscope). ③ The PD tester and oscilloscope obtain the signal respectively at the different time to reduce the mutual interference. When they obtain the signal at the same time, even if not boosting the voltage, the quantity of PD displayed at the PD tester increases obviously. ④ Use the oscilloscope's build-in low-resistance filter function to restrain the low-frequency interference; Fig.3 shows discharge waveform at different different setting.

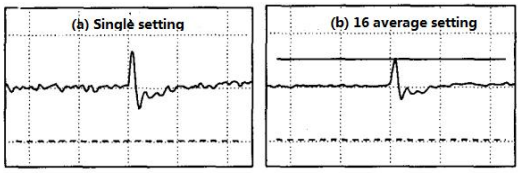

Fig.3 Output waveform at different sampling setting

3. Comparison of Interference before and after Improvement

The test capacitor is the same; the calibration charge is 5pC and the measuring band width is 10~300kHz. The time window selects the same one; the HVDC power supply starts but the voltage is not applied; the discriminate time is 60s. Before improvement: no filter, isolating transformer and earth wire. After improvement: adding filter, isolating transformer and earth wire. Through the comparison, the number of PD generated by background interference at the same quantity of discharge is less than the one before improvement. To facilitate observation, the comparison curve between Q (Discharge quantity) and N

(Number of discharge/s) is drawn (See Fig.4.)

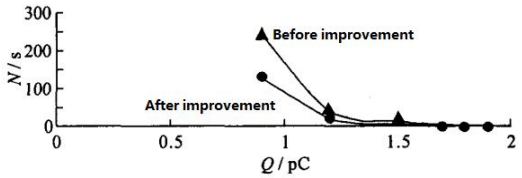

Fig.4 Comparison curve of Q,n before and after-improvement

What's more, the PD tester is replaced by the oscilloscope and background noise waveform is also measured before and after anti-interference (see Fig.5).

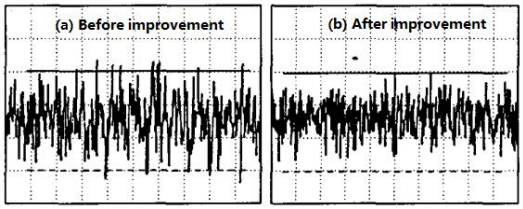

Fig.5 Background noise before and after anti-interference improvement

4. Conclusions

Anti-interference measures including adding isolating transformer, filter and independent earth wire can reduce the number of discharge and noise amplitude greatly in the HV capacitor DC PD measurement.