Application of Serial Resonant in the Electric Test

Gang Li

HIMALAYAL - SHANGHAI - CHINA

Abstract: Serial resonant withstand voltage test uses reactor inductance and test equipment to generate serial resonance, obtaining high voltage and large current from test objects. Main tuning methods are variable inductance and variable frequency. The variable inductance adopts reactor with adjustable core air gap. Adjusting the inductance value makes circuit in power frequency resonant condition. Besides loud noise and complicated mechanical structure, the device is so heavy that it is difficult to carry. The variable frequency adopts the capacitor with fixed inductance, and adjusting exciting power source makes test circuit reach resonant. With small volume, light weight and high quality factor, it is easy to use and is gradually taking place of variable inductance.

Key Words: Serial, Resonant, withstand Voltage, Test

Serial resonant is resonant current filtering circuit, which can improve the waveform distortion of power voltage, obtain excellent sinusoidal voltage waveform and effectively prevent harmonic peak from damaging test objects. In serial resonant condition, when breakdown of insulation weakness of test objects occurs, the circuit detunes and loop current reduces into one tenth of normal test current \((1/Q)\) immediately. However, breakdown current rises ten times in a minute if adopting shunt resonance or test transformer to conduct voltage withstand test. There is hundredfold difference in breakdown current through comparing both. Therefore, withstand voltage of serial resonant not only effectively locates insulation weakness but also is free of burning fault points due to short circuit current. When the breakdown of flashover occurs, because of losing resonant condition, the high voltage disappears and arc extinguishes immediately besides reduction of short circuit current. In addition, it takes longer time to rebuild resonant voltage and it is highly possible that exciting power cuts off before reaching flashover voltage again. The voltage restoration waveform is an interval oscillation process of energy-accumulating. Its process is long and restoring over-voltage will never occur.

1. Application of Serial Resonant in the Cable Test

Cables are applied in urban and rural network in large quantities and often break down. In order to ensure safe operation of cross-linked cables, the State Grid set a new regulation for handover and preventive test that original DC voltage withstand test should be replaced with AC voltage withstand test to prevent DC test from damaging cables. Operation experience proves that many cables operate well in DC voltage withstand test according to GB50150-91. However, soon after
cables are put into operation, insulation breakdowns tend to occur and cables in normal operation are sometimes damaged by DC voltage withstand test. Because its electric field distribution conforms to actual operation situation, AC voltage withstand test is the most effective way for cables. In order to facilitate AC withstand voltage test on site, variable frequency resonant equipments is recommended. According to IEC517 and GB7674, 30-300HZ AC voltage is almost equivalent to power frequency voltage.

2. Application of Serial Resonant in the Transformer Test

The AC voltage withstand test plays a decisive role in measuring main insulation strength of transformers and inspecting local defects. The AC test can effectively find main insulation of winding being moistened and cracked, or loosened and shifted because of vibration during the transportation, resulting in conditions such as insufficient lead distance as well as winding insulation covered with dirt etc.

AC voltage withstand test must be conducted after transformers are fully filled with qualified insulating oil and are kept for a certain time.

Goals of induction withstand voltage test are as follows. The first goal is to inspect longitudinal insulation of complete insulation transformer (winding between layers, turns and disks); the second goal is to inspect main insulation and longitudinal insulation of graded insulated transformer (main insulation refers to winding to earth, between phases and windings of different voltage grade).

The AC applied voltage test of power transformer just measures electric strength of main insulation of transformer but longitudinal insulation doesn't bear voltage, so withstand voltage test is also necessary. For many large and medium 110 and 220kV transformers, its neutral point is 35kV and 110kV. This kind of product is called neutral point grade insulation or semi-insulation transformer. Its voltage between windings and earth insulation increase from terminal to head, which needs to be applied different voltage. Main insulation test of power transformer with graded insulation cannot adopt the mode of general external applied high voltage but adopt induction withstand voltage test.

3. Application of Serial Resonant in the GIS System

After the GIS is assembled as a whole in the factory, an adjustment test is carried out. If qualified, it will be transported to installment site in transportation unit. Mechanical vibration or collision during the transportation may cause GIS elements or fasteners in assembly parts to loosen or shift relatively. During the installation, failure in dealing with technologies such as connection and sealing etc leads to electrode surface scraped and installation dislocation, resulting in electrode surface defect; it is difficult to inspect dust in the air, impurities of conductive particles and burr on the installation site, which will bring about insulation fault. Due to limited equipments and conditions, most of earlier GISs don't conduct strict on-site withstand voltage test. Fault statistics shows that although it is not guaranteed that insulation fault GISs,
which have undergone on-site withstand voltage test, won’t occur during the operation. However, GISs without on-site withstand voltage test break down in most cases. Hence, in recent years, it has been acknowledged widely both at home and abroad that GIS must conduct on-site withstand voltage test.

GIS on-site withstand voltage adopts test devices such as AC voltage and lighting impulse voltage with oscillation etc. The AC withstand voltage test, the most common method of GIS on-site withstand voltage test, can effectively inspect abnormal structure of electric field, such as electrode damage. At present, only DC withstand voltage test is conducted on site because of limited equipments and conditions.

According to IEC517 and GB7674, test voltage frequency within the range of 10-300HZ is almost equivalent to power frequency voltage test. At present, variable frequency serial resonant device is mostly adopted to conduct GIS on-site AC withstand voltage test at home and abroad.

3.1 Test Requirements

3.1.1 GIS should be installed well; SF6 inflates to a rated density; complete measurement of contact resistance of main circuit, test of elements and test of micro-moisture content and leak detection of SF6. Short circuit of secondary winding of all current transformers is grounded and open circuit of secondary winding of voltage transformers is grounded.

3.1.2 Before the test, following devices should be separated from GIS:
- High voltage & overhead line

- Power transformers & most of electromagnetic voltage transformers (If withstand voltage device of variable frequency serial resonant is adopted, calculation of test circuit based on frequency does not cause magnetic saturation. In addition, withstand voltage standard is the same and can also conduct the withstand voltage test with main circuit.)

- Arrester & spark protection gap

3.1.3 Each newly-installed part of GIS should conduct the withstand voltage test meanwhile expanded parts need to be withstand voltage with original parts of adjacent devices being powered off and grounding. Otherwise, sudden breakdown will impose a negative impact on original devices.

3.2 Method of Raising the Test Voltage

Test voltage is applied to the place between each phase conductor and shell in one phase one time manner while other non-test conductor should be connected with grounded shell. The test voltage is usually applied through in-out lines bushing and each part of GIS should be applied at least one time during the test. Meanwhile, to prevent one part from bearing voltage many times and causing insulation aging, test voltage should be applied among several parts respectively. Only relative AC voltage test is conducted on site. If disconnector fracture of circuit breaker is damaged during the transportation and installation or disintegrated, fracture withstand voltage test must be conducted and withstand voltage value and relative AC withstand test value can be the same. If the whole capacity is
large, withstand voltage can be conducted in segments.

3.3 Procedure for the AC Withstand Voltage Test
The first phrase of GIS on-site AC voltage test is "complete purification", aiming to eliminate conductive particles or non-conductive particles which may exist in the GIS. These particles may be brought into and are not completely removed or are metal fragments after many operations, or they are formed of cutting debris of fasteners and burr on the electrode surface. The "complete purification" can drive conductive particles shift to low voltage field or shift burrs in the particles and electrode surface, preventing them from damaging the insulation. The voltage value of "complete purification" should be lower than withstand voltage value while the time should last several minutes. In summary, as for test objects, whose capacity varies within certain range, adding compensation capacitors and combining several reactors can keep resonant frequency within the power frequency range. Because volume and weight of variable frequency serial resonant devices and demanded power source capacity are much less than test transformer, adopting variable frequency serial resonant devices rather than traditional withstand voltage devices can largely reduce the field test workload.

REFERENCES