Application of Resonant Technology in the XLPE Cable Test

Wang Jun

HIMALAYAL - SHANGHAI - CHINA

Abstract: Due to many advantages of cable including strong capability of load and small line loss, it has been widely used. According to the requirement of new regulation, only the AC test is conducted for the XLPE cable. The paper presents the application of resonant technology in the cable test.

Key words: Variable frequency resonant, XLPE cable, test

1. Application and Superiority of Variable Frequency Resonant

The variable frequency resonant test is mainly used for conducting the on-site AC dielectric test for electric equipment with large capacity, including medium-low voltage, high voltage and ultra-high voltage XLPE, GIS, motor stator, large-sized transformer and electric capacitor.

It is best to use the power frequency to carry out the AC dielectric test for the above-mentioned electric equipment. However, the capacitance of test object is large and the power that needs to provide for test equipment is so big that the on-site inspection is cannot made. The variable inductance series resonant test is only used for dielectric test of generator stator. In the 1970s, the foreign electric sector found that the DC dielectric test did not work for rubber and plastic insulation and is hazard. Practice and research has proved that the DC dielectric test cannot effectively detect some defects under the role of AC voltage such as mechanical damage within the cable accessories. By adopting the ultra-low frequency (0.1Hz) AC test method, the volume of equipment is smaller but it has limitations. First of all, at present semi-electronics semi-mechanical mode to produce the 0.1Hz frequency and the output waveform cannot reach the sine square wave with good equivalence; secondly, the test time requires 1h and the working efficiency is very low; meanwhile, the super-low (0.1Hz) dielectric test is only applicable to XLPE cable and cannot meet the requirements of main insulation test for UHV cable.

2. Components of Series Variable Frequency Resonant System

The series variable frequency resonant system is to change the system inductance and test frequency to make circuit in resonant condition. Its electric circuit is shown in Fig.1. The adoption of variable frequency

resonant technology reduces the capacity of power source and the weight of equipment, which facilitates on-site test.

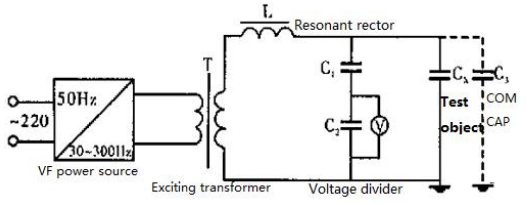

Fig.1 Wiring of series variable frequency resonant test

(1) Variable frequency power supply: frequency 30~300Hz adjustable, 5, 10, 20 and 50kVA.

(2) Exciting transformer: used for providing the energy for inductance and capacitance resonant system; the characteristic is that the iron core of transformer can be applicable to voltage response at broad frequency. Specifications are 5, 10, 20 and 50kVA etc.

(3) Resonant reactor: used for capacitance resonant of the same test object to get the reactor with high voltage (or high current). Specifications are 30H/20kV/2A and 40H/40kV/3A. The number of reactors can be equipped based on the actual demand (from 1 to 3).

(4) Capacitance voltage divider: used for precisely measuring the voltage applied on the terminal of test object.

(5) Compensation capacitor: Because the capacitance of large-sized transformer and motor is very small, the compensation is needed to increase capacitance to ensure resonant frequency within the range. However, it is not necessary for the cable test.

3. Notice for On-site Usage

3.1 Preparations before use

Learn some information about XLPE cable, including voltage level, length and section area and look up the capacitance (uF/km) and calculate the total capacitance. For instance: 8.7/10kV, 300mm^2, 5km. And it is found that the capacitance per km is 0.37uF. C=5×0.37uF/1km=1.85uF.

According to the cable specification, you can get the required test voltage. Take 8.7/10kV cable as an example:

$U_{test}=2U_0=2\times1.8kV=17.4kV$

When the resonance is at very low frequency, the test current is low (I=2πfCU). According to that principle, the resonant frequency is estimated. The reactors are in series and the inductance increases, which is suitable for short cable. The reactors are in shunt and the inductance decreases but the withstand voltage remains the same. That is right for long cable.

$$f_o=\frac{1}{2\pi}\frac{1}{\sqrt{LC}}$$ L=10/3=3.33H

$$f_o=\frac{1}{6.28}\frac{1}{\sqrt{3.33\times1.85}}=64.156Hz$$

Estimate the test current value to determine whether the reactor and exciting transformer can withstand 12.969A (I=2πfCU=6.28×64.156×1.85×10^{-6}×17.4×10^3).

If both requirements are met, the test

can be carried out as planned.

3.2 Wiring methods of series variable frequency resonant system test

There are three kinds of wiring methods:

(1) Wiring of test object with large capacitance: the length of cable ＞ 3km see Fig.2.

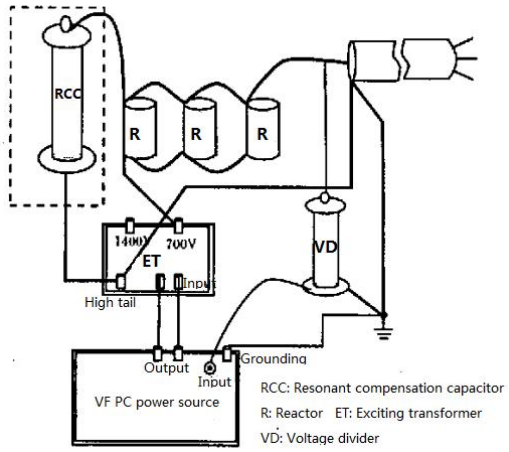

Fig.2. Wiring of three parallel reactors, low voltage and long cable test

(2) Test wiring of test object with medium/small capacitance: the length of cable ≈1km, see Fig.3.

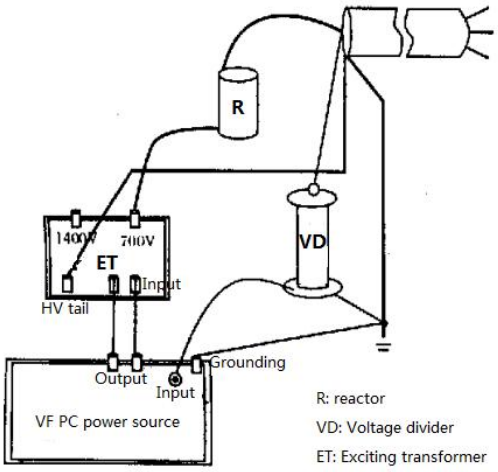

Fig.3 Wiring of single reactor, low voltage and medium/short cable test

(3) Test wiring of test object with small capacitance or HV test object (≥35kV), see Fig.4.

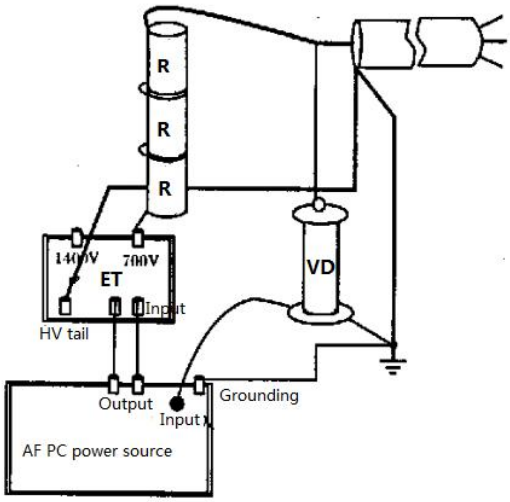

Fig.4 Wiring of three series reactors and short cable or HV cable test

From the Fig.2 to Fig.4, the bold line represents main circuit of current while thin line for the measuring circuit. The compensation capacitance in the dotted line plays a role if necessary. Keep in mind that unfasten and clean the tail end of cable and keep the insulation distance.

4. Conclusions

Compared with traditional power frequency and variable inductance resonant (50Hz) test method, the application of variable frequency resonant technology in the XLPE cable test just begins and it has broad prospect.