AC RESONANT TEST SYSTEMS

AC Resonant Test Systems are especially valuable in any application where the load is largely capacitive with low loss such as power cables, gas-insulated switchgear, generator windings, and dry testing of insulator strings.

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Resonance is defined as the condition at which the net inductive reactance cancels the net capacitive reactance. The resonant circuit must have both capacitance and inductance. (In addition, resistance will always be present due either to the lack of ideal elements, or the control offered on the shape of the resonance curve.)

When resonance occurs, the energy absorbed at any instant by one reactive element is exactly equal to that released by another reactive element within the system. In other words, energy pulsates from one reactive element to the other. Therefore once the system has reached a state of resonance, it requires no further reactive power since it is self-sustaining. The total apparent power is then simply equal to the average power dissipated by the resistive elements.

The average power absorbed by the system will also be at a maximum at resonance. The commonly used measure of the quality in a resonant circuit is the quality factor, or Q. The power source of resonant circuits operating in the resonant mode (exciter and regulator) is used to supply the dissipated energy. Q is approximately equivalent to the ratio of the output kVA to the input kVA. Given kVA requirements of the load and the Q of the test sytem, the input power can be obtained by dividing the kVA by the Q.

PARALLEL OR SERIES RESONANT MODE

The proper mode of operation must be chosen according to the test objects and the measurements to be carried out.

The series resonant mode is well suited for sensitive partial discharge measurements. Harmonics from the supply are better suppressed than in parallel mode.

The parallel resonant mode provides a more stable output voltage with test specimens, such as large generator windings, or other specimens with corona losses.

The test voltage rate of rise is stable in parallel mode, independent of the degree of tuning and the Q of the circuit.

Furthermore, parallel mode allows the test set to be energized to full voltage without a load. This is useful for calibrating the instrumentation and checking for the partial discharge level of the test equipment.

PRINCIPLE OF OPERATION IN PARALLEL RESONANT MODE

Figure 1 is a simplified diagram of a parallel resonant test system. The difference between series and parallel mode can be seen in the connection from the exciter transformer to the high voltage reactor.

The start of the high voltage winding is grounded instead of being connected to the high voltage output of the exciter transformer, as in the series resonant mode. The output of the exciter transformer is connected to a tap provided on the high voltage reactor. Notice that the high voltage reactor is in the configuration of an auto-transformer.

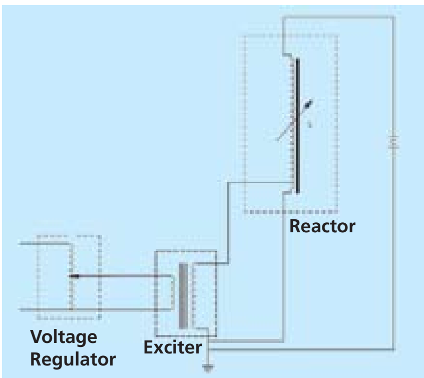

Figure 1 Parallel Resonance

Furthermore, in this configuration the high voltage reactor is electronically in "parallel" with the load capacitance. In the event of a breakdown of the test sample, the output current of the test set is limited by the short-circuit impedance of the regulator, exciter transformer, and the "auto-transformer." In most cases it can be said that the short-circuit current of a parallel resonant system is below the nominal current.

PRINCIPLE OF OPERATION IN SERIES RESONANT MODE

Figure 2 is a simplified diagram of a series resonant test system. A voltage regulator of an auto-transformer type (Toroidal, CTVT or Thoma) is connected to the supply voltage. The regulator provides a variable voltage to the exciter transformer.

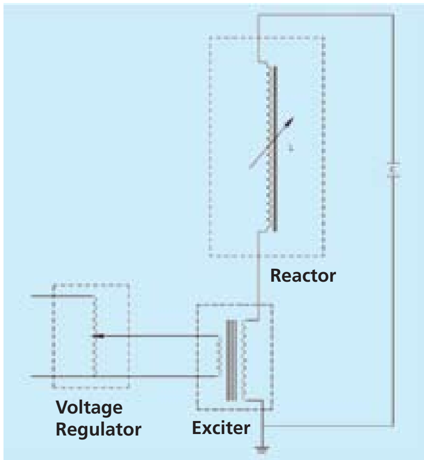

Figure 2 Series Resonance

The exciter transformer is fed by the output of the voltage regulator. This transformer steps the voltage up to a usable value by the high voltage portion of the circuit.

The high voltage reactor L and the load capacitance C represent the high voltage portion of the circuit. The inductance of the high voltage reactor can be varied by changing the air gap of the iron core. The load capacitance C consists of the capacitance of the load. The coupling capacitance for PD measurement, stray capacitance and, in the case of tank-type (T), sets the high voltage bushing. When testing, the high voltage reactor is adjusted so that the impedance of L corresponds to the impedance of C at the frequency of the supply voltage. Thus the circuit is tuned to series resonance at 50 or 60 Hz.

The Q of the basic resonant circuit or with a low loss test specimen (e.g. of cable, XLPE cable, SF switchgear, bushing, etc.) is typically 50 to 80. The high voltage reactor is designed for a minimum Q of 40. The system Q is designed around the anticipated load. For example if the set is operated in conjunction with water terminations, the system will operate at a Q as low as 20. If the system is used for testing samples with large resistive losses, such as generator windings, the system will provide full power with a Q as low as 10.

In case of a flashover during testing on the high voltage side, the resonant circuit is detuned and the test voltage collapses immediately. The short circuit current is limited by the impedance of the high voltage reactor. This means that the short circuit current of a series resonant system with a Q of 40 is 2.5% of the load current to which it is tuned.

Both resonant and conventional AC test systems have their fields of operation. For all applications where the test specimen represents, in addition to capacitance, a relatively high ohmic content, a conventional test set (possibly with reactive compensation) is recommended.

When testing specimens representing a highly loss-free capacitive load, the series resonant test system has some outstanding advantages. In the event of a breakdown, the fault current is very small as the resonance circuit is detuned. In most cases, the complete test system can be trailer or truck-mounted to provide mobility for field tests of installed power cables or generators.

Being operated in a resonant mode results in the system operating at a unity power factor, thus, these systems are ideal for on-site operation due to reduced power consumption needs when compared to conventional AC dielectric test systems.

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