Method to Monitor Conditions of Substation Capacitors

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1. Introduction

Power capacitors are widely used in substations for voltage regulation and reactive power compensation. However, even if equipped with some kinds of protections, affected by the bad operation environment, capacitors are still apt to be damaged, which may lead to serious consequences for power system. Therefore, online monitoring conditions of substation capacitors is significant for power system security and stability.

2. Proposed scheme

Capacitor consists of lots of small units which are connected in parallel and series. If the capacitor is equipped with individual fuse for each unit, the originally damaged unit will be isolated immediately by its fuse, which will have negligible impact on capacitor and allow it to work well until a certain number of units are damaged. Therefore, discovering small unit disorder in time is very useful in monitoring the whole capacitor’s operation condition.

In this poster, disturbances caused by the damage of small unit in substation capacitor is detected and used to monitor the whole capacitor’s operation condition, see Fig.1.

3. Characterize disturbance

As small unit in capacitor usually damages during capacitor switching, it’s more meaningful to detect unit damage during switching. Abrupt change in whole capacitor’s voltage is selected to characterize disturbance caused by unit damage due to the fact that capacitor voltage cannot change abruptly. Equivalent circuits for analyzing voltage abrupt change caused by a small unit breakdown in phase A after three-phase capacitor switching are shown in Fig.2, where Fig.2b illustrates the additional fault state and has a zero initial state at the moment of small unit breakdown according to fault analysis theory. \( R \) and \( L \) are equivalent system resistance and inductance, \( C \) is capacitance of single phase capacitor, \( L_s \) is the series inductor in capacitor, \( S \) is the number of series units in single phase capacitor, \( P \) is the number of parallel units in a series capacitor unit, \( u_{u,s} \) is total voltage of phase A capacitor.

4. Detect disturbance

1) Extraction of all disturbances

The first step of the voltage abrupt change detection is extracting all disturbances from bus voltage. Disturbances caused by capacitor switching, small capacitor unit breakdown and fuse blowing are got through subtracting steady voltage before switching \( u_{sw} \) from overall bus voltage during and after capacitor switching, see Fig.3.

From equation (10) we can find that after each subtraction prescribed in (6)-(7), the magnitude of a sinusoidal waveform will multiply \( \Delta t \). If sampling interval \( \Delta t = 1/2 \), the magnitude of a sinusoidal waveform will continue to decrease with the increase of subtraction times, see Fig.4.

5. Conclusion

Online monitoring conditions of substation capacitors is significant for power system security and stability. Disturbances caused by damage of small unit in capacitor during capacitor switching are used in this poster to online monitor conditions of substation capacitor and anticipate its final fault. This method only rely on the voltage and current waveform data measured at the exit of substation capacitor and is easy to carry out in the field.

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