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Shunt capacitor bank fundamentals and the application of differential voltage protection of fuseless single star earthed shunt capacitor banks

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2010-02-16T13:24:56Z
http://hdl.handle.net/10539/7515

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Abstract

The research investigates reactive power compensation and protection of shunt capacitor banks. The characteristics of capacitors including, formulae, design, manufacturing, and testing is presented. Capacitor units using extended foil solder type elements have losses as low as 0.1 watt/kVAr. Failure of capacitors generally occurs due to overvoltage stress. The type and aging properties of the dielectric determines the lifespan of the capacitor. Polypropylene film is commonly used as the dielectric. Basic capacitor bank design calculations are presented. A detailed discussion on the configurations and protection philosophies is described for single star earthed, single star H-bridge, double star, and C-type filter H-bridge capacitor banks. A novel approach to unbalance voltage detection and the protection of fuseless single star earthed shunt capacitor banks is investigated, engineered and tested. This methodology explores the potential evolution towards distributed protection. This involves two programmed multifunction protection relays communicating via the IEC 61850 Ethernet protocol. One relay receives voltage measurements from the high voltage busbar. The other relay receives voltage measurements from the low voltage capacitor tap point. The two relays share their measurements via the Ethernet link. The difference in measurements is used to initiate alarm and trip operations. The relay protection function satisfies criterion for reset-ability, selectivity, stability, accuracy, and loss of potential blocking. Spurious operation occurs when the Total Harmonic Distortion level is above 8%. The major short coming is the cyclic processing of the logic function. The algorithm processing duration is 396ms as opposed to an anticipated time of 60ms. This application has a competitive overall cost advantage. This is based on the number of components required, manufacturing and testing times, and onsite installation and commissioning works. It is recommended to further investigate the cyclic processing of the logic functions, as well as, to test the protection function on a power system simulator. Future prospects involve using the programmability and flexibility of the onboard relay PLC to count capacitor element failure, on a discrete basis, instead of detection and protection based on analogue threshold settings. This will mitigate ambiguous measurements and spurious operation.