

Ralph Fehr, "Power Factor Correction," in *Industrial Power Distribution*, 1, Wiley-IEEE Press, 2016, pp.440-
doi: 10.1002/9781119065180.ch11

Abstract: Shunt capacitors can be used to provide reactive power to inductive loads, thereby raising or correcting the power factor. Three-phase capacitor banks can be connected in delta, wye, or grounded wye. The optimal configuration depends on whether the system is grounded or ungrounded, fusing considerations, and concerns about harmonics. Energizing a shunt capacitor is discussed by analyzing the voltage and current waveforms produced by the capacitor breaker closing operation. While harmonic currents and voltages present during capacitor switching can be potentially disrupting or damaging to power system components, they are transient in nature and are quickly damped by the system impedance. Harmonic currents and voltages are analyzed using symmetrical components. Shunt capacitors can create undesirable resonance conditions. Large transmission-class shunt capacitors are sometimes fuseless, relying on protective relays to de-energize them in the event of an internal fault or an excessive number of capacitor units shorted.

Mohamed A. Ibrahim, "Power System Phenomena and their Impact on Relay System Performance," in *Disturbance Analysis for Power Systems*, 1, Wiley-IEEE Press, 2012, pp.736-
doi: 10.1002/9781118172094.ch3

Abstract: This chapter contains sections titled:

- Power System Oscillations Leading to Simultaneous Tripping of Both Ends of a Transmission Line and the Tripping of One End Only on an Adjacent Line
- Generator Oscillations Triggered by a Combination of L-g Fault, Loss of Generation, and Undesired Tripping of Three 138-kV Lines
- Stable Power Swing Generated During Successful Synchronization of a 200-MW Unit
- Major System Disturbance Leading to Different Oscillations for Different Transmission Lines Emanating from the Same Substation
- Appearance of 120-Hz Current at a Generator Rotor During a High-Side Phase-to-Ground Fault
- Generator Negative-Sequence Current Flow During Unbalanced Faults
- Inadvertent (Accidental) Energization of a 170-MW Hydro Generating Unit
- Appearance of Third-Harmonic Voltage at Generator Neutral
- Variations of Generator Neutral Third-Harmonic Voltage Magnitude During System Faults
- Generator Active and Reactive Power Outputs During a GSU High-Side L-g Fault
- Loss of Excitation of a 200-MW Unit
- Generator Trapped (Decayed) Energy
- Nonzero Current Crossing During Faults and Mis-Synchronization Events
- Generator Neutral Zero-Sequence Voltage Coupling Through Step-Up Transformer Interwinding Capacitance During a High-Side Ground Fault
- Energizing a Transformer with a Fault on the High Side within the Differential Zone
- Transformer Inrush Currents
- Inrush Currents During Energization of the Grounded-Wye Side of a YG/Delta Transformer
- Inrush Currents During Energization of a Transformer Delta Side
- Two-Phase Energization of an Autotransformer with a Delta Winding Tertiary During a Simultaneous L-g Fault and an Open Phase
- Phase Shift of 30° Across the Delta/Wye Transformer Banks
- Zero-Sequence Current Contribution from a Remote Two-Winding Delta/YG Transformer
- Conventional Power-Regulating Transformer Core Type Acting as a Zero-Sequence Source
- Circuit Breaker Re-Strikes
- Circuit Breaker Pole Disagreement During a Closing Operation
- Circuit Breaker Opening Resistors
- Secondary Current Backfeeding to Breaker Failure Fault Detectors
- Magnetic Flux Cancellation

- Current Transformer Saturation
- Current Transformer Saturation During an Out-of-Step System Condition Initiated by Mis-Synchronization of a Generator Breaker
- Capacitive Voltage Transformer Transient
- Bushing Potential Device Transient During Deenergization of an EHV Line
- Capacitor Bank Breaker Re-Strike Following Interruption of a Capacitor Normal Current
- Capacitor Bank Closing Transient
- Shunt Capacitor Bank Outrush into Close-in System Faults
- SCADA Closing into a Three-Phase Fault
- Automatic Reclosing into a Permanent Line-to-Ground Fault
- Successful High-Speed Reclosing Following a Line-to-Ground Fault
- Zero-Sequence Mutual Coupling-Induced Voltage
- Mutual Coupling Phenomenon Causing False Tripping of a High-Impedance Bus Differential Relay During a Line Phase-to-Ground Fault
- Appearance of Nonsinusoidal Neutral Current During the Clearing of Three-Phase Faults
- Current Reversal on Parallel Lines During Faults
- Ferranti Voltage Rise
- Voltage Oscillation on EHV Lines Having Shunt Reactors at their Ends
- Lightning Strike on an Adjacent Line Followed by a C-g Fault Caused by a Separate Lightning Strike on the M...

D. L. Boneau and W. J. McCoy, "OICA joint tests, procedures, and conclusions [power systems]," in *IEEE Transactions on Power Delivery*, vol. 6, no. 1, pp. 43-48, Jan 1991.

doi: 10.1109/61.103720

Abstract: To determine the applicability of J.R. Carson's mutual impedance equations in inductive coordination, field measurements were made and compared to calculations. The measurements were made on three phases distribution power lines with a capacitor bank about two miles from the test site and no intermediate significant loads between the test site and the capacitor bank. The site required a communications cable paralleling the power system without intermediate cable taps. Also, tests were conducted on several specific power system changes to identify the correlation with different values of voltage on the power system, with different sizes of capacitor banks, and with different values of impedance between the center of the wye of the capacitor bank and the neutral. The impedance values were varied from solidly grounded to floated or open circuited. A multitap inductor was placed in the circuit to identify the effect on the harmonic current flow on the power system. The tests and calculations discussed substantiate the relationship between the current on the power system and the induced voltage on parallel conductors (probe wires and telecommunications cable) as recommended in IEEE Std. 776-1987

keywords: {capacitor storage;distribution networks;power cables;power systems;testing;3-phase distribution power lines;IEEE Std. 776-1987;OICA;Oklahoma Inductive Coordination Association;capacitor banks;communications cable;field measurements;harmonic current flow;induced voltage;inductive coordination;multitap inductor;mutual impedance equations;parallel conductors;power system;Capacitors;Circuits;Communication cables;Impedance;Power cables;Power system harmonics;Power system measurements;Power systems;System testing;Voltage},

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=103720&isnumber=3207>

R. G. Coney, G. H. Topham and M. G. Fawkes, "Experience and problems with the protection of series compensated lines," 1989 *Fourth International Conference on Developments in Power Protection*, Edinburgh, 1989, pp. 177-181.

Abstract: The authors discuss the experience of Eskom in protecting series compensated lines starting with the original type 1 scheme consisting of permissive over-reaching and electromechanical impedance techniques. As more lines were constructed type 2 protection, consisting of electronic relays using sequence component operating and restraint quantities, was implemented. In 1985 a program was started to replace type 1 with type 3 protection, electronic phase and ground hybrid directional comparison protection. The main problem to be overcome, subsynchronous resonance, is also discussed. The series capacitors used in the capacitor banks and their operation are described

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H. Jouybari-Moghaddam, T. S. Sidhu, M. R. Dadash Zadeh and P. P. Parikh, "Enhanced Fault-Location Scheme for Double Wye Shunt Capacitor Banks," in *IEEE Transactions on Power Delivery*, vol. 32, no. 4, pp. 1872-1880, Aug. 2017.

doi: 10.1109/TPWRD.2016.2583381

Abstract: Determining the location of internal failures in shunt capacitor banks (SCBs) helps to expedite their repair process and, thus, increase the time during which the power system benefits from this crucial component. This paper elaborates on fault location for a common configuration in high-voltage SCBs, which is the double wye connection (Y-Y). The neutral current unbalance protection is adapted to suit the development of an algorithm that detects the location of internal failures in ungrounded and grounded Y-Y SCBs. The proposed method is capable of detecting consecutive failures, and also can mitigate gradual capacitance and temperature change effects. Both internally fused and fuseless banks are considered in the proposed technique.

The presented fault-location method is further enhanced by detecting the number of failed elements. Simulations are performed using PSCAD and MATLAB. The results validate the proposed method performance under pre-existing internal unbalances, system voltage unbalance, and faults in the grid. Illustrative simulation scenarios are provided to show the application and significance of the proposed method properties.

keywords: {fault location;power capacitors;MATLAB;PSCAD;SCB;double wye connection;double wye shunt capacitor banks;enhanced fault-location scheme;fault location;fault-location method;internal failures;internal unbalances;neutral current unbalance protection;system voltage unbalance;Capacitors;Current measurement;Fault location;Impedance measurement;Maintenance engineering;Phase measurement;Temperature measurement;Double wye;fault location;fuseless;internal failure;internally fused;relay;shunt capacitor bank},

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7496839&isnumber=7932251>

R. B. Shipley, H. J. Holley and D. W. Coleman, "Digital Analysis of Single-Pole Switching on EHV Lines," in *IEEE Transactions on Power Apparatus and Systems*, vol. PAS-87, no. 8, pp. 1679-1687, Aug. 1968.

doi: 10.1109/TPAS.1968.292129

Abstract: Long distance EHV transmission and generator installations at remote locations have intensified stability problems. Transmission necessary to improve stability is expensive. Single- pole switching is being reviewed as an alternate. Phase-to-ground fault current in the open phase of the line is reduced by reactor compensation to make arc extinction possible. A means for increasing the line capability when one phase is open is investigated. The effectiveness is analyzed in detail using a digital computer.

keywords: {Capacitors;Digital relays;Fault currents;Impedance;Inductors;Machine windings;Power generation;Power system protection;Power system stability;Synchronous machines},

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M. Michalik, W. Rebizant, M. Lukowicz, Seung-Jae Lee and Sang-Hee Kang, "High-impedance fault detection in distribution networks with use of wavelet-based algorithm," in *IEEE Transactions on Power Delivery*, vol. 21, no. 4, pp. 1793-1802, Oct. 2006.

doi: 10.1109/TPWRD.2006.874581

Abstract: A new simple and effective algorithm of arcing fault detection in distribution networks with the application of a wavelet transform technique is presented in this paper. The protection algorithm developed observes the phase displacement between wavelet coefficients calculated for zero-sequence voltage and current signals at a chosen high-level frequency. The final decision in regards to feeder switching off (or alarm issuing) is met either with a deterministic logic scheme or with the use of a neural net trained especially for that purpose. The developed wavelet-based high-impedance fault (HIF) detector has been tested with Electromagnetic Transients Program-Alternative Transients Program (ATP)-generated signals, exhibiting better performance than traditionally used algorithms and methods. The protection method proposed may be used for HIF detection independent of the network neutral-point grounding mode. The scheme proved to be robust against transients generated during normal events such as feeder energizing and de-energizing as well as capacitor bank switching

keywords: {EMTP;fault location;neural nets;power distribution faults;power distribution protection;wavelet transforms;alternative transients program;arcing fault detection;capacitor bank switching;distribution networks;electromagnetic transients program;feeder switching;high-impedance fault detection;network neutral-point grounding;neural net;wavelet transform technique;wavelet-based algorithm;zero-sequence voltage;Detectors;Electromagnetic transients;Fault detection;Frequency;Logic;Neural networks;Protection;Voltage;Wavelet coefficients;Wavelet transforms;High-impedance faults (HIFs);medium-voltage (MV) networks;protective relaying;transient analysis;wavelet transformation},

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=1705533&isnumber=35993>