Guide for the Application of Autoreclosing to the Bulk Power System

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Notes:
Terms in bold face type are defined in the NPCC Glossary of Terms. Italicized terms are defined in Section 3.0 of this Guideline.

The terms autoreclosing, high-speed autoreclosing and synchronism-check are defined in the Glossary. These terms are included in the definition list (Section 3.0) of this document for reference only, in order to make the document easier to read.
1.0 Objectives

The purpose of this document is to establish guidelines for the application of autoreclosing facilities to circuit breakers on the NPCC bulk power system. This document is not intended to provide guidance for the operation of the bulk power system in matters of reclosing, such as enabling or disabling autoreclosing or providing for manual closures following automatic tripping of an element.

2.0 Introduction

Autoreclosing should be applied for the purpose of restoring transmission lines to service subsequent to automatic tripping of their associated circuit breakers due to electrical faults. Experience of the NPCC member companies indicates that many faults on the bulk power overhead transmission system are temporary. In the absence of autoreclosing, longer duration outages could be experienced unnecessarily. Successful autoreclosing can enhance stability margins and overall system reliability. However, autoreclosing into a permanent fault may adversely affect system stability, hence due consideration must be given to this aspect of any application.

3.0 Definitions

3.1 Autoreclosing\(^1\) is the automatic closing of a circuit breaker in order to restore an element to service following automatic tripping of the circuit breaker. Autoreclosing does not include automatic closing of capacitor or reactor circuit breakers.

3.2 Breaker reclosing time is the elapsed time between the energizing of the breaker trip coil and the closing of the breaker contacts to reestablish the circuit by the breaker primary contacts on the reclose stroke.

3.3 High-speed autoreclosing\(^2\) refers to the autoreclosing of a circuit breaker after a necessary time delay (less than one second) to permit fault arc deionization with due regard to coordination with all relay protective systems. This type of autoreclosing is generally not supervised by voltage magnitude or phase angle.

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\(^1\) See note on Table of Contents Page.
\(^2\) See note on Table of Contents Page.
3.4 Delayed autoreclosing refers to the autoreclosing of a circuit breaker after a time delay which is intentionally longer than that for high-speed autoreclosing.

3.5 Synchronism-check\(^3\) refers to the determination that acceptable voltages exist on the two sides of the breaker and the phase angle between them is within a specified limit for a specified time.

3.6 Multiple-shot autoreclosing refers to the autoreclosing of the circuit breaker(s) more than once within a predetermined reclosing sequence.

3.7 Blocking refers to the automatic prevention of an action following specific relay tripping operations.

3.8 Single-pole autoreclosing refers to the autoreclosing of one pole of a circuit breaker following a designed single-pole trip for single-phase-to-ground faults.

3.9 Manual refers to either local or remote switching operations that are initiated by an operator.

3.10 Automatic refers to either local or remote switching operations that are initiated by relay or control action without the direct intervention of an operator.

3.11 Lockout refers to the complete disabling of the reclosing sequence until reset.

4.0 Common Considerations to High-Speed and Delayed Autoreclosing

4.1 Blocking of Autoreclosing

Autoreclosing should be blocked during the reception of a direct transfer trip signal. Autoreclosing should be blocked, or not be initiated, following any manual operation of a circuit breaker.

4.2 Turbine-Generator Considerations

Manual closing or autoreclosing at line terminals that are in electrical proximity to turbine-generators may subject them to excessive shaft torques and winding stresses with resultant loss of life of the turbine-generator system. Another consideration is the electrical/mechanical stress on the electrical insulating system (stator and rotor) as well as on the endcaps, also called “retaining rings (rotor).” These effects should be studied and evaluated before autoreclosing is applied. It is preferable to

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\(^3\) See note on Table of Contents Page.
re-energize a line at a terminal remote from the generator bus, and then autoreclose or close at the generator end. The autoreclosing at the generator end should be supervised by synchronism-check function as required.

4.3 Circuit Breaker Capability

The design and implementation of autoreclosing system should consider the circuit breaker capability. Autoreclosing times and sequences should be selected with due regard to circuit breaker interrupting capability, duty cycle, derating, voltage withstand capability, resistor thermal capability, and overall breaker design.

4.4 Number of Operations

Multiple-shot autoreclosing systems should be designed considering the breaker operating time, available stored energy for breaker operation, and system stability margins.

4.5 Breaker Failure Operations

Autoreclosing time delay should be coordinated with breaker failure trip time including any remote clearing time.

Autoreclosing following breaker failure operation should not occur until the failed breaker is isolated.

4.6 Other System Elements

Risks versus benefits should be evaluated before applying autoreclosing following faults on transformers, enclosed busses, cables, etc. For these types of system elements, it is generally not advisable to autoreclose since the probability of a fault being permanent is high and the probability of aggravating equipment damage is increased. Under specific circumstances, however, the benefits of autoreclosing may justify its use.

Caution also should be taken when applying autoreclosing following faults on lines that terminate with or include transformers, enclosed busses, cables, etc. In these situations the same precautions should be applied unless means are provided to differentiate between faults on the line from faults on the transformer, enclosed bus, or cable, and to supervise autoreclosing.

4.7 Multiple Circuit Breaker Line Termination
The recommended mode of autoreclosing at a terminal with more than one breaker per line is to autoreclose with a preselected breaker. Following successful autoreclose operation, the other breaker(s) associated with the line at that terminal may be autoreclosed. Since simultaneous closing of two or more breakers is difficult to achieve, autoreclosing into a permanent fault by more than one breaker at the same line terminal could result in the fault being maintained on the system for a longer than intended period, and may be followed by an incorrect breaker failure operation for certain relay designs. In addition, the severity of the system disturbance may be increased.

4.8 Line Connected Shunt Capacitor

It is preferable that reclosing of line circuit breakers be completed before closing (normally by operator action) the shunt capacitor breaker.

5.0 High-Speed Autoreclosing Considerations

5.1 Tripping Requirements

High-speed autoreclosing should be initiated only if all terminals of the line are tripped without intentional time delay for line faults.

5.2 Stability Considerations

When high-speed autoreclosing is under consideration as a means for increasing the transient stability margin of a system, restoring service to critical loads, or restoring needed system interconnections, it should be recognized that there is a risk as well as a possible benefit associated with its use. The risk is that stability may be endangered rather than benefited if a line is autoreclosed into a permanent fault. Stability studies should indicate whether or not the use of high-speed autoreclosing should be restricted.

5.3 Out-of-Step Conditions

Since high-speed autoreclosing is generally unsupervised, it should be blocked following an out-of-step relay operation.

5.4 Switching Surge Considerations

High-speed autoreclosing should not be used where transient voltage analysis studies indicate that high-speed autoreclosing may produce switching surge magnitudes exceeding the equipment design levels.
6.0 Delayed Autoreclosing Considerations

6.1 General Use

Delayed autoreclosing may be used following design analysis and may be preferable to high speed automatic reclosing.

6.2 Frequency, Phase Angle and Voltage Considerations

Synchronism-check relays should be used where analysis shows that for credible system conditions there may be harmful effects on the system due to excessive frequency differences, phase angles, or voltage magnitudes across the closing breaker.

When applying synchronism-check relays, appropriate consideration should be given to avoiding excessive restriction on breaker autoreclosing or on manual closing, which may be particularly challenging to the operator, following major system disturbances.

It may be necessary to employ means to ensure undesired autoreclosing modes do not take place. For example, dead-line supervision of autoreclosing or manual closing may be used where harmful effects on the system would result from connection of energized facilities.

6.3 Autoreclosing Time Considerations

A time delay should be used, as determined by stability studies, to allow damping of system oscillations following a disturbance. If stability studies are not available, a 15-second time delay appears to be conservative for most systems. Following the initiation of an autoreclosing sequence, autoreclosing attempts should be prevented after a predetermined time period. This time period should not prohibit completion of the autoreclosing sequence and must include circuit breaker fault clearing time, synchronism-check timing and protective relay and control system response times. To prevent unexpected operation, the autoreclosing sequence must be completed or go to a lockout state prior to the commencement of operator-initiated switching. Re-arming of the autoreclosing scheme may be achieved by automatic, manual or remote methods.

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Reference: *NPCC Glossary of Terms*