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IEEE Guide for Automatic Reclosing of Line Circuit Breakers for AC Distribution and Transmission Lines

IEEE Power Engineering Society

Sponsored by the
Power System Relaying Committee



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Power System Relaying Committee
of the
IEEE Power Engineering Society

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Abstract: Guidelines for the application of automatic reclosing facilities to circuit breakers are established. Decisions concerning the use of such facilities in specific cases are left to the user.

Keywords: automatic operation, circuit breaker, distribution, reclosing, transmission

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Introduction

(This introduction is not part of IEEE Std C37.104-2002, IEEE Guide for Automatic Reclosing of Line Circuit Breakers for AC Distribution and Transmission Lines.)

The art and science of protective relaying for the automatic reclosing of circuit breakers associated with distribution and transmission lines following the clearing of a temporary fault have evolved over many years. This newly developed guide is an effort to compile information on the application considerations associated with this practice. The guide presents generally accepted practices for autoreclosing. Its purpose is to describe the methods and considerations associated with situations in which it is desirable to reclose automatically. It is intended for engineers who have a basic knowledge of power system protection. This is an application guide and does not cover all of the requirements for autoreclosing for every situation or protection scheme. Additional reading material is suggested so that the reader can evaluate the application of autoreclosing for the individual situation.

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IEEE Guide for Automatic Reclosing of Line Circuit Breakers for AC Distribution and Transmission Lines

1. Overview

1.1 Scope

This guide describes current automatic reclosing practices for ac distribution and transmission lines. Included within this description are application considerations and coordination practices for reclosing.

1.2 Purpose

The purpose of this guide is to establish guidelines for the application of automatic reclosing facilities to circuit breakers. This guide is not intended to provide guidance for the operation of the bulk power system in matters of reclosing, such as enabling or disabling automatic reclosing or providing for manual closures following automatic tripping of an element. Automatic reclosing can restore or facilitate restoration of the system to normal, following automatic tripping of distribution and transmission facilities. Throughout this guide, the shorter term “autoreclosing” will be used in place of *automatic reclosing*. Italicized terms are defined in Clause 3 of this guide.

Autoreclosing may be applied for the purpose of restoring distribution and transmission lines to service subsequent to automatic tripping of their associated circuit breakers due to electrical faults. Experience indicates that many faults on the overhead power 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 can adversely affect system stability, damage equipment, or have adverse effects on customers; hence, due consideration shall be given to this aspect of any application. See Annex B for a brief history of automatic reclosing.

2. References

This guide shall be used in conjunction with the following publications. When the following publications are superseded by an approved revision, the revision shall apply.

ANSI C37.06TM-2000, American National Standard for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis—Preferred Ratings and Related Required Capabilities.¹

IEEE Std C37.04TM-1999, IEEE Standard Rating Structure for AC High-Voltage Circuit Breakers.^{2,3}

IEEE Std C37.010TM-1999, IEEE Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis.

IEEE Std C37.2TM-1996 (Reaff 2001), IEEE Standard Electrical Power System Device Function Numbers and Contact Designations.

IEEE Std C37.60TM-1981 (Reaff 1992), IEEE Standard Requirements for Overhead, Pad Mounted, Dry Vault, and Submersible Automatic Circuit Reclosers and Fault Interrupters for AC Systems.

IEEE Std C37.61TM-1973 (Reaff 1992), IEEE Standard Guide for Application, Operation, and Maintenance of Automatic Circuit Reclosers.

IEEE Std C37.90TM-1989 (Reaff 1994), IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus.

IEEE Std C37.100TM-1992 (Reaff 2001), IEEE Standard Definitions for Power Switchgear.

3. Definitions

For purposes of this guide, the following terms and definitions apply. IEEE 100TM [B6]⁴ should be referenced for terms not defined in this clause.

NOTE—Those terms marked with an asterisk (*) are also listed in IEEE 100 [B6].

3.1 automatic: Refers to either local or remote switching operations that are initiated by relay or control action without the direct intervention of an operator.*

3.2 autoreclosing: 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 the circuit breakers associated with shunt or series capacitor banks or shunt reactors.

3.3 blocking: Refers to the automatic prevention of an action following specific relay tripping operations.

3.4 breaker autoreclosing time: The elapsed time between the energizing of the breaker trip coil and the closing of the breaker contacts to re-establish the circuit on the autoreclose operation.

3.5 dead time: That period of time the circuit breaker is open and the controlled circuit is de-energized following the tripping operation for a fault and the autoreclosing attempt.*

3.6 delayed autoreclosing: Refers to the autoreclosing of a circuit breaker after a time delay that is intentionally longer than that for high-speed autoreclosing.

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⁴The numbers in brackets correspond to those of the bibliography in Annex A.

3.7 high-speed autoreclosing: Refers to the autoreclosing of a circuit breaker after a necessary time delay 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.

3.8 lockout: The state of the reclosing relay wherein the controlled line breaker is open and the relay disabled from making any further reclose attempts.*

3.9 manual: Refers to either local or remote switching operations that are initiated by an operator.

3.10 multiple-shot autoreclosing: Refers to the autoreclosing of the circuit breaker(s) more than once within a predetermined autoreclosing sequence.

3.11 permissives: Those measured functions or system conditions that must be satisfied prior to allowing the reclosing action to proceed.

3.12 shot: Autoreclose attempt that is initiated by command of the reclosing logic.

3.13 single-pole autoreclosing: Refers to the autoreclosing of one phase of a circuit breaker following a designed single-phase trip for single-phase-to-ground faults.*

3.14 synchronism check: 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.*

3.15 transfer trip: A form of remote trip in which a communication channel is used to transmit a trip signal from the relay location to a remote location.*

4. Fundamentals

4.1 Basics

As most faults on overhead electrical systems are temporary in nature, the use of autoreclosing aids in the restoration of the system. To apply autoreclosing properly, several concerns need to be addressed. Some of the most frequently asked fundamental questions are as follows:

- a) What is the probability of successfully reclosing the faulted circuit?
- b) What is the potential for damage to the system components by autoreclosing into a fault?
- c) Are special interlocks required to inhibit autoreclosing under certain conditions?
- d) Should the autoreclosing be time delayed or is high-speed autoreclosing allowed?
- e) How many autoreclosing attempts should be used for the application?
- f) Should voltage supervision be applied?
- g) Should there be a synchronism check?
- h) What are the consequences of not autoreclosing?

The above fundamental questions are discussed in the remainder of this guide.

4.2 Timing nomenclature

One other fundamental concern deals with timing nomenclature. A problem occurs with how the autoreclosing times are indicated. Various utilities may indicate the same autoreclosing sequence but in different ways that can lead to misunderstandings between them. For example (using the basic symbol R to indicate one autoreclosing shot):

One utility may not indicate a time if the inherent time of the reclosing relay is used. For example, if the inherent time delay were 0.2 s, then this utility would indicate the autoreclosing mode as R.

However, settings from another utility may use $R_{0.2}$. Confusion could arise as to whether this means an autoreclosing time of 0.2 s or 0.4 s. For the purpose of this guide, the notation $R_{0.2}$ indicates a setting of 0.2 s in addition to any internal delay of the relay.

Additional confusion can arise in how multiple autoreclosing shots are indicated. For example, a two-shot autoreclosing sequence of 15 s and 30 s may be designated as $R_{15}R_{30}$. The 30 s may indicate the time after the first autoreclose attempt failed and the breaker tripped a second time or the total elapsed time from the initial trip. In the first instance, this means that the second attempt would happen at the 45+ s point after fault initiation. In the second interpretation, this means that the second attempt would occur 30 s after fault initiation. A standardized method of indicating the autoreclosing mode and timing is required. Figure 1 illustrates the standard method used to indicate the autoreclosing interval times that will be utilized in this guide. This method uses the point of breaker position recognition by the reclosing relay as the beginning of the timing measurement, which is the first instance previously described.

The following shorthand method may be used to describe common autoreclosing modes in use today on a single line diagram or other system operational drawing. These include the following:

R	Autoreclosing with no voltage supervision and no external time delay.
R_{T1}	Autoreclosing with no voltage supervision and time delayed T1.
R_{DT1}	Autoreclosing with dead-line supervision and time delayed T1.
R_{AT1}	Autoreclosing with live-line supervision and time delayed T1.
R_{DBAT1}	Autoreclosing with line dead before becoming alive; alive for time T1.
R_{AST1}	Autoreclosing with synch check and synchronism maintained for time T1.
$R_{DT1}R_{T2}$	Autoreclosing with the first attempt having dead-line supervision and time delayed T1. Second attempt with no voltage supervision and time delayed T2. From Figure 1, T1 is 0.2 s and T2 is 15 s as measured from recognition of the breaker opening following the second trip.

The autoreclosing sequence illustrated in Figure 1 involves two autoreclosing attempts, followed by a reset of the reclosing relay. In this example, it is assumed that the initial autoreclose of the breaker was not successful and the fault detection devices retripped the breaker. The initial autoreclosing delay setting provides a delay time of 0.2 s ($R_{0.2}$) from the sensed closure of a breaker auxiliary contact, indicating the breaker is open, to the initiation of the closing coil of the breaker. The second autoreclosing delay provides a similar interval of 15 s (R_{15}). The reset interval will begin each time the breaker closes. In the sequence shown in Figure 1, the reset timing function is halted and reinitialized when the breaker trips. The autoreclosing relay will reset to its initial state providing that the breaker does not open during this (reset) interval. The reset delay for this example is 30 s.

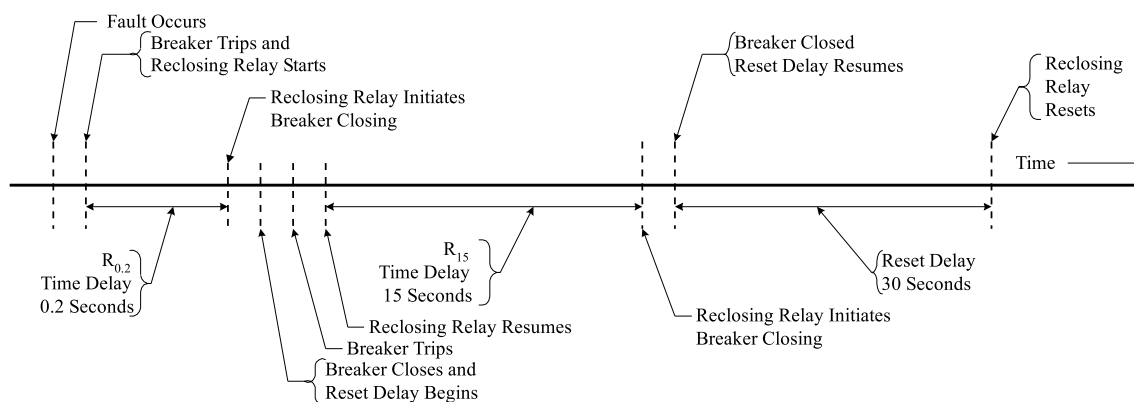


Figure 1—Autoreclosing time line

ANSI C37.06-2000⁵ indicates that the minimum autoreclosing time delay should be 20 cycles (0.333 s). A breaker manufacturer may incorporate this delay into an operational mechanism of the breaker. This internal delay may need to be taken into consideration when setting the delay of a critical high-speed autoreclosing attempt.

Figure 1 includes more detail perhaps than necessary for this description, and is not drawn to scale. The detail shown is to indicate to the reader that there are a number of events that must take place in clearing a fault, some of which need to be considered when determining delay settings for the reclosing relay. Other details, which need to be considered, are the time required to open and close the controlled breaker, and that the reclosing relay must recognize the position of the breaker by monitoring an auxiliary contact on the mechanism. In some electromechanical relays there is a short delay as the internal logic sets itself for timing. In electronic designs, a short period is allowed to recognize the position of the sending contact (debounce time). While these intervals may be short enough to be neglected in the longer delay settings, they are still a part of the overall sequence of events and may need to be considered when fast autoreclosing is desired. It should also be noted that Figure 1 is typical and the reader needs to be aware of how the timing functions of the relay are initiated and reset. Care needs to be taken to assure that reset time initiation, cancellation, successful reclosing sequence completion, pausing, and lockout logic are considered. The operation of the relay can vary according to its manufacturer, vintage, and programmed (applied) logic scheme variables.

Figure 1 illustrates the definitions to be used within this guide relative to the timing of a reclosing relay. The fault clearing sequence begins with the inception of a fault, followed by the controlled breaker being tripped. When the controlled breaker opens, the reclosing relay starts timing toward its initial autoreclose attempt. At the completion of this delay, the reclosing relay closes its output contact and initiates breaker closing. At this point, the reclosing relay starts its reset timer. In the illustrated sequence, the fault is not cleared and the protection initiates a second trip. The reset timer is stopped and reset and the reclosing relay begins timing toward a second autoreclosing attempt and initiates closing of the breaker. Since the fault has now been cleared and the breaker remains closed for the interval of the reset delay timer, the reclosing relay resets itself to its initial states.

If the fault persists and the number of programmed autoreclosing attempts expires, the reclosing relay advances to its lockout state, leaving the breaker open. The reclosing relay is now disabled until the breaker is closed by other means. Depending on the design of the reclosing relay, the relay may then reset immediately or after the reset time delay. In the event that the breaker is manually closed and fails to remain closed, care should be taken in the reclosing circuitry to prevent the reclosing relay from operating.

4.3 Autoreclosing permissives

4.3.1 General

Autoreclosing is initiated either by the transition of a circuit breaker auxiliary contact on breaker opening or by protective relay trip, but not both. When a recloser is substituted in a substation for a feeder circuit breaker, the IEEE recloser standards and codes should be used for application (IEEE Std C37.60-1981; IEEE Std C37.61-1973).

Control circuitry is required to ensure that circuit breakers autoreclose only when intended. The control circuitry is different depending on the type of autoreclose initiation required by the relay design and its available features. If the reclosing relay is to be initiated by a 52b contact, then a slip contact of the circuit breaker control switch is installed in series with the close initiation. This contact of the

⁵Information on references can be found in Clause 2.

circuit breaker control switch disengages when the circuit breaker is manually opened. It engages when the circuit breaker is closed manually. A control switch OFF contact should be added to this circuit such that an instantaneous autoreclosure is not enabled until after a successful manual reclosure and the control switch is released. This series combination prevents the reclosing relay from recognizing the open position of the circuit breaker when it is manually tripped, and permits the reclosing relay to reclose the circuit breaker automatically following a manual closure. Protective relay circuits, when properly designed, operate only during a fault. Autoreclosing should not be initiated by protective relays when the breaker is opened manually. Autoreclosing is initiated by the closure, then opening of protective relays' contacts, signifying that a fault has occurred. This operation cycle signifies that a fault was interrupted and autoreclosing can now proceed.

It may be desirable that a time delay be used when restoring the autoreclosing function when the circuit breaker is manually closed. Some reclosing relay and control circuit designs disable the reclosing relay for a manual operation of the circuit breaker by setting the reclosing relay to the "locked out" condition. When enabling the autoreclosing function, these relays can be caused to wait for the period of the reset time delay within the relay. This feature, sometimes referred to as *switch onto fault*, is used to ensure that if the breaker were closed into a permanent fault, then the reclosing relay would not be initiated and attempt its programmed number of operations prior to locking out.

Autoreclosing is also *locked out*, or terminated, after the programmed number of attempts to re-energize the line are tried and unsuccessfully completed. Even if the autoreclosing is successful, the reclosing relay is not rearmed until the reset time delay expires. This lessens the possibility of excessive tripping and autoreclosing for intermittent faults.

Another timing circuit can disable autoreclosing if autoreclosing permissives are not satisfied within the prescribed time interval. For example, for dead-line autoreclosing, if the line voltage does not drop to zero (less than the setting of the undervoltage element) on all monitored phases within a time interval after the reclosing relay is initiated, usually 30 s, then autoreclosing is disabled. This prevents unexpected autoreclose operations later when the permissive condition is satisfied. For autoreclose initiation by protective relay, if the protective relay does not reset within the prescribed time interval, then autoreclosing is also disabled.

4.3.2 Voltage supervision of autoreclosing

Autoreclosing is often supervised by voltage permissives. These voltage permissives are often single phase, connected phase-to-phase, or phase-to-neutral. If a line has tapped terminals and these terminals can backfeed the line, then the main terminal, which re-energizes the protected line, should be supervised by dead-line voltage sensing. Voltage supervision allows for the time delays of the reclosing relay to be decreased, thus improving system restoration performance. Without voltage supervision, the autoreclosing need to be delayed longer to permit all terminals to clear the fault.

A method to ensure that all three phase voltages for autoreclosing supervision are proper is to use three single phase-to-ground voltage transformers connected grounded wye-grounded wye or two phase-to-phase voltage transformers connected open delta-open delta. If only one voltage transformer connected single phase to ground is employed, then proper voltage sensing may not occur, especially if the source of backfeed is a delta-connected transformer. If a single phase-to-ground fault occurred with backfeed from such a source and single phase sensing was utilized, then two phases may have high voltage and one phase almost at zero. Thus, if dead-line voltage supervision was used, then the autoreclosing could occur in error. A single phase-to-phase connected voltage transformer could possibly be used if the source of backfeed did not use independent pole operated circuit breakers. If the unmonitored phase did not open properly, the autoreclosing could occur in error. Also, failure of the voltage supply by a blown fuse or other defect could cause autoreclosing in error. Therefore, sensing

should be by two relays connected to different phases or dropout of a single relay should be monitored or alarmed.

Autoreclosing of the low-voltage circuit breakers on a transformer that is tapped on a transmission line should be supervised by voltage sensing. Autoreclosing of these breakers can be initiated by the receipt of a transfer trip signal followed by the reset of the transfer trip. Autoreclosing is completed if the transfer trip is reset and the transformer is re-energized. Transformer re-energization is typically detected by voltage sensing, either three phase or single phase, that monitors the transformer secondary voltage. Autoreclosing of the low-voltage circuit breakers is typically delayed by several seconds after the secondary voltage is detected to ensure that the primary supply is stable.

5. Autoreclosing for distribution systems

5.1 Distribution system overview

The *distribution system* is that portion of the electrical system used to transfer electric energy from the low-voltage side of the substation transformers to the customer's metering points. The distribution system can be a grounded or ungrounded system.

The *distribution circuit* is the composite of all system elements from the point of contact at the substation, usually the bus connected to the low-voltage side of the substation transformer, to the point of contact at the customer. It is normally a radial line comprised of overhead conductors, underground cables, or a combination of both. The primary voltage of a distribution circuit is typically, but not limited to, 35 kV or below. Distribution circuits often contain sectionalizing equipment such as fuses, reclosers, and sectionalizers to isolate faulted sections of the circuit.

5.2 Distribution autoreclosing practices

5.2.1 Number of autoreclose attempts

There is never a reason to autoreclose an electrical circuit breaker following a trip unless there is reason to believe that the fault is no longer present on the circuit. Historically, when distribution circuit breakers would trip and result in a circuit outage, the circuit was patrolled before the circuit breaker was closed. This practice delayed restoration. Records were kept of these events. It was discovered that for 85–90% of the occurrences, no permanent faults were found. It generally became accepted to autoreclose these distribution circuit breakers. With the advent of additional protective devices available to the distribution engineer such as fuses, sectionalizers, and reclosers with which coordination was necessary, multiple autoreclose attempts were chosen.

In many areas, three autoreclose attempts were chosen. This results in four trips to lockout. This practice continued for several years.

As time went on, load increased and it became necessary that distribution source transformer size increased as well as the number of supplied feeders. It is known that when transformers are subjected to any fault on the secondary that the transformer windings are stressed. If the transformer was not designed for the exposure that is encountered in distribution operation, it is possible that autoreclosing into a fault that would allow the transformer to contribute its maximum available short circuit current could result in deformation of the windings and subsequent arc damage to the transformer core and mounting structure. Often, repeated occurrences of these stress levels resulted in transformer failure. The practice of some utilities is to block autoreclosing for close-in faults or for faults with a fault current magnitude in excess of the transformer design capability, in an effort to mitigate the cumulative effect of these severe faults.

Observation of fault events resulted in the conclusion by a number of utilities that the third autoreclose attempt was seldom successful. As source transformer size and distribution voltage increased, many engineers decided to remove the last autoreclose attempt as a means of reducing the exposure to through fault events.

5.2.2 Dead time

Several factors are important to consider before attempting to autoreclose any circuit breaker that has just tripped for a fault. An autoreclose attempt without sufficient time delay to allow the dielectric to re-establish its strength results in an unsuccessful event. The ionized-gas path created by the fault arc will start conducting again after the autoreclose, if sufficient time is not allowed for the gas to disperse.

When applied with induction disk overcurrent relays, the dead time is usually set greater than the reset time of the overcurrent relay to avoid miscoordination with downstream overcurrent relays. This is discussed in more depth in 5.4.5.

The dead times typically applied by engineers vary, based on voltage levels, stability, system configuration, and many other factors that affect each utility's philosophy. Table 1 illustrates an example of a range of reclosing dead times used at distribution voltages (less than 35 kV).

Table 1—Dead time intervals

Dead time interval	Typical setting range (s)
Initial trip to 1st reclose (R_{T1})	0–5
2nd trip to 2nd reclose (R_{T2})	11–20
3rd trip to 3rd reclose (R_{T3})	10–30

5.2.3 Lockout reset time

A reset timer can be provided in a reclosing relay that resets the relay after successful autoreclosure of the circuit interrupting device. If the autoreclosure is not successful, the relay moves to the lockout position so that the interrupting device cannot be automatically closed. The lockout condition is useful in preventing excessive wear on the interrupting device from multiple operations due to frequent transitory faults on the distribution feeder, which can be caused by wind, tree contact, or lightning during storm conditions. Lockout is also useful in preventing a circuit interrupting device from inadvertently autoreclosing when it is closed manually into a faulted distribution line. The lockout condition is automatically reset after the breaker is closed manually or remotely and remains closed for the preset period of time to assure a fault does not exist at the instant of closure.

5.2.4 Distribution bus breaker autoreclosing

For buses constructed for operation at distribution voltages, the height of bus insulators and transformer bushings and the spacing between adjacent phases of buswork are smaller than those for higher voltage buses. In open-air substations, animals that make their way into a substation are more likely to cause a short circuit on distribution buses than on higher voltage buses. These faults are temporary if the animal falls away from the bus following the incident and no permanent damage has occurred to the bus equipment.

In an attempt to restore service quickly to all customers connected to the distribution feeders supplied by the bus, it may be desirable to test the bus by autoreclosing a source to the bus after a dead time

interval sufficient for a temporary fault to clear itself. For a bus supplying a distribution network, a breaker from the weakest source of fault current can be autoreclosed first. If the breaker is not tripped back out, then the rest of the breakers connected to the bus can be autoreclosed after a period longer than required for the bus protection to detect and retrip the closed breaker.

For enclosed distribution buses built inside a switchgear row and underground distribution circuit buses, bus faults cannot be considered temporary, so no autoreclosing is recommended.

5.2.5 Delayed autoreclosing

Delayed autoreclosing may need to be considered when the upstream protection is provided by electromechanical relays or fuses and the circuit protection is provided by microprocessor-based relays, unless the microprocessor-based relays can be set to mimic the reset characteristic of the electro-mechanical relays. Without this time-delay reset feature on the microprocessor-based relay, it is possible to have the upstream device operate incorrectly, resulting in an overtrip. As an example of this, the low-set instantaneous trip on a distribution feeder is eliminated to improve *power quality* by eliminating momentary service interruptions. If an instantaneous autoreclose is used after a time-delayed trip, an additional time margin needs to be used between the operating times of protective devices in order to maintain coordination of the feeder overcurrent relays and an upstream electro-mechanical relay or fuse. By delaying an upstream protective device to coordinate with the back-to-back operation of the feeder relay, coordination is maintained with the instantaneous reclose. Delaying the autoreclosing eliminates this problem by allowing all devices time to rest before the next fault.

Delayed autoreclosing is used on circuits that have automatic sectionalizers to allow proper coordination with the distribution circuit breaker. The time-delay autoreclosing of the distribution circuit breaker needs to be set to match the programmed time intervals of the sectionalizer switches to allow successful isolation of the faulted line section.

Distribution circuits that have customer-owned generators connected to them present a special problem. In most cases, it will be necessary to delay autoreclosing to allow the customer generator to be disconnected before the circuit is re-energized from the utility source. Removal of the customer generation is normally accomplished by the operation of an underfrequency, undervoltage, or reverse power relay, which tend to have longer tripping times. As the operating time for these devices may be slower to remove the connected generator than the relays that detected and cleared the fault, autoreclosing times could need to be extended to allow these devices to operate or the function be disabled. In cases where the connected generator is comparable to the load, it may be necessary to provide additional security against energizing the generator out of synchronism. This additional security can be provided by dead-line autoreclosing logic, synchronizing check, or transfer trip protection.

5.2.6 Substation controller

A substation controller consists of an intelligent device to control operations of the circuit breakers at the distribution substation and incorporates all the techniques described in this guide so far, just as a group of electromechanical or electronic devices would. By monitoring the conditions of all the controlled breakers, the controller adds another versatile dimension to autoreclosing, which can be used to improve outage times, or the time required to restore service after an event. It can also be used for load planning purposes to block or allow autoreclosing when certain lines are out of service. The controller can react to an event, or series of events, remote to an individual circuit or bus.

The substation controller can adjust autoreclosing times or sequences for different load or voltage conditions, different outage conditions, or even for different weather conditions. This provides a finer tuning of the autoreclosing system, which can minimize outage times.

5.2.7 SCADA

Supervisory control and data acquisition (SCADA) adds yet another dimension to distribution circuit autoreclosing. Depending on the complement of installed substation devices, the control center can either receive the circuit status and remotely adjust autoreclosing depending on system conditions, or it can remotely broadcast signals that will perform autoreclosing function changes at several substations. There are many different opportunities for adapting autoreclosing once SCADA is installed in a distribution substation.

5.3 Autoreclosing coordination practices

5.3.1 Circuit reclosers

A circuit recloser is a self-contained device that can sense and interrupt fault currents as well as reclose automatically in an attempt to re-energize the line. When a recloser is substituted in a substation for a feeder circuit breaker, the IEEE recloser standards and guides should be used for application (IEEE Std C37.60-1981, IEEE Std C37.61-1973).

Protective devices are coordinated such that the device closest to the fault will operate prior to any other upstream device locking out. This practice serves to limit fault-induced service interruptions to the fewest possible customers. Autoreclosing practices impact on the coordination of series connected protective devices. During the dead time of an autoreclosing cycle, the backup device begins to reset if it is a relay or cool if it is a fuse. Depending on the length of dead time provided, however, complete resetting of the backup relay or cooling of the backup fuse may not occur. The shorter the dead time, the less resetting or cooling is allowed. This effect needs to be taken into consideration when setting the associated protective devices and autoreclosing schedules in order to assure that proper coordination will exist.

5.3.2 Sectionalizers

A sectionalizer is a protective device, used in conjunction with a recloser, or breaker and reclosing relay, which isolates faulted sections of lines. The sectionalizer does not interrupt fault current. Instead, it counts the number of operations of the interrupting device upstream and opens while the interrupting device is open.

Reclosing relays and automatic sectionalizing equipment are used together to isolate a faulted portion of a distribution circuit. After the downstream line sectionalizer has operated, the reclosing relay at the substation should have one autoreclosing cycle left to re-energize the unfaulted section of the circuit. It should be noted that line sectionalizers are not intended to operate at any time when the circuit is actually energized. The line sectionalizer operates its contacts only during the time that the circuit is de-energized. The actual making and breaking of the current is accomplished by the circuit breaker.

If the sectionalizing sequence is to be successful, the autoreclosing times associated with the feeder breakers need to coordinate with the line sectionalizer on the distribution circuit. Various types of sectionalizing equipment and numerous sectionalizing schemes exist on distribution systems. The intent here is to discuss two of these sectionalizing schemes and the coordination required between the reclosing relay and the sectionalizing equipment.

The pulse-counting sectionalizing scheme utilizes a downstream line sectionalizer that counts the number of high current pulses that pass through it. After a predetermined number of high current pulses (typically two), it will open on the next loss of voltage when the feeder breaker opens.