ECE 586b Course Project Report

Auto-Reclosing

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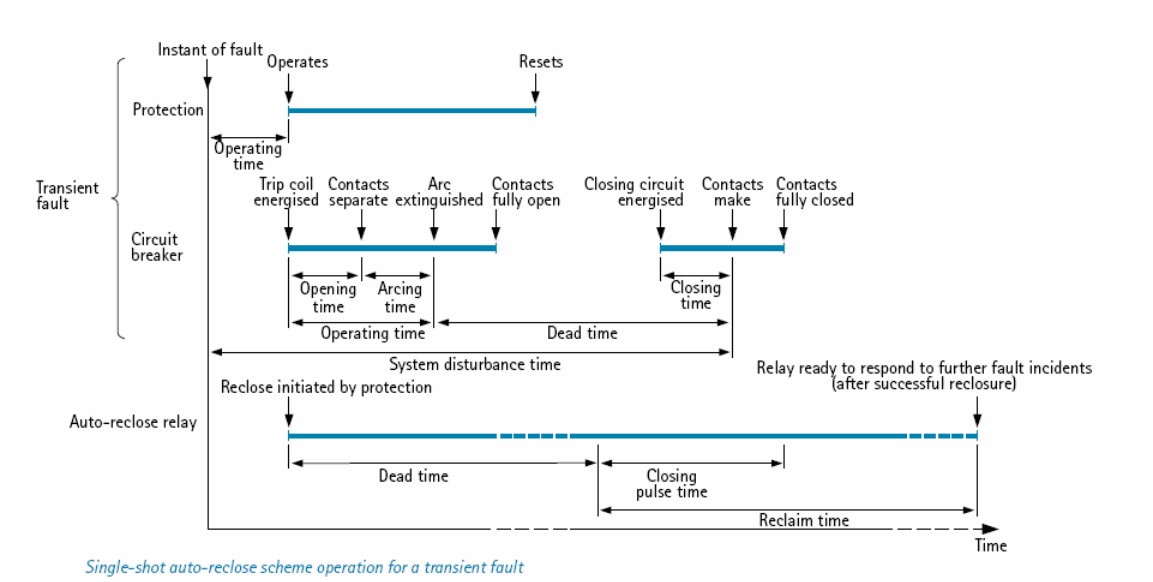
Introduction:



Single-shot auto-reclose scheme operation for a transient fault

Studies reveal that a vast majority of faults on overhead lines are transient in nature. Statistical data indicate that 80-90% of the faults are transient and the remaining 10-20% of the faults are either permanent or semi permanent faults. A transient fault is one like a lightning strike or an insulator flash over that is cleared by tripping of circuit breaker and that which does not re occur when the line is energized again. The major cause for faults is the lightning strike. The other causes could be swinging wires and temporary contact with foreign objects like tree branches. A branch falling on the line could be an example for a semi-permanent fault. This kind of fault will not be cleared by subsequent tripping and auto-reclosing but a time delayed trip will allow the branch to be burned out fully. A permanent fault is one which is not cleared by tripping and reclosing .A example for permanent fault is a broken conductor or a broken pole causing the phases to short. Normally faults on under ground cables are considered permanent in nature. In case of permanent

faults measures are needed to be taken for clearing the fault and closing the breaker again. An auto-reclose method can be used to trip the faulted line and re-energize it after an intentional time delay. This time delay is normally required for the de-energization of the fault arc otherwise the arc will restrike.This kind of auto-reclose is very beneficial especially to maintain the continuity of supply and in EHV systems to maintain system stability and synchronism.

Objective:

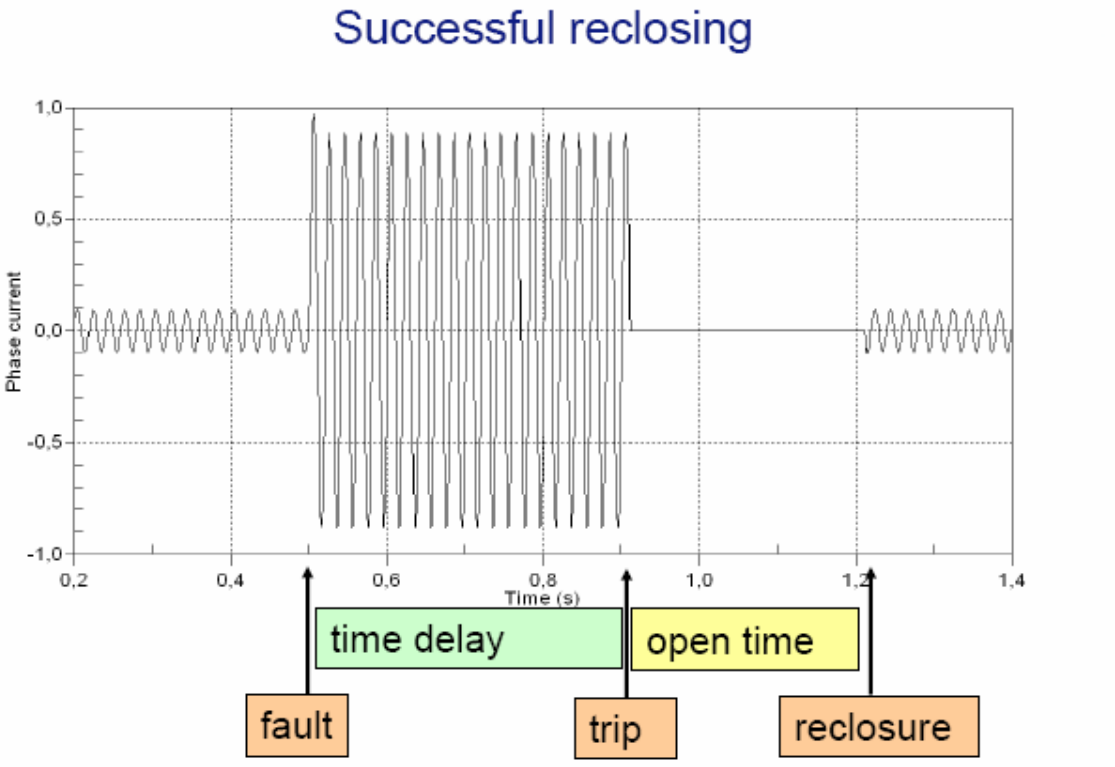
The objective of this paper is to review various protection concepts associated with auto-reclose function and also look at various parameter considerations for applying auto-reclosing to HV and EHV systems.

Background:

Auto-reclose was first applied in the early 1900's on radial feeders. The protection used in these feeders were instantaneous over current and fuses. These schemes performed the reclose function for two to three times before getting lockedout.High speed reclosing was first used by an American Electric Power System in 1935.The main idea was to reclose a single line rapidly rather than providing a second, redundant path for flow of power. High speed reclosing is applied to maintain system stability and synchronism rather than maintaining supply continuity. The reasons for applying auto-reclosing function can be summarized as follows.

1. Ensuring continuity of supply to customers by minimizing interruption.
2. Maintaining the stability and synchronism of the system.
3. Auto-reclose can be used as a method of saving fuses thereby minimizing permanent outages for transient faults beyond the fuses
4. Ability to run unmanned substations thereby reducing labor costs
5. Relieves the operator of burden especially during system outages caused by non permanent faults.
6. Delayed tripping and auto-reclosing can be sometimes employed to clear semi-permanent faults.

Definitions:



1. Auto-reclosing:

It is the closing of the circuit breaker after an automatic tripping by any protection element in order to restore the system into service. The definition excludes the automatic closing of the capacitor or reactor circuit breakers.

2. Reclosing time:

It's the time between the energizing of the circuit breaker trip coil and the actual closing of the breaker contacts.

3. Dead time:

It's the time between the circuit interruption of a breaker pole during the opening stroke and the re-establishment of the circuit during the closing stroke.

4. Reclaim time:

It's the time elapsed between the closing pulse given by relay to the breaker and the time the auto-reclose function resets ready for the next new cycle.

5. De-ionization time:

It's the time required to de-energize the fault arc in an overhead line so that arc will not restrike.

6. Operating Time :(circuit breaker)

It's the time between the energizing of the circuit breaker trip coil and the time when the fault arc is extinguished.

7. Operating Time :(Protection)

It's the time between the fault inception and the making of the relay contacts.

8. High speed reclosing:

It's the auto-reclosing of circuit breaker after an intentional time delay .The time delay is usually less than a second to allow for the deionization of the fault arc.

9. Delayed auto-reclosing:

It's the auto-reclosing of a circuit breaker after an intentional longer time delay as compared to high speed auto-reclosing.

10. Synchronism check:

It refers to the determination that acceptable voltage difference exists on the two sides of the breaker and also the phase angle difference between the two voltages is within a specified limit for a specified period of time.

11. Single shot reclosure:

Their reclosing sequence allows for only one reclose operation and lockout for subsequent tripping.

12. Multi shot reclosure:

It refers to the auto-reclosing of the circuit breaker more than once within a predetermined reclosing sequence.

General considerations for applying Auto-reclosing:

1. Turbine-generator considerations:

Closing at line terminals that are in electrical proximity to the turbine generators either manually or through auto-reclose may subject them to excessive shaft torques and winding stress. So before applying auto-reclose these effects need to be studied and evaluated. One way is to re-energize the line at the remote

terminal of the generator first and then close the breaker at the generator end.

2. Circuit breaker capability:

While applying auto-reclosing due regard should be given to the circuit breaker interrupting capability. The speed of circuit breaker operation to interrupt the fault is also important especially where stability is critical.

3. Multiple reclose operations:

When applying multishot reclosing due consideration should be given for available air or gas pressure for breaker operation.

4. Other system element considerations:

For faults on buses, transformers or cables generally autoreclosure is not applied since the probability of the fault being permanent is high and the probability of aggravating equipment damage is increased.

5. Single phase and multiphase auto-reclosing considerations:

Sometimes single phase auto-reclosing is employed where in only the faulted phase is tripped and reclosed.The advantage of using a single pole auto-reclose is that there is still exchange of synchronizing power between the healthy phases so any phase difference between the systems will be correspondingly less. Because of the capacitive coupling between the faulted and the healthy phases the fault arc takes longer time to de-ionize so the dead time should be longer than for three phase auto-reclosing.

High Speed Auto-reclose considerations:

High speed reclosing in conjugation with high speed clearing of faults is used normally to improve system stability. The following are the considerations when applying high speed auto-reclosing

1. Stability Considerations:

When high speed autoreclosure is used as a means for increasing transient stability. It should be recognized that there is a risk as well as possible benefit attending its use. The risk is that stability is endangered if a line is reclosed on to a permanent fault. So stability studies should be performed before applying high speed auto-reclose.If these studies indicate that reclosing following a specific type of fault or system condition would result in an unacceptable system condition then high speed auto reclosing should not be used or it should be used with some intiating elements.

2. Tripping time requirements:

The high speed auto-reclosing requires that all the terminals of the line are tripped instantaneously without any time delay. Any time during which one breaker is tripped in advance of the other breaker represents a effective reduction in the dead time and may jeopardize the chances of successful autoreclosure

3. Switching Surge Considerations:

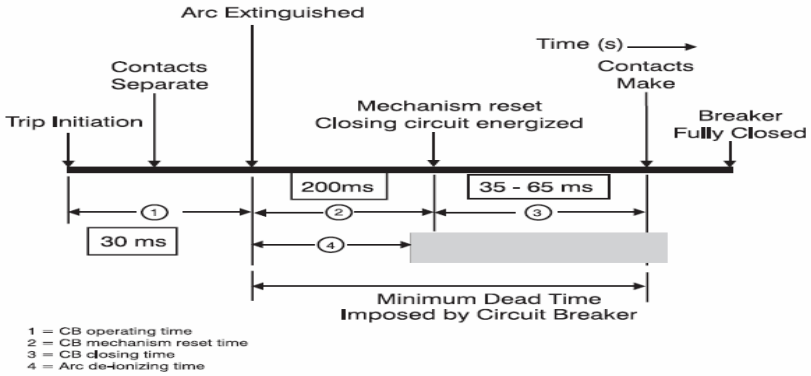
High speed reclosing should not be used where transient voltage analysis studies indicate that high speed auto-reclosing may produce switching surge magnitudes exceeding the equipment design levels.

4. De-ionization of Arc Path:

The time duration for which the line has to be de-energized is very important factor to be considered when applying high speed auto-reclosing.This time is required for the complete deionization of the fault arc. The deionization time required depends on the circuit voltage, conductor spacing, fault current magnitude and weather conditions.

5. Choice of dead time:

5.1 Arc de-ionization time:



Arc De-ionization Time Longer Than Breaker Dead Time

The dead time setting on high-speed auto-reclosing relay used on transmission lines should be longer to allow complete arc de-ionization. It should be noted that at some time the de-ionization time is longer than the breaker dead time. For these conditions additional dead time must be introduced outside breaker.

5.2 System stability and synchronism:

While applying high speed auto-reclose is applied the dead time should be kept minimum so that reclose is achieved without the loss of system synchronism .Also the dead time must be sufficient to allow for complete fault arc de-ionization.

5.3 Choice of reclaim time:

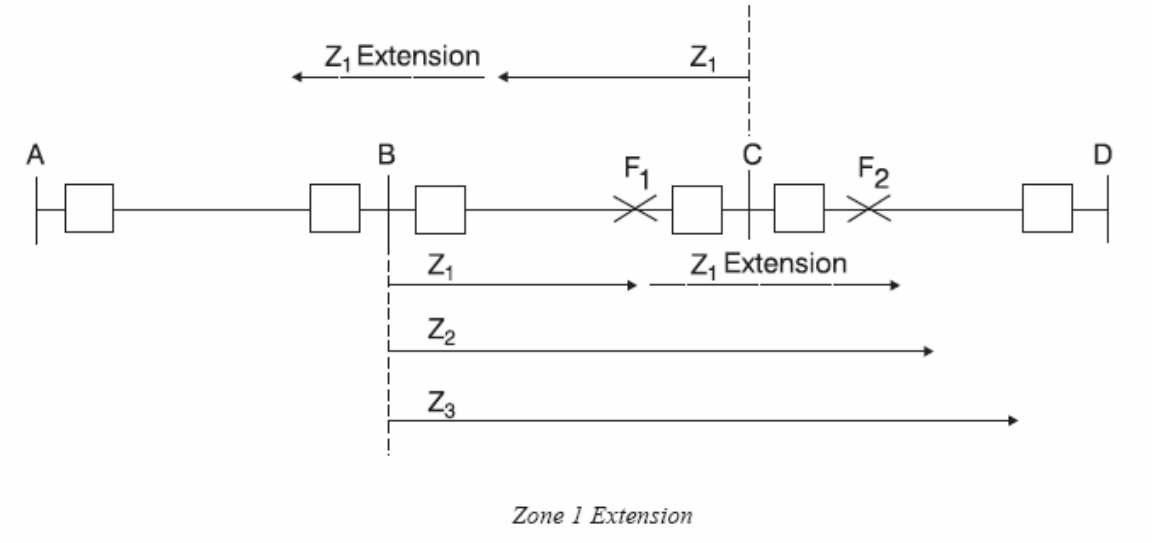
The choice of reclaim time should be kept long enough for the protection to trip and lock out for a permanent fault. But in some cases where the incidence of transient faults are more it's advisable to have shorter reclaim times since the use of longer reclaim times causes the breaker to trip and lock out for a second transient fault within the reclaim time.

5.4 Circuit breaker operating time:

Circuit breakers usually have their time delays associated with tripping and reclosing operation. These times vary based on the type of circuit breaker used. These times need to be considered when applying high speed auto-reclosing.

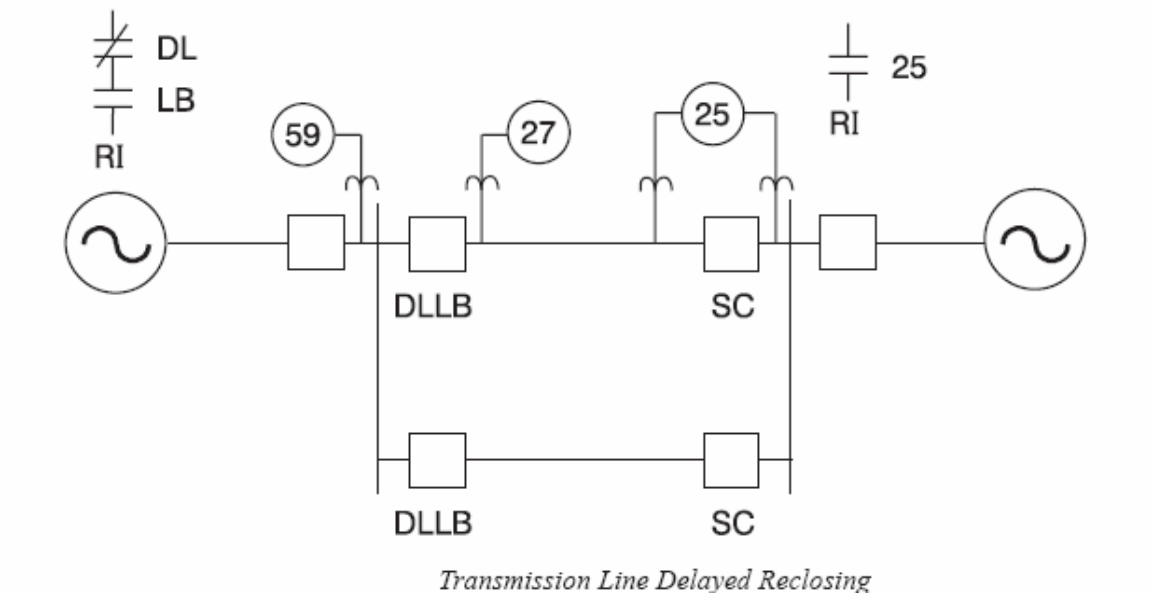
High speed auto-reclosing on lines with distance protection:

When applying high speed auto-reclosing to lines with distance protection, simultaneous tripping at the both ends of the line is important. This is normally accomplished using signaling channels (Pilot protection).Another method is using zone 1 extension scheme .In this method zone one reach is normally set to cover 120% of line .When fault occurs anywhere in the protected line breakers at both ends are tripped simultaneously without time delay and reclosed.A contact from reclose relay is used to reset the zone to 80% of line so that if the fault is permanent the breakers will be tripped based on the respective zone timers when reclosed.



Zone 1 Extension

Delayed Auto-reclosing considerations:



Transmission Line Delayed Reclosing

Normally in highly interconnected transmission systems the loss of a single line doesn't cause the loss of synchronism between the two ends .Time delayed auto-reclosing can be applied in such systems .In time delayed auto-reclosing schemes, the dead times are normally set long enough for any power swings on the system to settle down before attempting to reclose.Thus the problems of fault arc de-ionization times and circuit breaker operating characteristics

are eliminated. Its usual practice to use a check synchronizing relay in reclosing scheme when applying the time delayed auto-reclose schemes. This done to ensure that there is no considerable voltage/and or phase difference between the two ends of the lines. When applying time delayed auto-reclosing function to distance protection schemes where the line is fed from both ends it is usual practice to close the breaker at one end first , a process know as dead line charging.Reclosing on the other end is under the control of check synchronism relay , process know as live line charging.

Auto-reclosing blocking conditions:

Auto-reclosing is normally blocked for the following conditions,

1. Reception of transfer trip
2. Manual trip operations
3. Operation of breaker failure protection
4. Hot line maintenance
5. Bus faults Bus differential protection operation
6. Transformer faults-transformer differential protection relay operation
7. Faults on under ground cables
8. Out of step condition
9. Underfrequency/overfrequency load shedding trips

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