
# EEE340 Protective Relaying

Lecture 15 – Autoreclosure 2

# Today

- Autoreclosure 2
  - Single Shot Three Pole Autoreclosure for Double Sources System
  - Time Setting for Reclosing

# Single Shot Three Pole Autoreclosure for Double Sources System

Characteristics:

•Synchronization needs to be checked;

•Breakers of both terminals may trip at different time, reclosing needs to consider the time for fault arc to deionize.

# Working Manner

High speed reclosing:

•Reclosing within 0.5~0.6s after breakers of both sides have been disconnected;

•In short time, the difference of power angles for both sides may be not so large;

•The influence of impact current to components and system would be acceptable.

# Working Manner

Asynchronous reclosing:

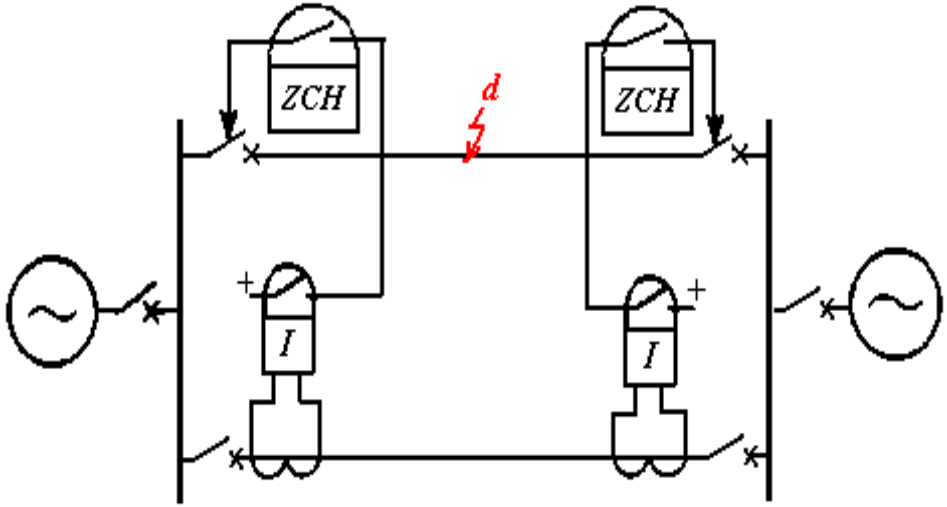
•Synchronization is not checked and considered during reclosing, synchronization should be maintained by interaction of systems themselves;

•The impact current at the reclosing moment should be under the tolerable extent of the system;

# Working Manner

Reclosing with check of synchronization:

•If the two sides are interconnected tightly, check of synchronization can be omitted;
•In case of two lines operating in parallel, current existing in the other line can be equally considered as synchronization;



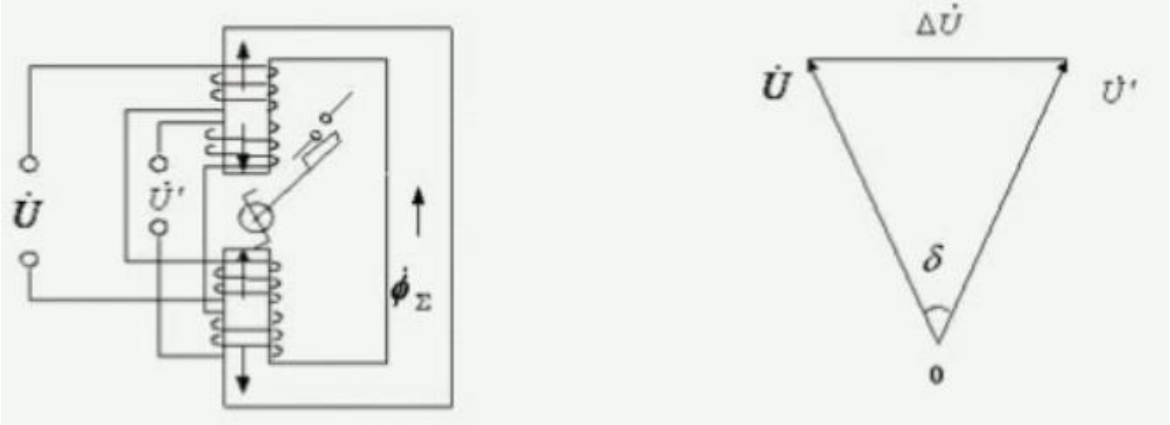
# Reclosing with Check of Synchronization

- In case of short circuit on line MN, breakers of M and N are disconnected.
- At side of N, reclosing is activated by checking no voltage on line MN, no check for synchronization is needed;
- After that, by checking if difference of voltage phase angles between line and bus at M is within acceptable range, then reclosing at breaker of M can be activated;

# Reclosing with Check of Synchronization

- Check of synchronization: the voltage phasor difference can be calculated as:

$$\Delta U = 2U \sin \frac{\delta}{2}$$




- Coordination between check of no voltage and check of synchronization:

check of no voltage + check of synchronization for one side, check of synchronization for the other side.

In case of false trip on the side with check of no voltage, check of synchronization on this side will activate reclosing.

# Reclosing with Check of Synchronization

- In case of permanent faults, the side with no voltage check will be impacted for twice, but the other side will not; so it would be better for two sides to work in turn.

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  - Coordination between Autoreclosure and Relay Protection

# Minimum Reclosing Time for Three Pole Autoreclosure of Single Source System

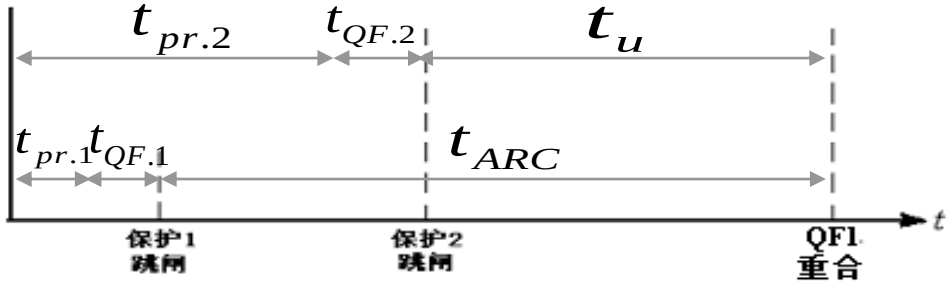
Minimum time to guarantee successful reclosing for transient faults or successful re-trip of breakers for permanent faults:

•Time for extinguishing of fault arc and the recover of insulation of surrounding medium;
•After tripping, the breaker needs time for recover of inside medium and reset of operating mechanism;
•If timing of reclosing is activated by protection, then the tripping time of breakers needs to be considered.

For system with double sources, besides the former conditions, the tripping time of the other side should be supposed slower than this side.

# Minimum Reclosing Time for Three Pole Autoreclosure of Double Sources System

It is supposed that the protection of this side trips earlier and the other side trips after.




$$t_{ARC.1} = t_{pr.2} + t_{QF.2} - t_{pr.1} - t_{QF.1} + t_u$$

$t_{pr.1}$ : Operating time of protection 1;
$t_{QF.1}$ : Operating time of breaker 1;
$t_{pr.2}$ : Operating time of protection 2;
$t_{QF.2}$ : Operating time of breaker 2;
$t_u$ : Time for fault arc to deionize and be extinguished;
$t_{ARC.1}$ : Time of reclosing for protection 1.

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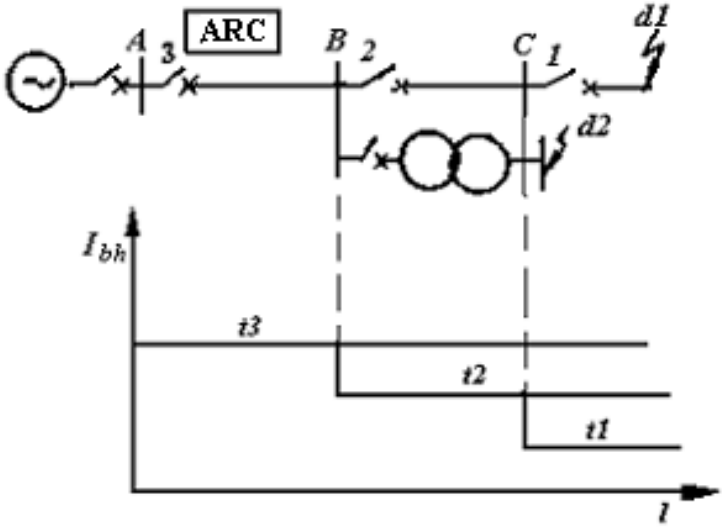
  - Single Pole Autoreclosure for HV Transmission Lines

# Instant Accelerated Protection Trip

- For any fault at any location, protection 3 will trip without time delay, reclosing will be activated after tripping of breaker.
- In case of reclosing to transient fault, power supply will be recovered, non-selectivity is corrected by reclosing.
- In case of reclosing to permanent fault, the second tripping will be selective by corresponding protection.



# Instant Accelerated Protection Trip

Advantages:

•Fast clearance of transient faults;

•The time for transient faults is not enough to develop to permanent faults;

•To ensure power quality to power plants and important loads;

•Only one set of autoreclosure is needed, more economical.

Defects:

•The breaker may trip more frequently with worse conditions;

•Incase of reclosing to permanent faults, the clearance time may be longer;

•In case of failure of reclosing, the scope of no electricity may be enlarged.

# Delayed Accelerated Protection Trip

- Protection with selectivity and ARC are installed at each line;
- In case of faults, the protections will operate according to selectivity;
- In case of permanent fault, the operating of protection will be accelerated to clear the fault again.

Advantages:

•The first tripping of protection is selective, scope of no electricity is not enlarged;

•Permanent fault can be cleared instantly with selectivity;

•No limits from system structure and load conditions;

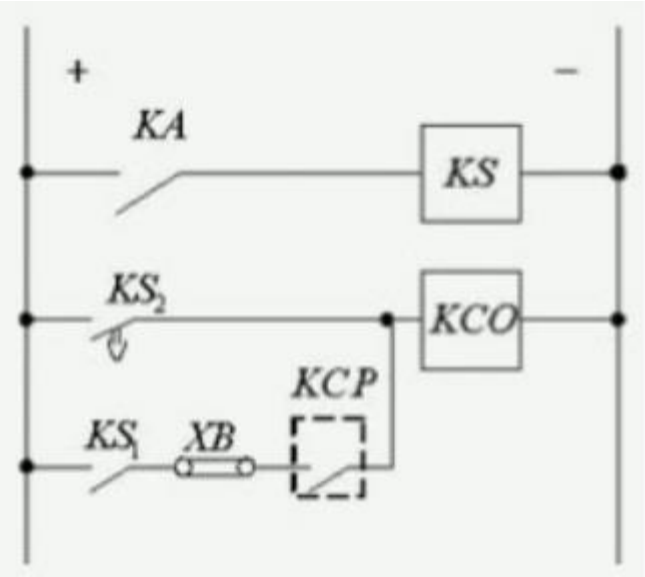
Defects:

•ARC is needed for each breaker, more complicated;

•Possible time delay for first tripping ;

# Delayed Accelerated Protection Trip

• KA: contactor of overcurrent relay, which can activate timing relay KS in case of faults;
• KS: Timing relay, which will close KS2 after preset time delay to trip KCO to disconnect breaker;
• After reclosing is activated, KCP will be closed for 1s;
• In case of reclosing to permanent fault, KA will operate again, instant contactor of KS1 can activate KCO instantly to trip the breaker.



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# Single Pole Autoreclosure for HV Transmission Lines

Characteristics of faults:

- Majority is overhead transmission lines;
- Most faults of overhead lines are single line-to-ground faults, over 90%;
- If only the faulted phase is disconnected, the power supply reliability and stability can be significantly improved.

Working manner:

Faults of single phase => only the faulted phase is disconnected by breaker => reclosing the faulted phase after preseted time delay:

1. In case of transient faults, power supply recovered;
2. In case of permanent faults, disconnect three phases with no more reclosing;
3. No reclosing for phase-to-phase faults.

# Single Pole Autoreclosure for HV Transmission Lines

Technical requirements:

- Be able to distinguish and select the faulted phase;
- Breaker can be operated for each phase respectively;

Technical challenges:

- During reclosing, open-phase operation may cause zero and negative sequence components;
- The zero and negative sequence components may cause false trip of relevant protections;

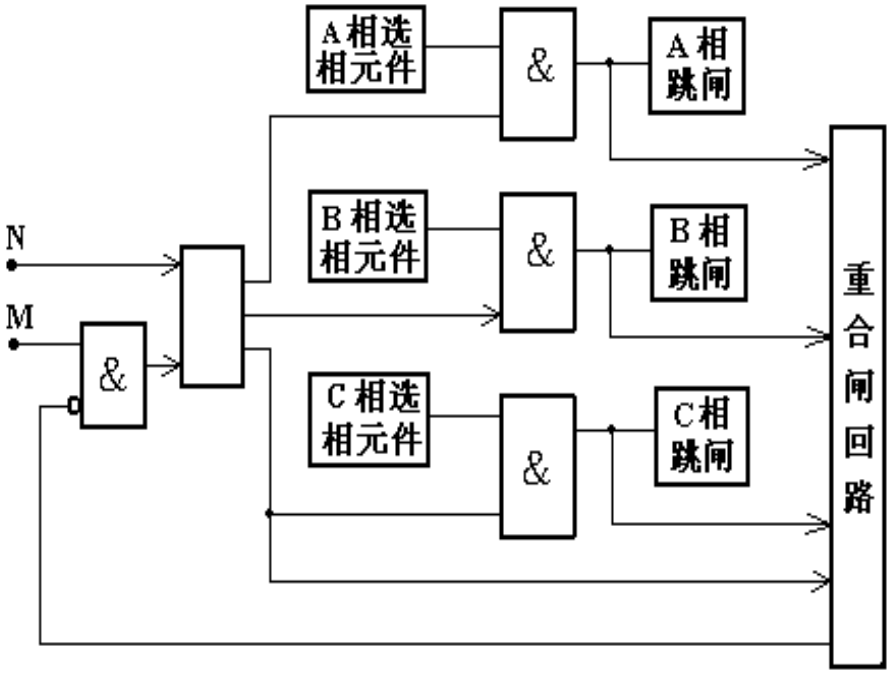
# Single Pole Autoreclosure for HV Transmission Lines

Solutions:

• During single pole autoreclosure, protections with possible false trip should be blocked;

• N terminal: protections which are not sensitive to open-phase operation;

• M terminal: protections which should be blocked during open-phase operation;



# Fault-phase Selector

To distinguish and select the faulted phase:

- Selectivity: to only trip the faulted phase;
- Sensitivity: to be enough sensitive for faults at the end of single phase;

Principles:

- Overcurrent relays on each phase is set higher than maximum load current; the current of faulted phase should increase significantly;
- Low-voltage relays on each phase is set lower than the minimum voltage of normal or open-phase operation, the faulted phase should have lower voltage;
- Select by impedance;
- Select by sudden change of difference of phase currents.

# Minimum Reclosing Time for Single Pole Autoreclore

Special factors to be considered:

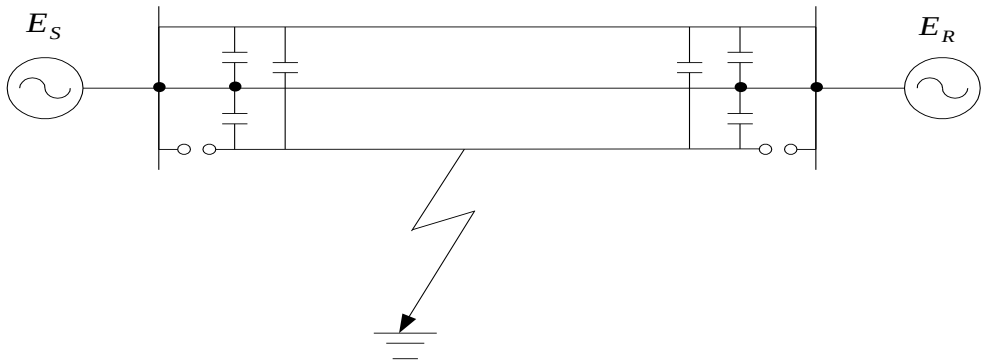
• Different time for selectors and protections of both sides to clear the fault;

• Influence of secondary arc current;

Secondary arc current:

• During single pole autoreclosure, the normal operating phases may supply current to the fault location through electrical and magnetic coupling.

• The secondary arc current may extend the time for fault arc to deionize and be extinguished. So the operating time for single pole autoreclosure is longer than three pole autoreclosure.



# Evaluation for Single Pole Autoreclosure

Advantages:

• Power supply reliability can be significantly improved;

• For systems with double sources, it can significantly improve the stability of system operation;

Defects:

• Breakers must be able to operate on each phase respetively;

• Fault-phase selector is needed, connection is complicated;

• Some protections may make false trip during open-phase operation, which makes setting and test more complicated;

# Adaptive Single Pole Autoreclosure

Defects of normal reclosing:

- No distinguish for transient and permanent faults;
- In case of permanent faults, system will be impacted for twice;

Adaptive Autoreclosure:

- To make decision for reclosing or not according to fault conditions;
- Reclosing in case of transient faults, no reclosing in case of permanent faults;
- The key challenge is to distinguish transient and permanent faults;
- After disconnection, the voltage of faulted phase depends on if it is connected to ground; lower voltage if connected to ground, higher voltage if not connected to ground.

# Next Lecture

Power Transformer
Protection 1

Thanks for your attendance