

PROTECTIVE DEVICES AND COORDINATION



CONTENTS

- INTRODUCTION
 - OBJECTIVES OF DISTRIBUTION SYSTEM PROTECTION
 - OVER CURRENT PROTECTION DEVICES
 - FUSE
 - CIRCUIT BREAKERS
 - AUTOMATIC CIRCUIT RECLOSERS
 - AUTOMATIC LINE SECTIONALIZER
 - CO-ORDINATION OF PROTECTIVE DEVICES
 - TYPES OF CO-ORDINATION
- 

INTRODUCTION

- Power system is subjected to faults and transients. These will result in over currents and over voltages that can cause damage to conductors as well insulation. That result in equipment loss and system failure.
- In distribution systems the main devices for over current or fault current protection are fuses and circuit breakers. In addition to these over voltage protection devices and relays are also employed.

- The modern power system is complex and even though protection equipment from 4 to 5% of the total cost involved in the system, they play a very important role in the system design for good quality and reliability.

OBJECTIVES OF DISTRIBUTION SYSTEM PROTECTION

- Minimize the fault duration
- Minimize the number of consumer effected by the fault
- Eliminates the safety hazards as fast as possible
- minimize the service failure to the smallest possible branch in the distribution system
- To discriminate between over loading, short circuit and very temporary faulty.

OVER CURRENT PROTECTION DEVICES

These include

- Fuses
- Relay controlled circuit breakers
- automatic circuit reclosers
- automatic line sectionalisers

Fuse

- A fuse is a type of low resistance resistor that acts as a sacrificial device to provide overcurrent protection, of either the load or source circuit.
- Its essential component is a metal wire or strip that melts when too much current flows through it, interrupting the circuit that it connects.
- The fuse element is generally made of materials having low melting point, high conductivity and least deterioration due to oxidation e.g. Silver, copper etc



Fuse

Advantages

- Cheapest form of protection available.
- Requires no maintenance
- Break heavy short circuit current without noise and smoke
- The minimum time of operation that can be made much shorter than that of the circuit breaker

Fuse

Disadvantages

- Considerable time is required in removing and replacing a fuse after operation.
- the current time characteristics of a fuse can not be correlated that of protected apparatus.

Circuit breakers

- These are the devices that can carry and interrupt normal load current, like switches; in addition, they interrupt short-circuit (fault) current.
- Circuit breakers are always paired with a relay which senses short-circuit condition using potential transformers (PTs) and current transformers (CTs).



- a circuit breaker is essentially consist of fixed and moving contacts called electrodes.
- Under normal operating conditions, these contacts remain closed and will not open automatically until and unless the system become faulted.
- circuit breakers are rated for low voltages (<1000 V), medium voltages (over 1000 V but less than 7200 V) and high voltages (>7200 V).

The circuit breakers used in the distribution systems are

- Air circuit breaker
- Oil circuit breaker
- Minimum oil circuit breaker
- Vacuum circuit breaker

Automatic circuit reclosers

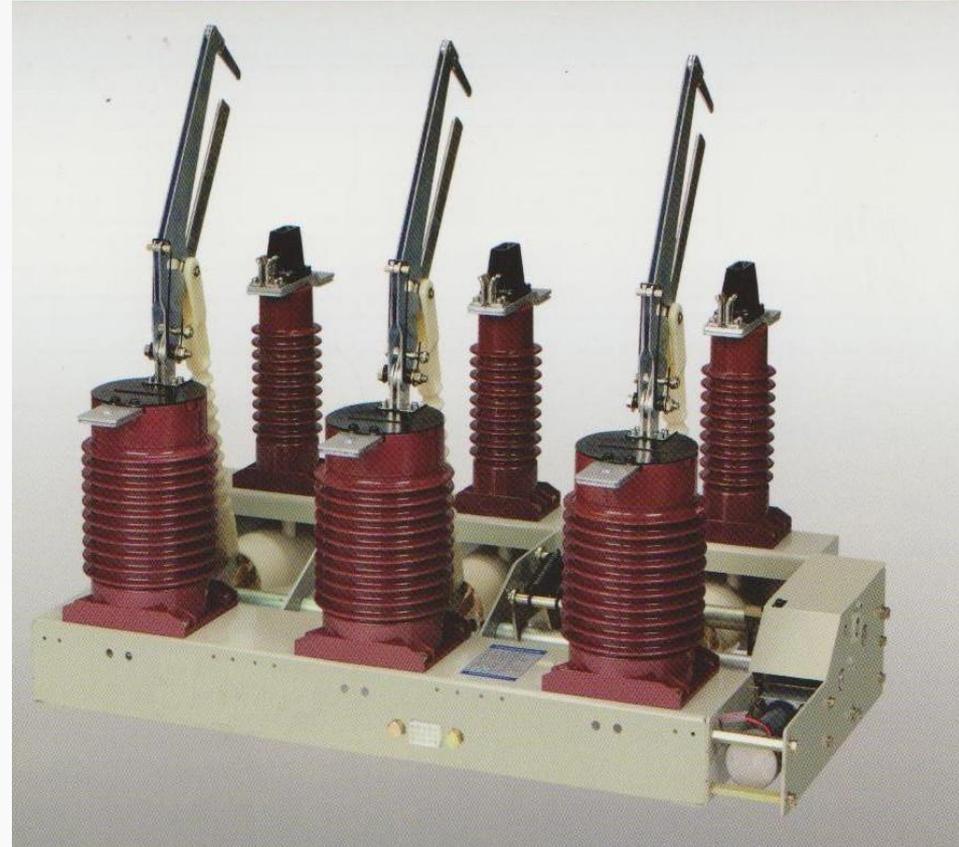
- These are the devices similar in function to circuit breakers, except they also have the ability to reclose after opening, open again, and reclose again, repeating this cycle a predetermined number of times until they lockout.



- The faults on cables are generally not temporary.
- If the temporary fault has vanished during the dead time, the auto recloser remains closed. If fault persists after first/second recloser one enclosing is attempted. If fault persists after third/final recloser, the autorecloser is opened and locked.

Automatic line sectionalizer

- 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.

Advantages

- Automatic sectionalizers are cheaper than auto reclosers.
- They may be employed for interrupting or switching loads within their rating.

CO-ORDINATION OF PROTECTIVE DEVICES

- Protective device coordination is the process of determining the "best fit" timing of current interruption when abnormal electrical conditions occur.
- The goal is to minimize an outage to the greatest extent possible.
- Historically, protective device coordination was done on translucent log–log paper. Modern methods normally include detailed computer based analysis and reporting.

- Protection coordination is also handled through dividing the power system into protective zones.
- If a fault were to occur in a given zone, necessary actions will be executed to isolate that zone from the entire system.
- Overlapped regions are created by two sets of instrument transformers and relays for each circuit breaker. They are designed for redundancy to eliminate unprotected areas.

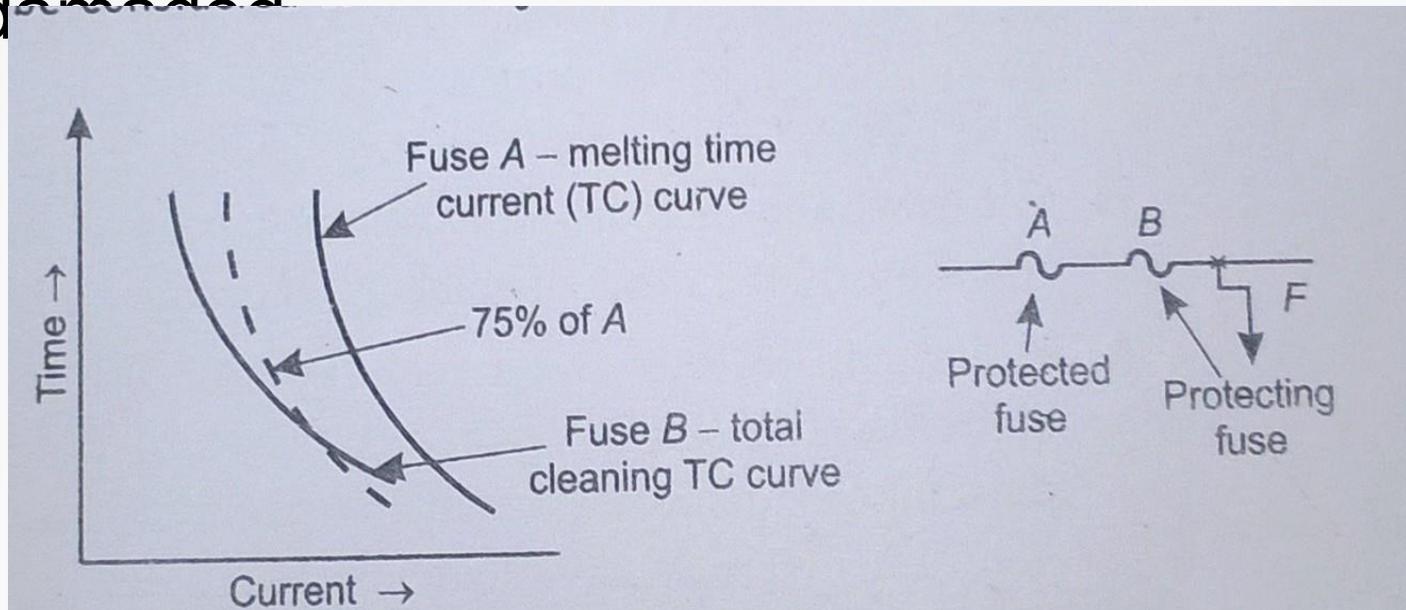
Objectives of co-ordination

- Minimize the extent of fault in order to reduce the number customers affected.
- Minimize the service interruption due to faults.
- Minimize the duration of service outages to identify the location of the fault.

- Types of co-ordination
 - Fuse to Fuse
 - Auto reclosers to Fuse
 - Circuit breaker to Fuse
 - Circuit breaker to Auto-Reclosers
- 

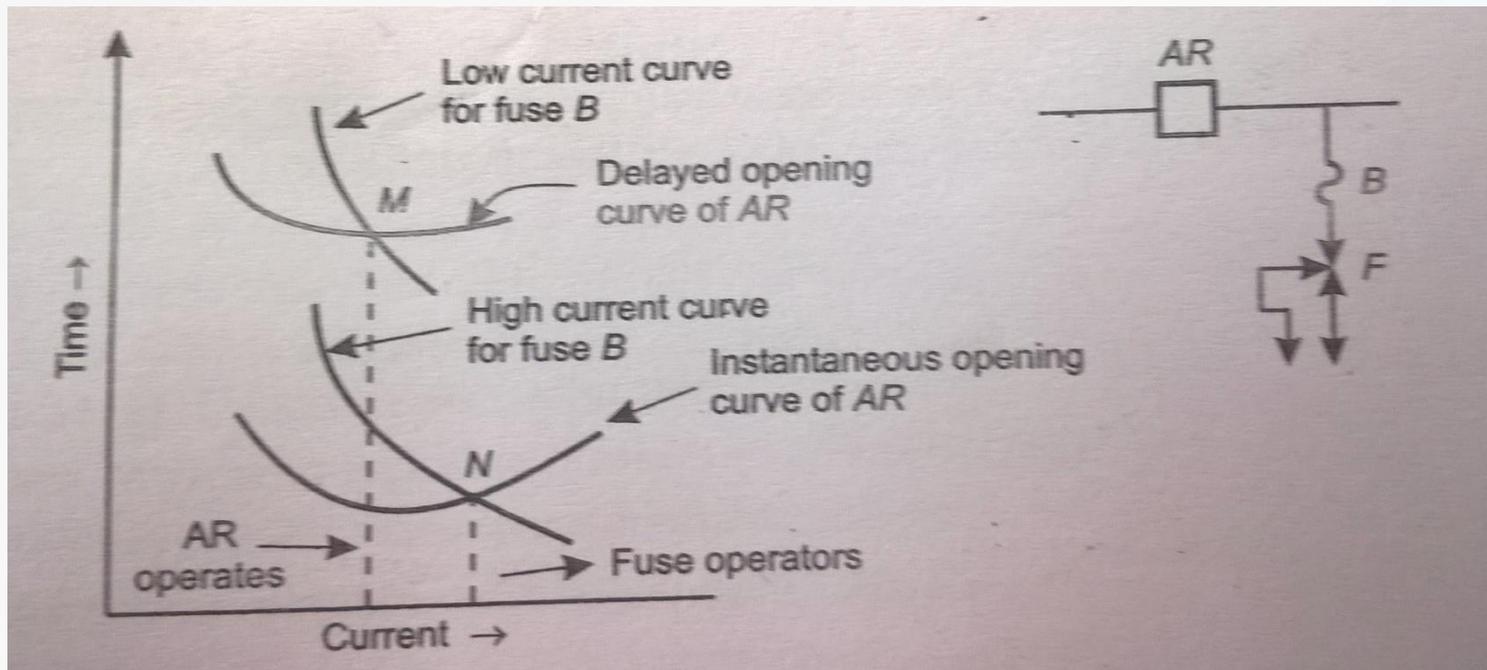
Fuse to Fuse coordination

- Fuse A is called protected fuse.
- Fuse B is called protecting fuse.
- For perfect coordination fuse B must melt and clear the fault before fuse A is damaged.



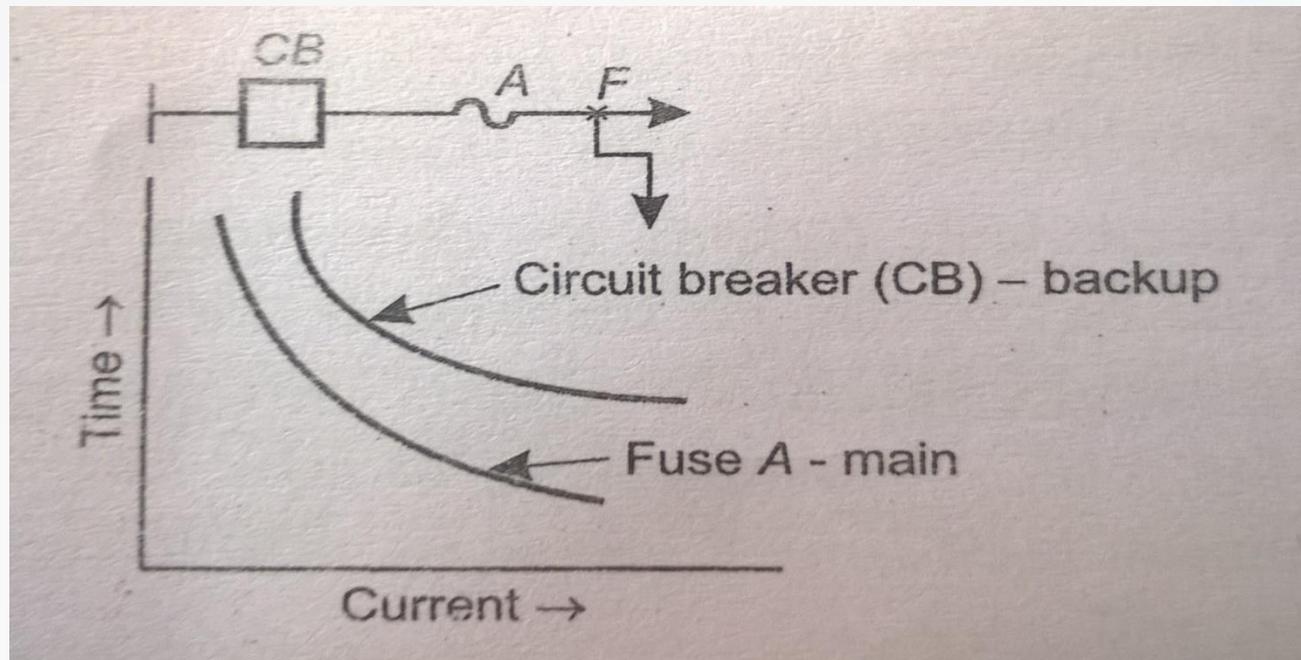
Auto reclosers to Fuse

- If the fault F beyond the fuse B is temporary, the auto recloser AR should clear it without blowing of fuse B .

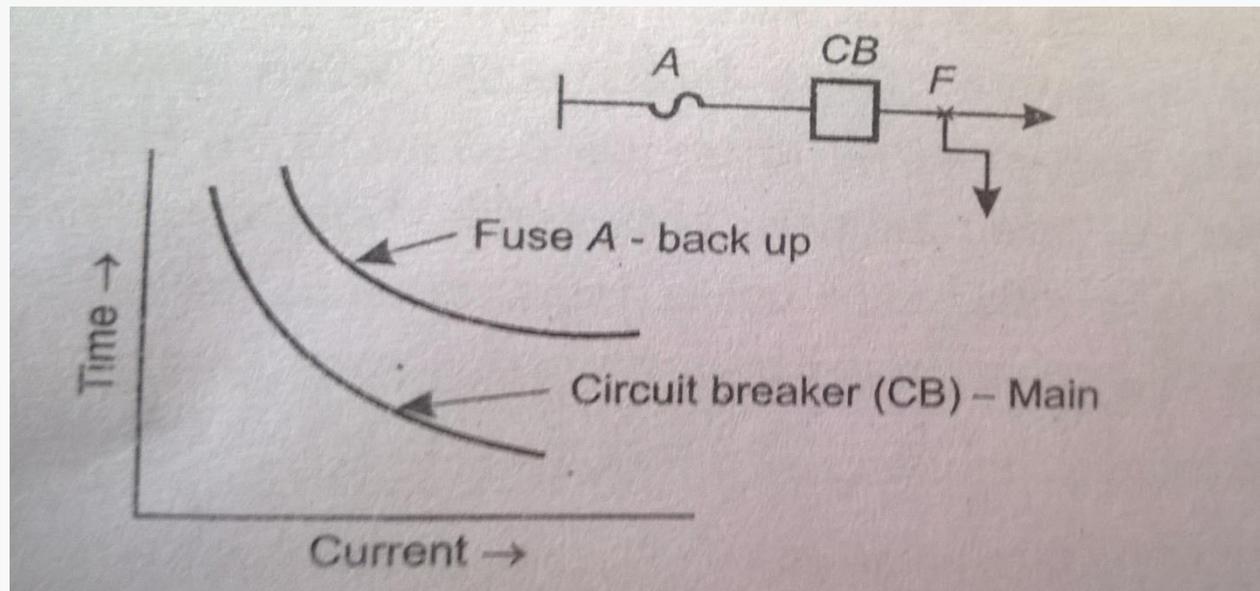


Circuit breaker to Fuse

- When fuse A is used as a main protection and circuit breaker as a back up, the operating time is selected as 150% of total operating time of the fuse of over current relays for phase to phase fault.
- Therefore the fuse A operates first and the circuit breaker operates next only if fuse fails to operate.



- If the circuit breaker provides main protection and fuse A as a backup, the relays should operate instantaneously and circuit breaker should isolate the fault before blowing the fuse.
- The minimum melting time of the fuse should be about 135% more than total fault clearing time of the circuit breaker relay combination for phase to phase faults.



Circuit breaker to Auto-Reclosers

- The circuit breaker provides a backup protection.
- The auto recloser provides main protection

