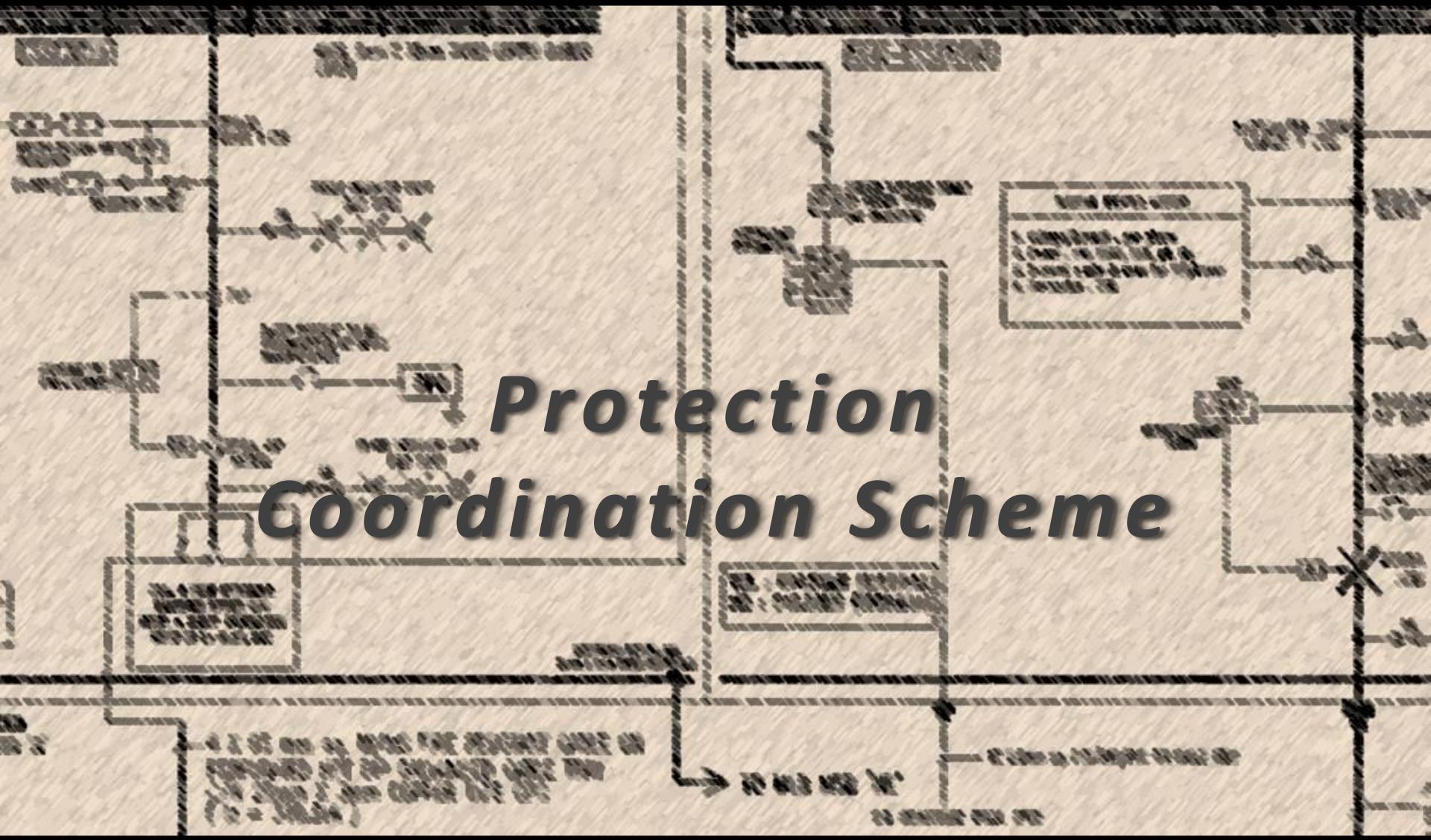


Protection Coordination Scheme

Requirement of Electrical Power Protection System

Protection Coordination

- A protection-coordination study is done **to determine the trip settings of each protective device** in the power system so that maximum protection with minimum interruption is provided for all faults that may happen in the system.
- When all the relay designs, schemes and configurations of a protection system are defined, the process of calculating the relay settings in order to make such a system coordinated is commonly called **protection coordination.**
- Engineers perform coordination studies **to assure that the protection system works according to the aforementioned philosophy.**
- Protection coordination or relay coordination, studies are **traditionally carried out using short circuit simulation programs** and relay simulation programs.
- In **traditional methods**, the relay settings are calculated using rules of thumb based on engineers' experience: faults are simulated over critical points of the system and the relays' behavior is observed for each fault. If **no coordination is achieved at one attempt, the process must be repeated as many times** as needed until the protection system works according to the coordination criteria.

Requirement of Electrical Power Protection System

The design of LV installations leads to basic protection devices being fitted for three types of faults:

- overloads
- short-circuits
- insulation faults.

1.1. Safety and availability of energy

Safety and availability of energy are the operator's prime requirements.

Coordination of protection devices ensures these needs are met at optimised cost.

Implementation of these protection devices must allow for:

- the statutory aspects, particularly relating to safety of people
- technical and economic requirements.

The chosen switchgear must:

- withstand and eliminate faults at optimised cost with respect to the necessary performance
- limit the effect of a fault to the smallest part possible of the installation in order to ensure continuity of supply.

Achievement of these objectives requires coordination of protection device performance, necessary for:

- **managing safety** and increasing durability of the installation by limiting stresses
- **managing availability** by eliminating the fault by means of the circuit-breaker immediately upstream.

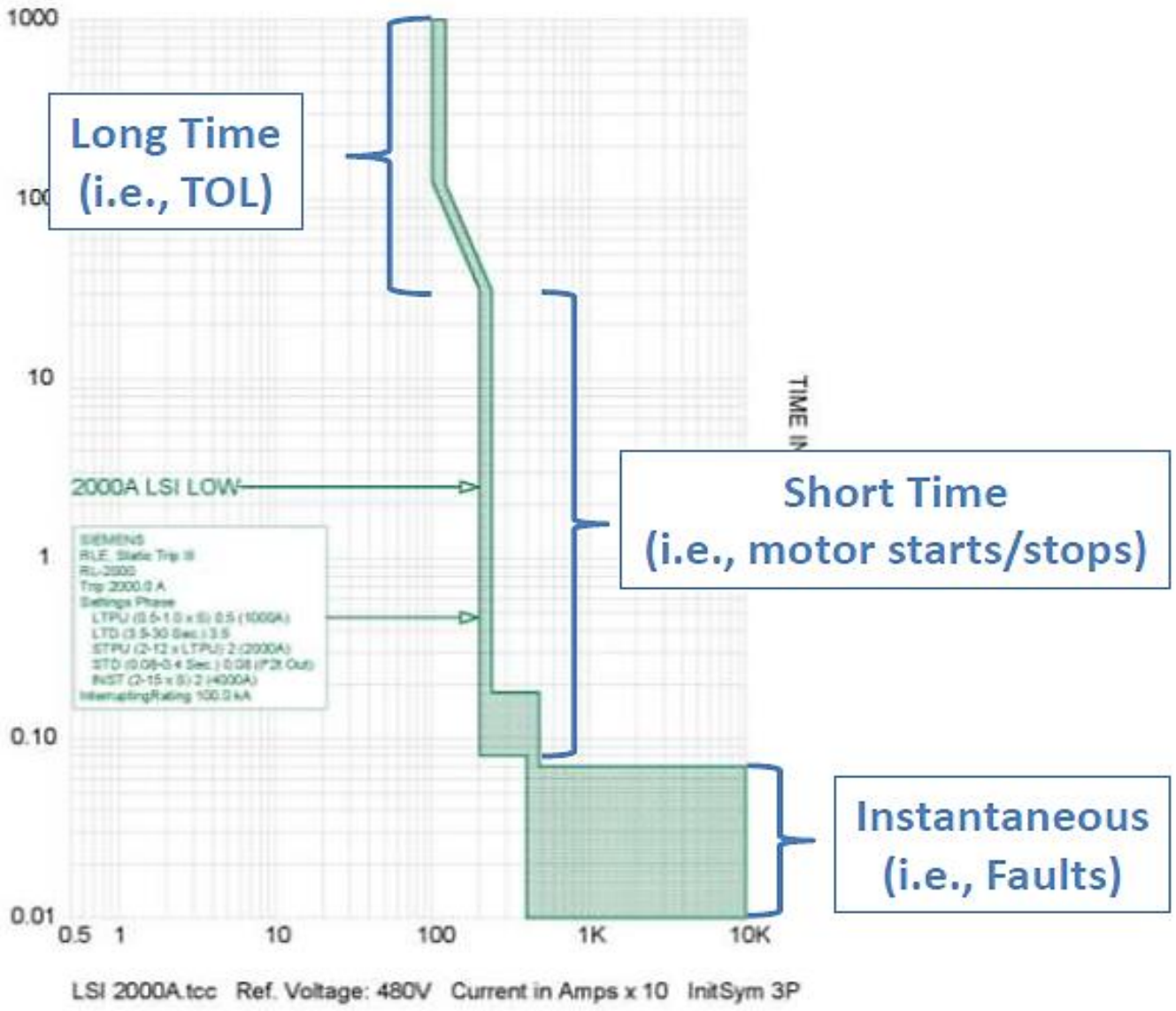
The circuit-breaker coordination means are:

- **cascading**
- **discrimination**.

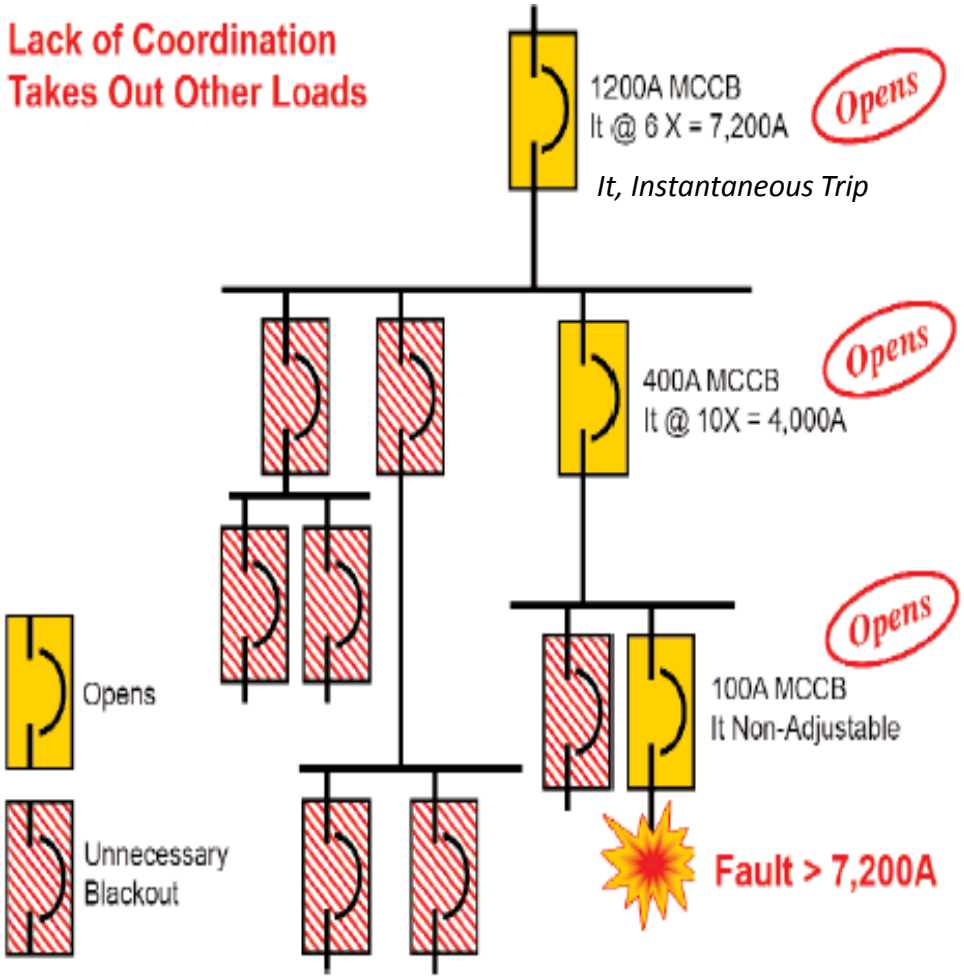
If the insulation fault is specifically dealt with by earth leakage protection devices, discrimination of the residual current devices (RCDs) must also be guaranteed.

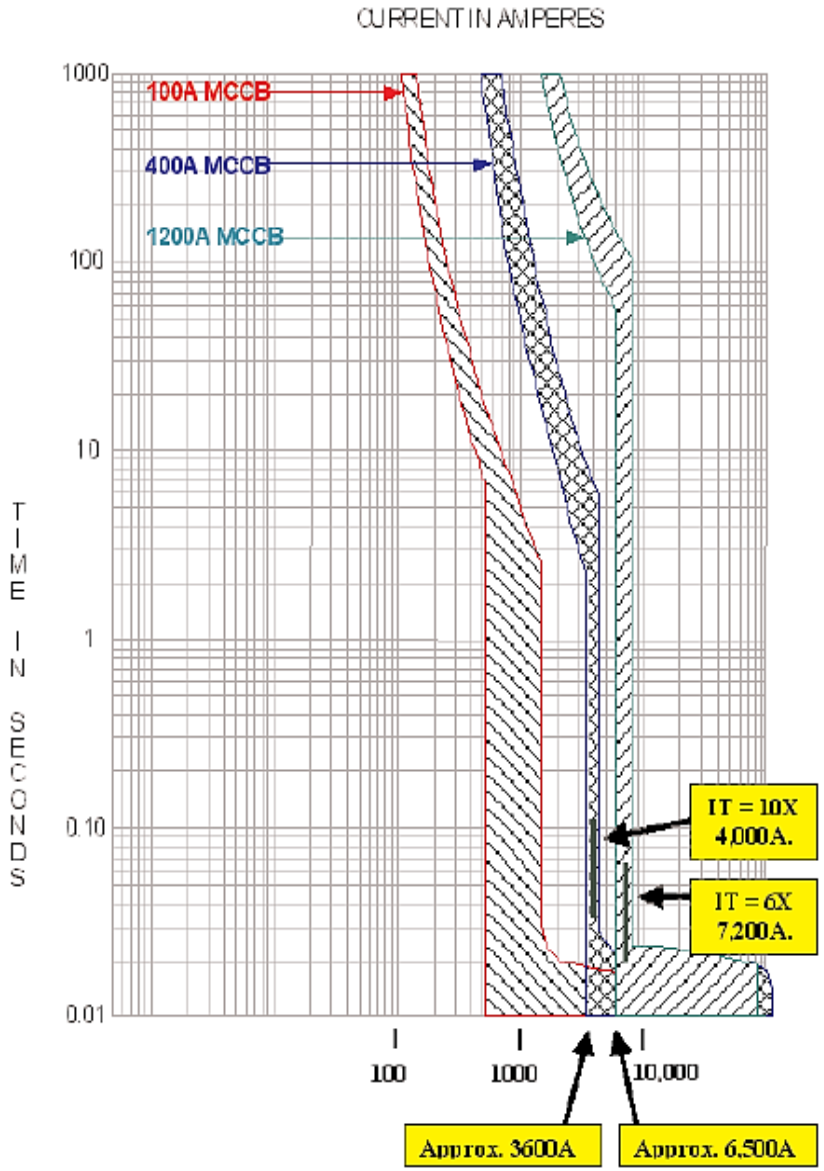
CB Coordination

Type of current condition (overload, starting, faults) and its time period.



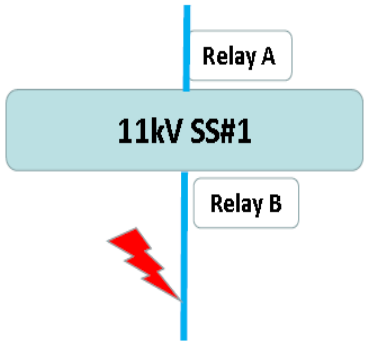
CB Coordination





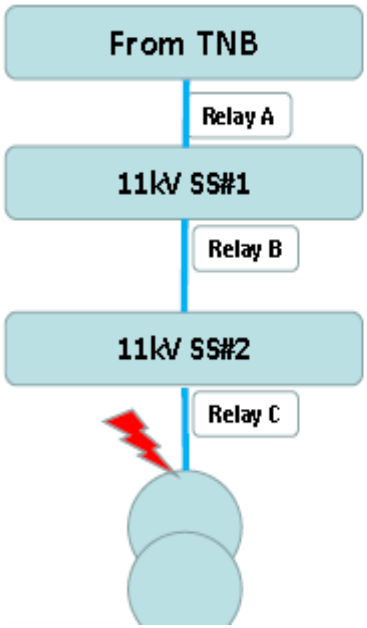
Case Study : Hi-Set

Case Study A



- Incoming Relay A with hi-set.
- Outgoing Relay B with hi-set.
- Outgoing Relay B fault, it will trip both Relay A & Relay B.

Case Study B



- Relay A without hi-set.
- Relay B with hi-set.
- Relay C with hi-set.
- TX fault, may trip both relay B & C.

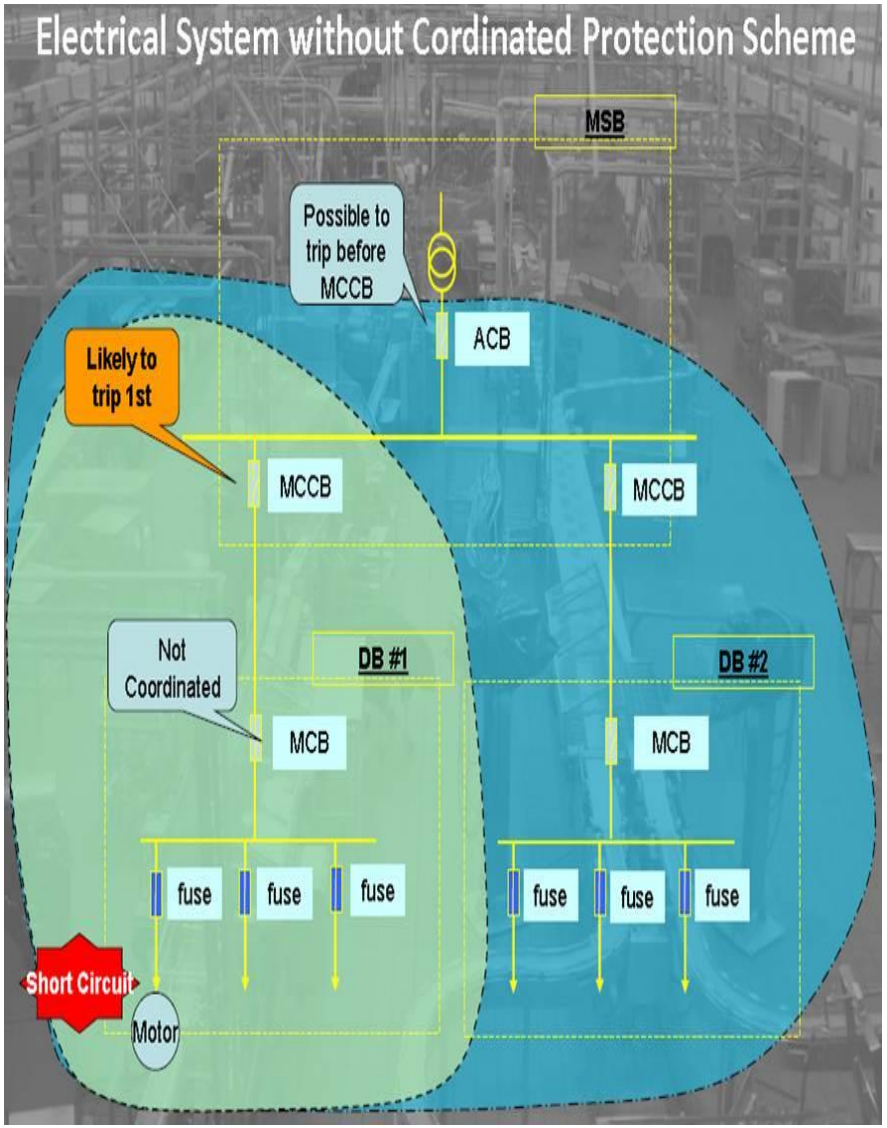
Zone Coordination Protection Scheme

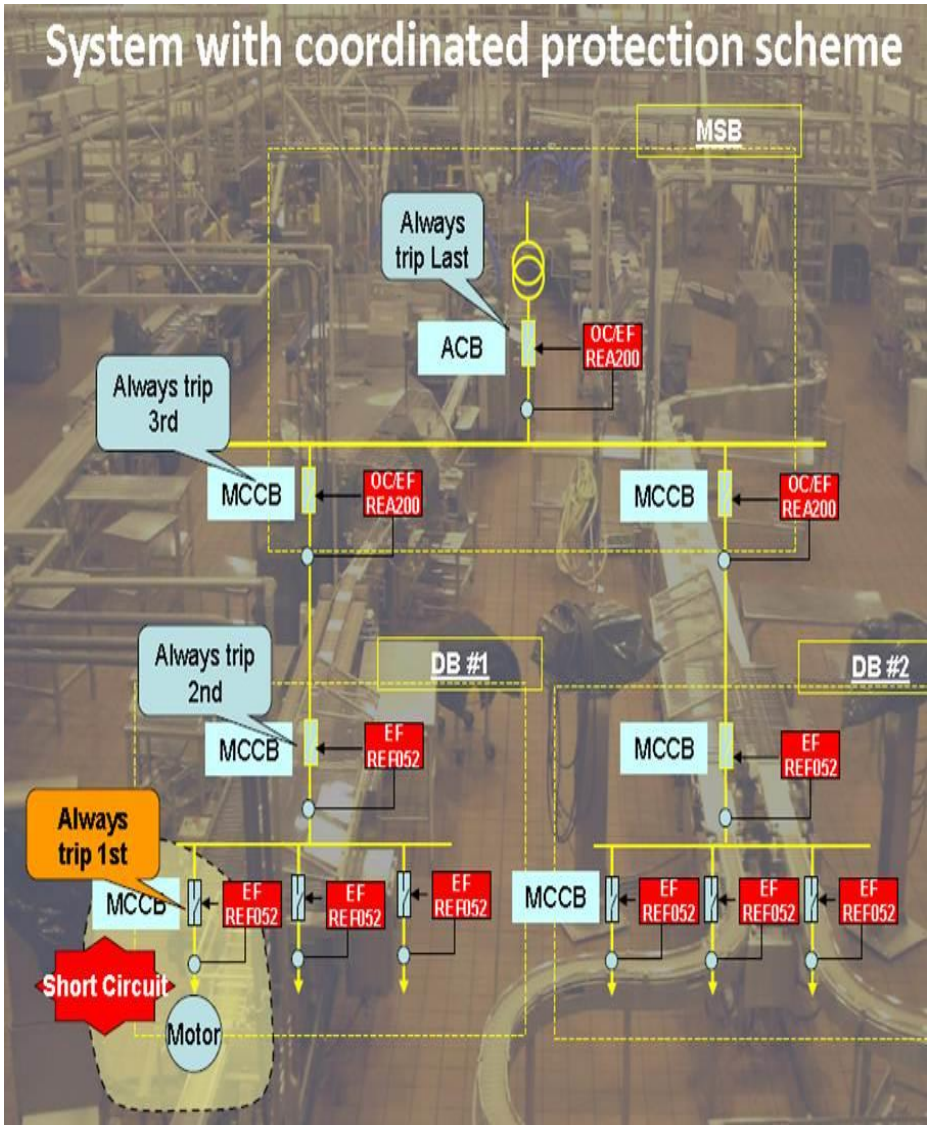
	Fault F1	Fault F2	Fault F3
Short Circuit Current	50kA	35kA	20kA

HighSet / Instantaneous

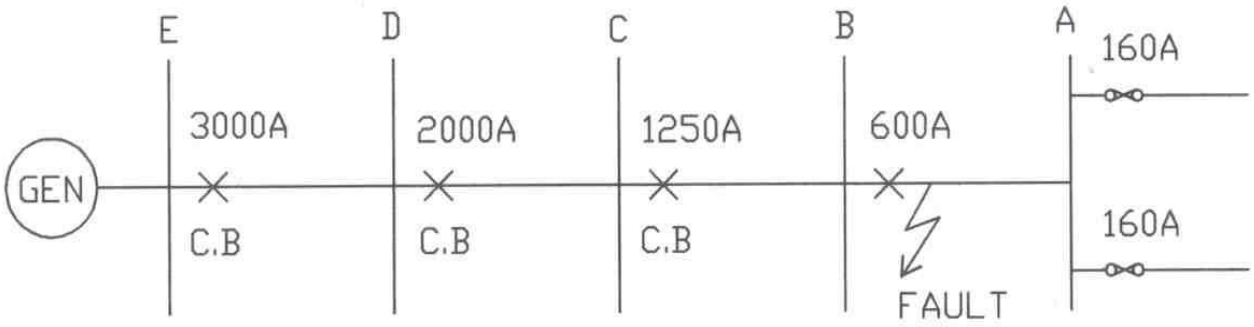
- Hi-set for overcurrent and earth fault protection **should not** be used at **incoming feeder**.
- Hi-set for overcurrent and earth fault protection **can be used** at outgoing feeder **but with care**.
- Hi-set for overcurrent and earth fault protection **recommended** at **outgoing to transformer**.

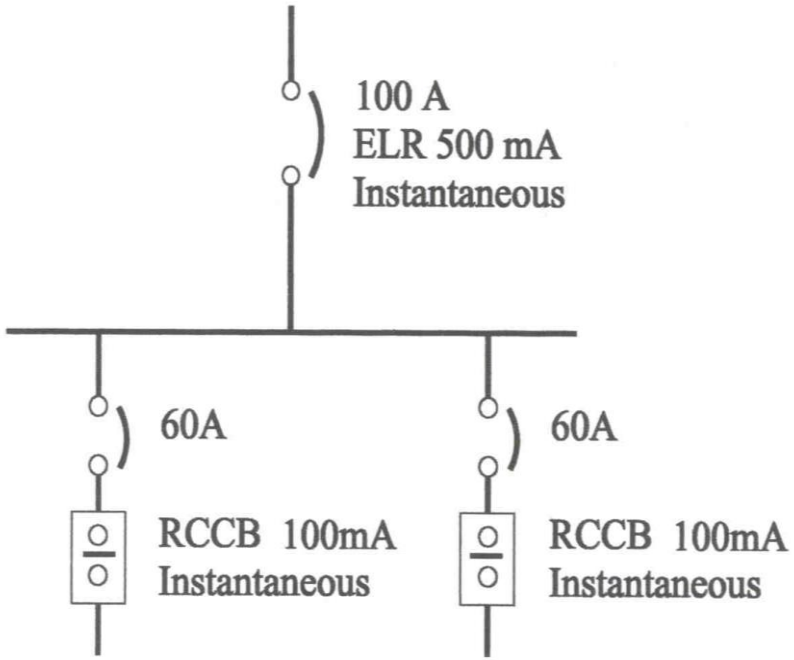
Protection Scheme Coordination





Discrimination - Current





Discrimination - Time

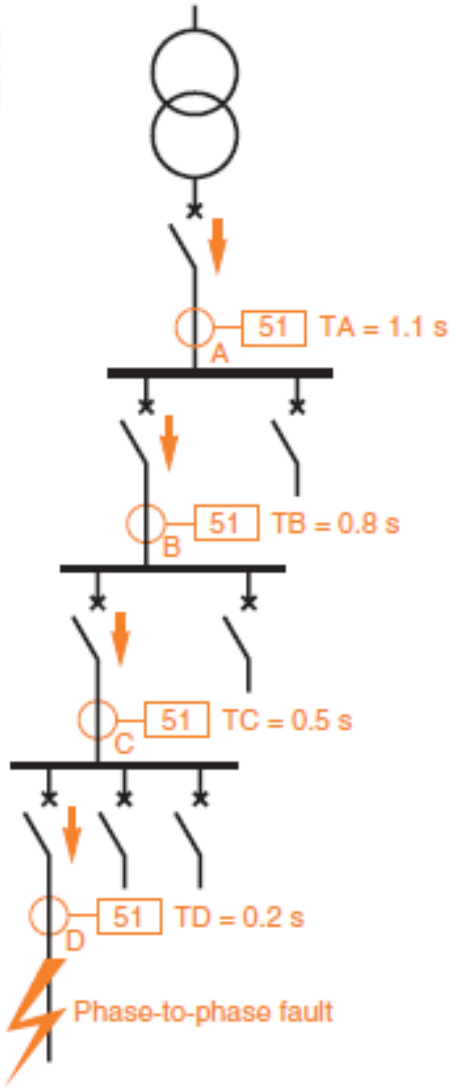


Fig. 1. Time-based discrimination principle.

Discrimination - Time

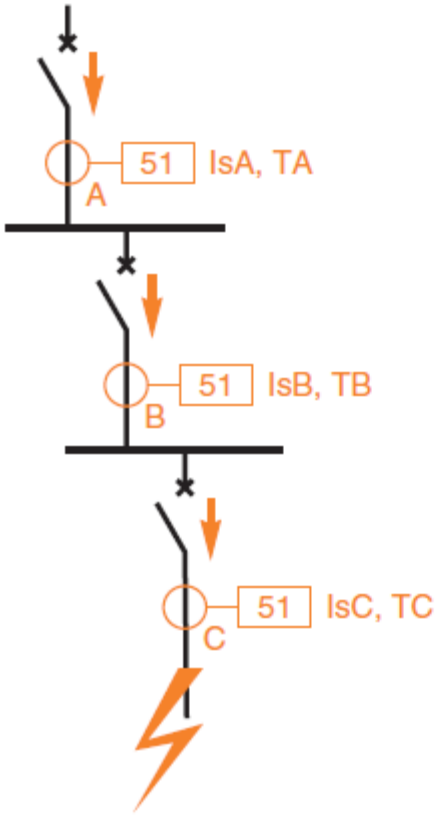


Fig. 1. Radial power system with time-based discrimination.

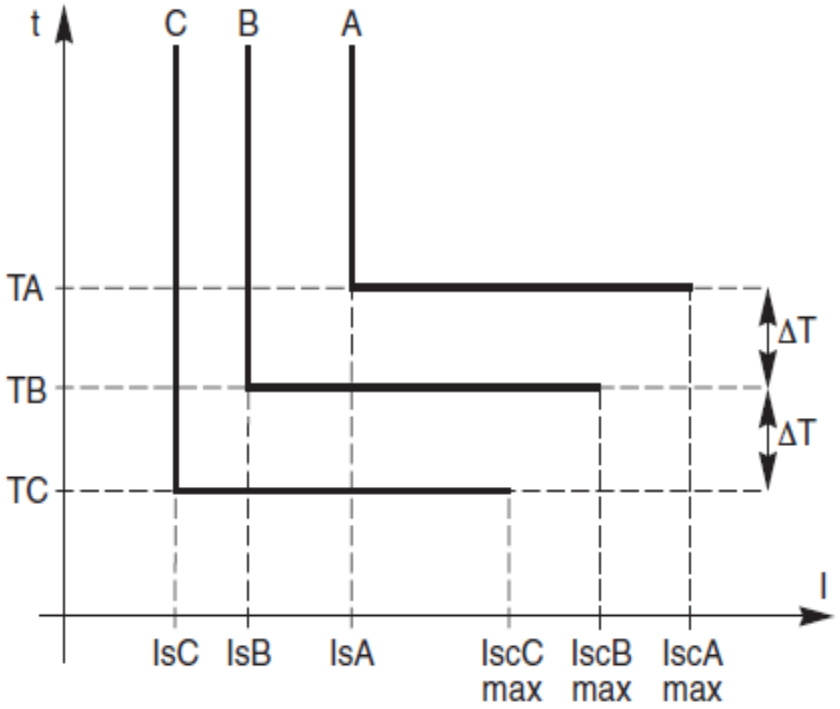
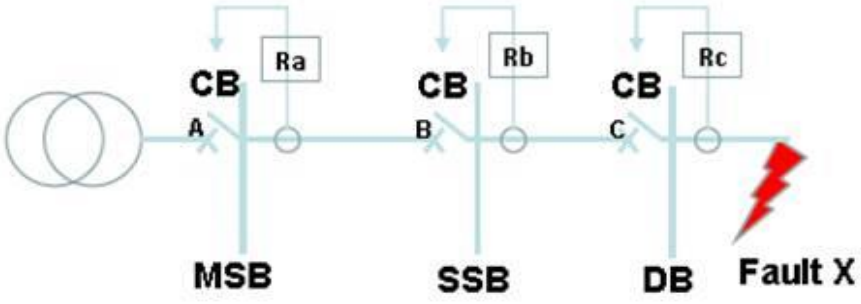
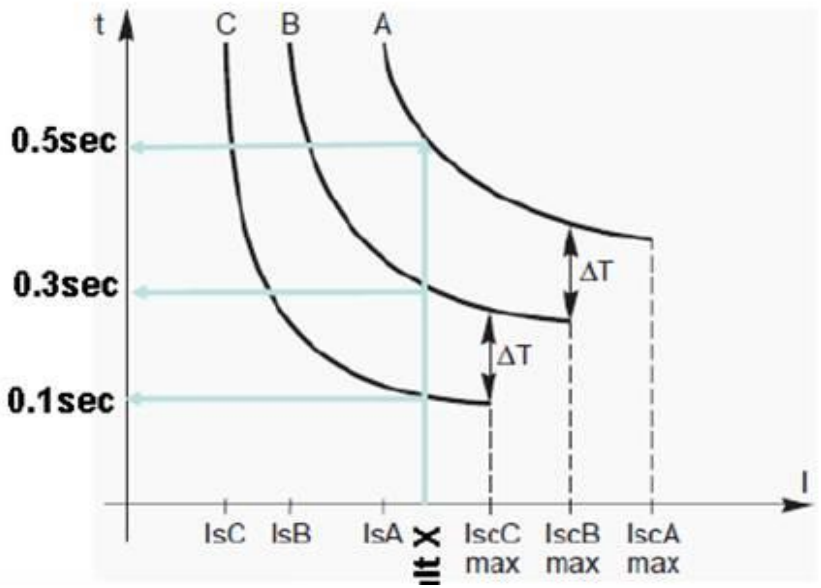


Fig. 2. Time-based discrimination with definite time relays.

IDMT : Time Grading & Fault Level Coordination





- Relay Rc is primary protection for DB
- Relay Rb and Ra serve as backup protection for Rc.
- When fault X happened on downstream of DB

E/F Trip Example at Fault X:

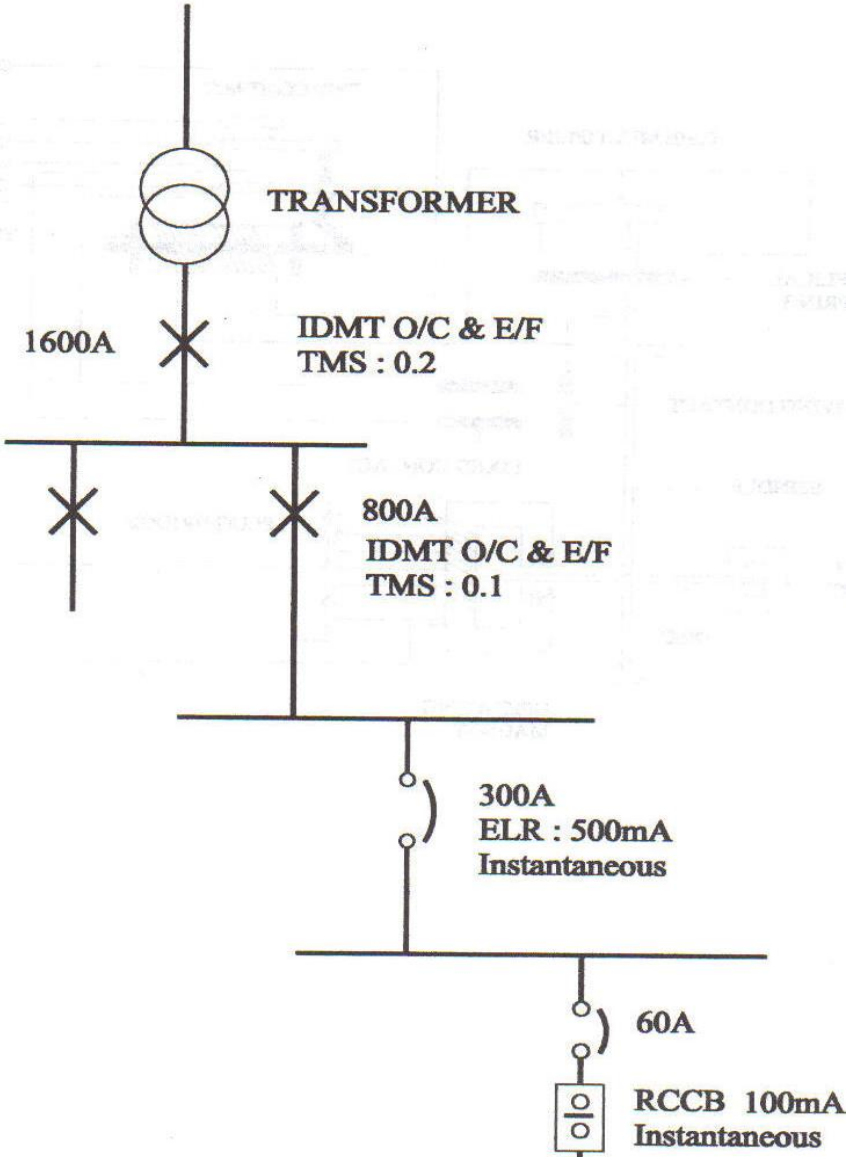
CB	Max Trip Time
CB C	0.1sec (primary protection)
CB B	0.3sec (1st backup protection)
CB A	0.5sec (2nd backup protection)

Discrimination – Current & Time

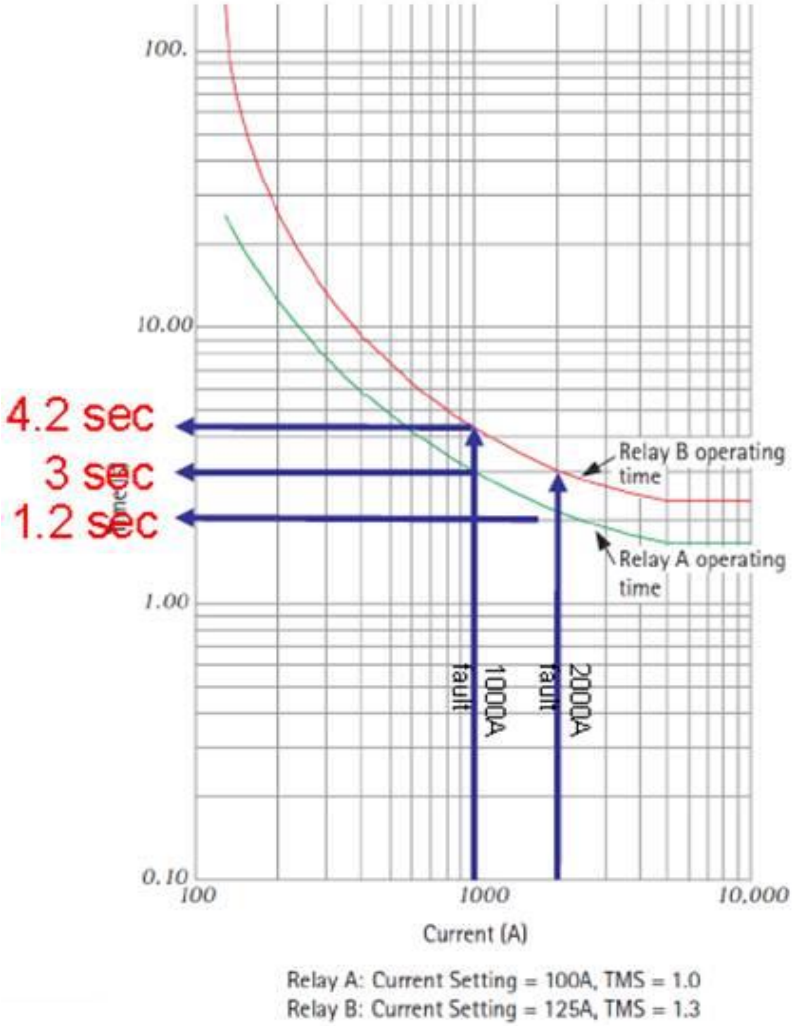
Discrimination by both Time and Current

- Each of the two methods described above has a fundamental disadvantage.
- Discrimination by time: more severe faults are cleared in the longest operating time.
- Discrimination by current: Unwanted tripping. Can be applied **only where there is appreciable impedance between the two circuit breakers concerned**.

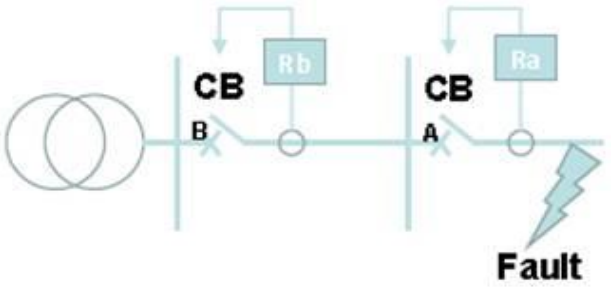
Discrimination – Current & Time



IDMT : Coordinated Scheme



Relay A: Current Setting = 100A, TMS = 1.0
Relay B: Current Setting = 125A, TMS = 1.3



Case #1

- Fault current = 1,000A
- Relay A trip first at 3sec
- If fault do not clear by 3sec, then Relay B trip at 4.2sec

Case #2

- Fault current = 2,000A
- Relay A trip first at 1.2sec
- If fault do not clear by 1.2sec, then Relay B trip at 3sec

Protection Coordination : Time Interval @ Grading Margin

Coordination Time interval = $t_{CB} + t_{RT} + t_{margin}$

t_{CB} = Circuit breaker operation time
t_R = Relay tolerance and setting errors
t_{margin} = Safety margin

t_{CB} = 3 to 4 cycles
t_R = 2 to 6 cycles
t_{margin} = 1 cycle

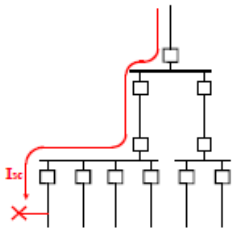
Minimum Coordination Time interval = 6 to 11 cycles or approx. **200ms**

Other factor to consider:

- Circuit breaker interrupting time
- Relay time error
- Overshoot
- CT errors
- Final Margin
- Overall accuracy

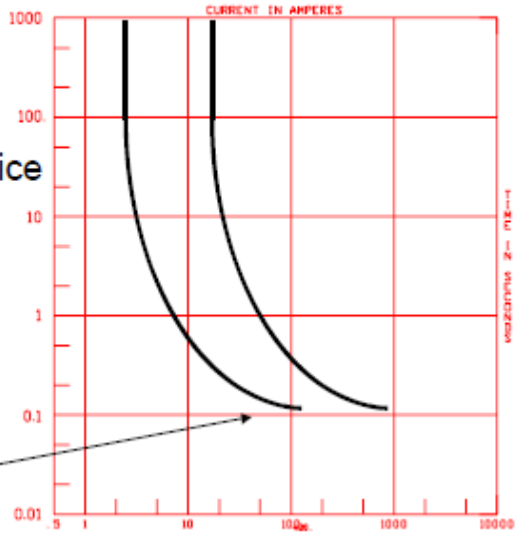
Discrimination Rules (Selectivity)

The Intended Result



Selectivity Rule #1

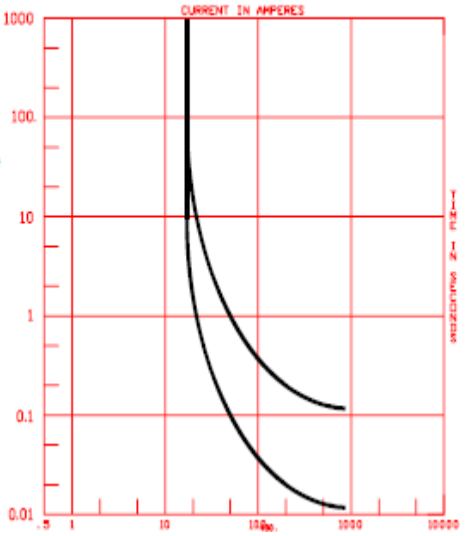
Upstream Device Pickup Level > Downstream Device Pickup



Maximum Fault Current

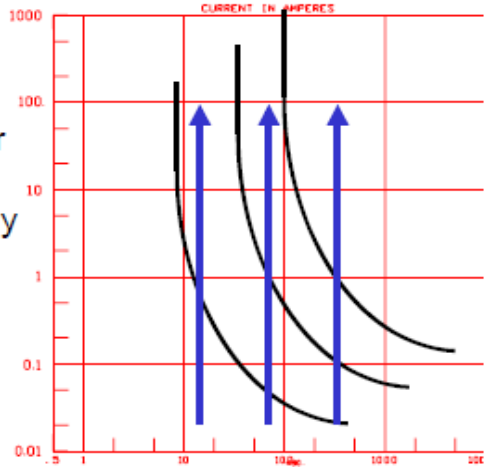
Selectivity Rule #2

Upstream Time Delay > Downstream Time Delay



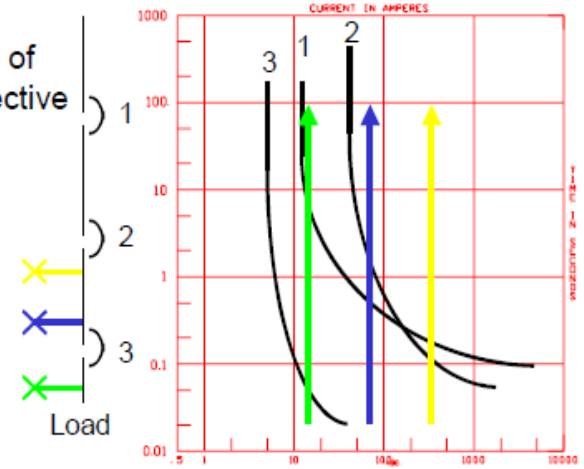
Rule for Complete Selectivity

Device curves should sequence from right to left or top to bottom as you go from supply to load with no crossings or overlaps

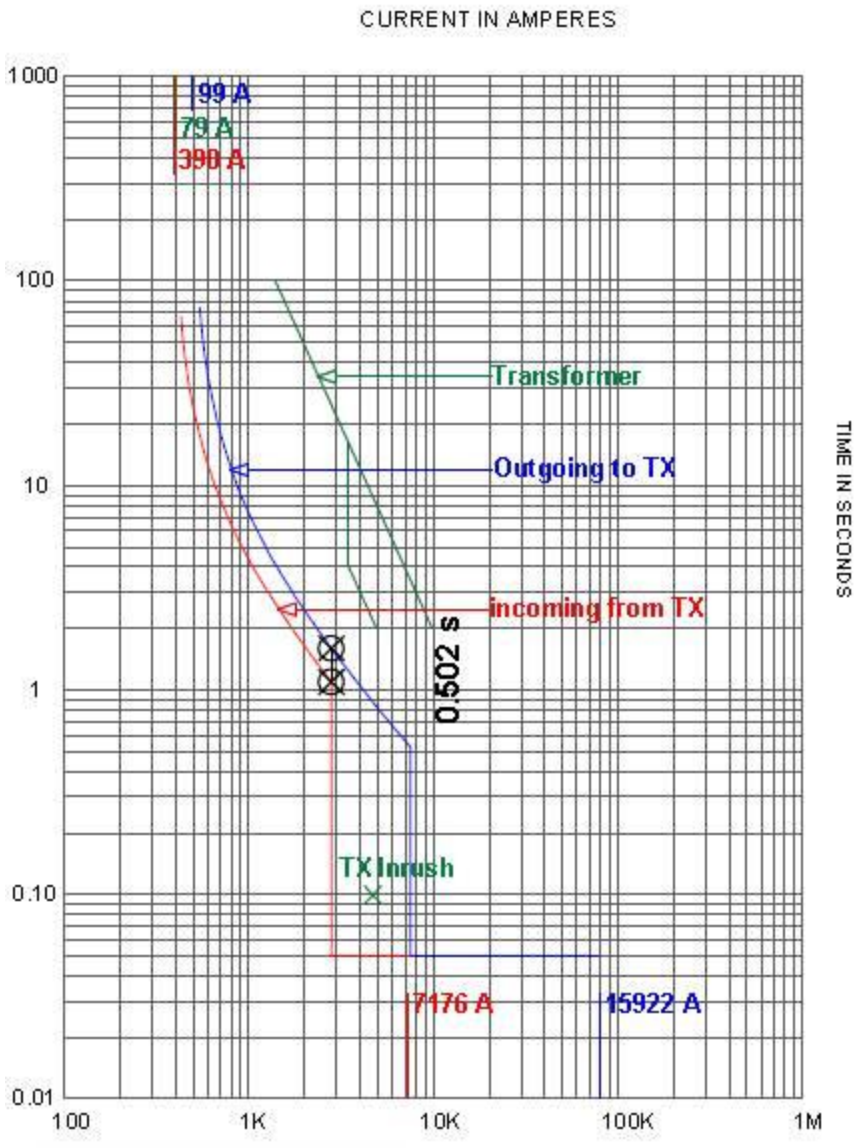


Rule for Complete Selectivity

Example of Non-selective System



Example of Coordination Study



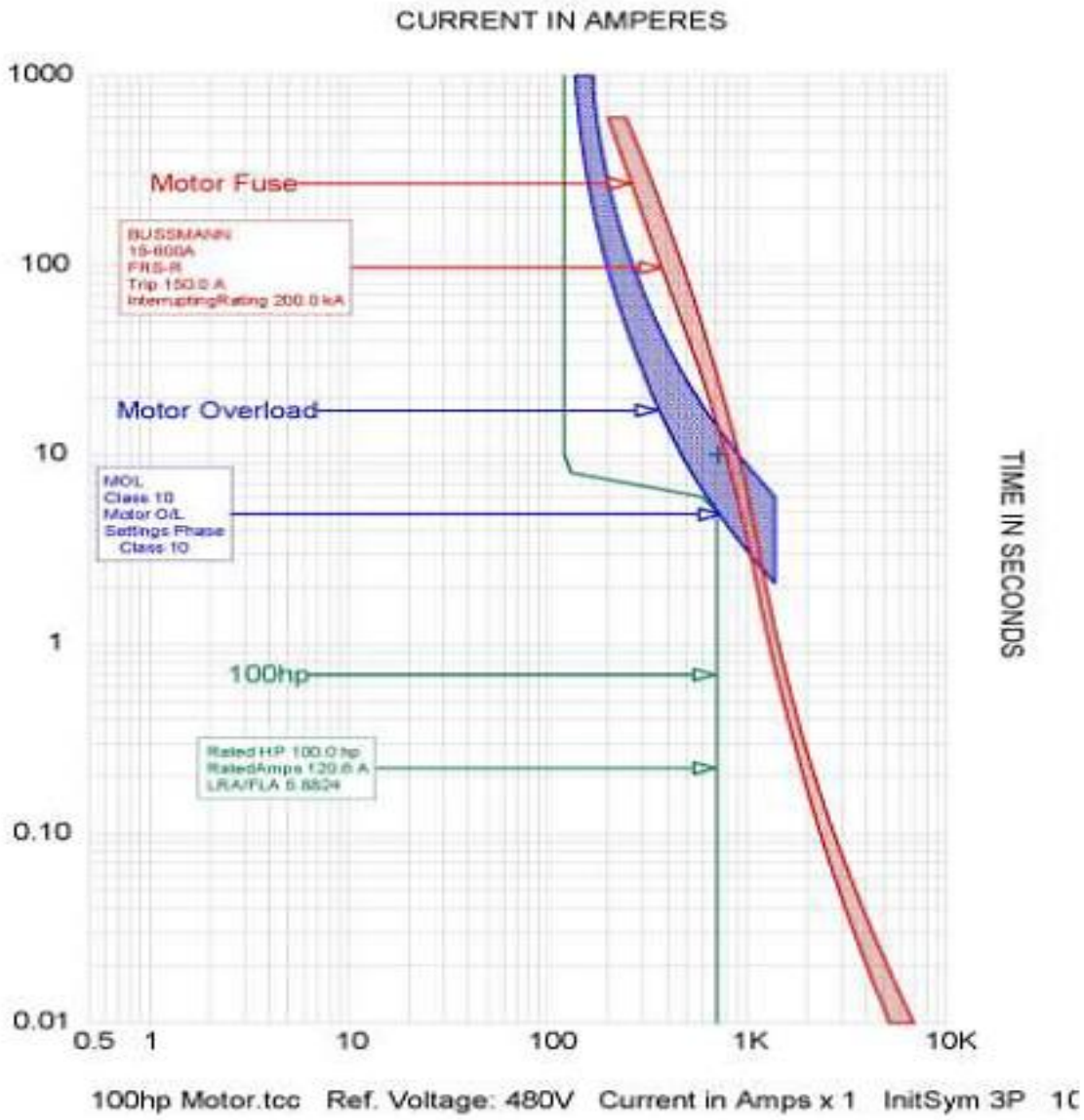
Blue – Outgoing to Transformer

Red – Incoming from Transformer

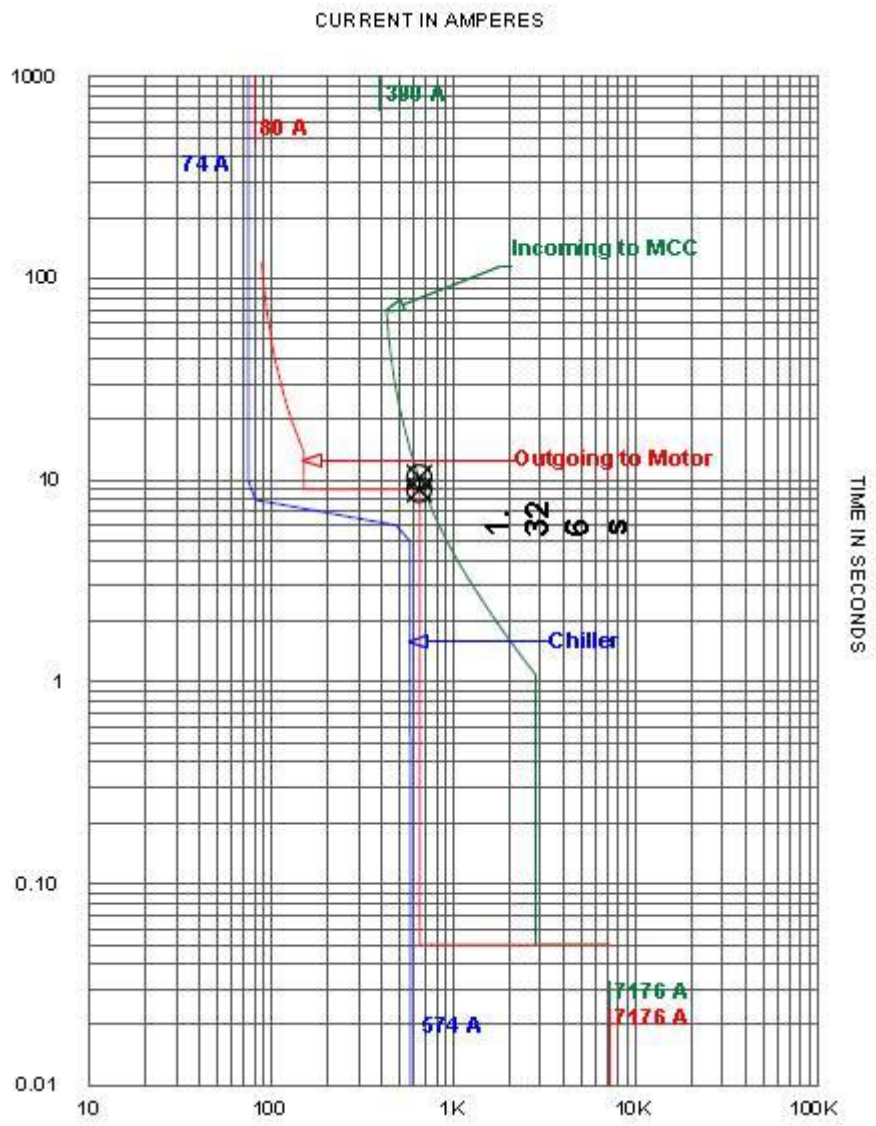
Green – Transformer Curve

Both relay with hi-set

Example of Coordination Study



Example of Coordination Study



Blue – Chiller starting curve

Red – Outgoing to Chiller

Green – Incoming to MCC