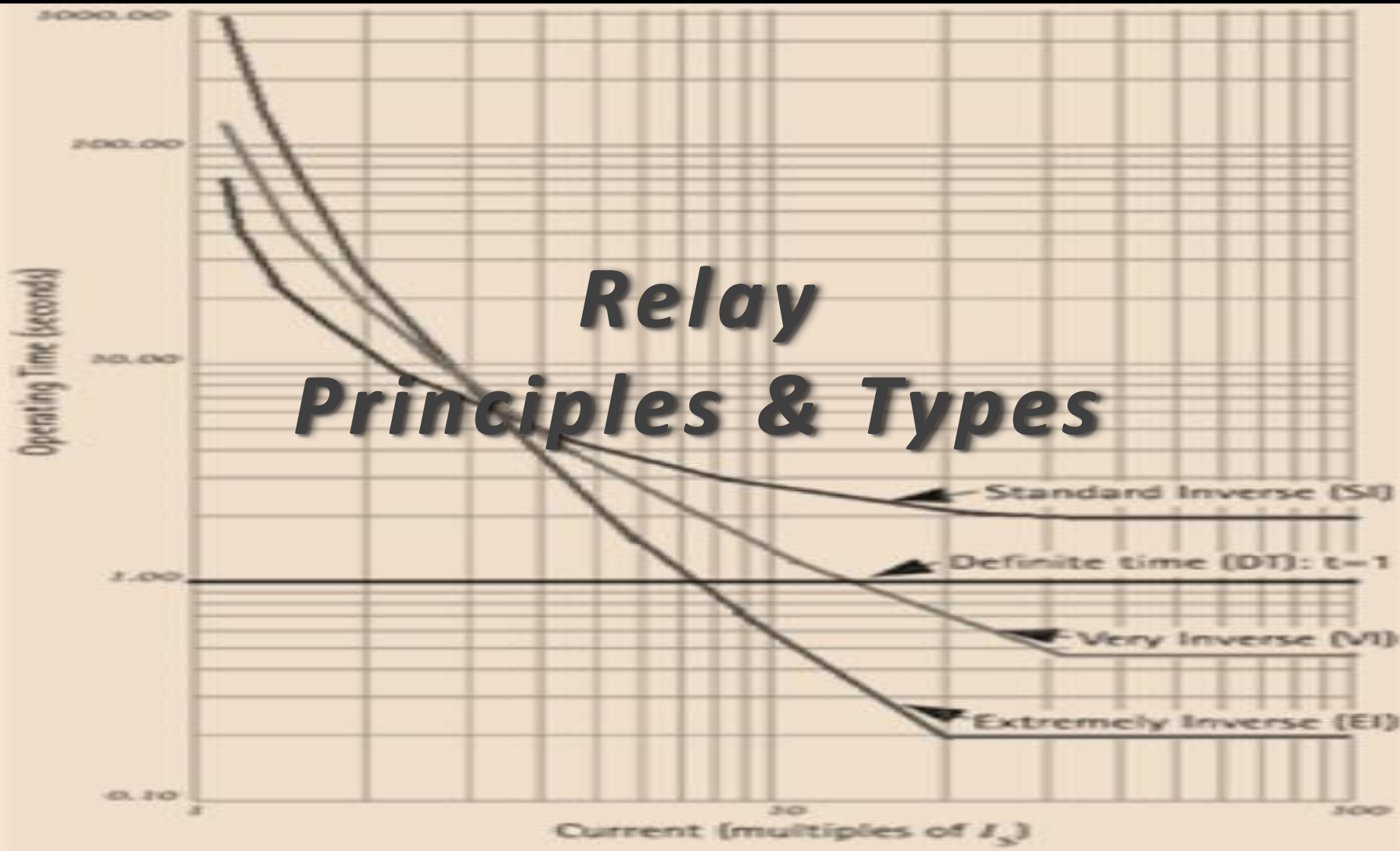
Relay Principles & Types



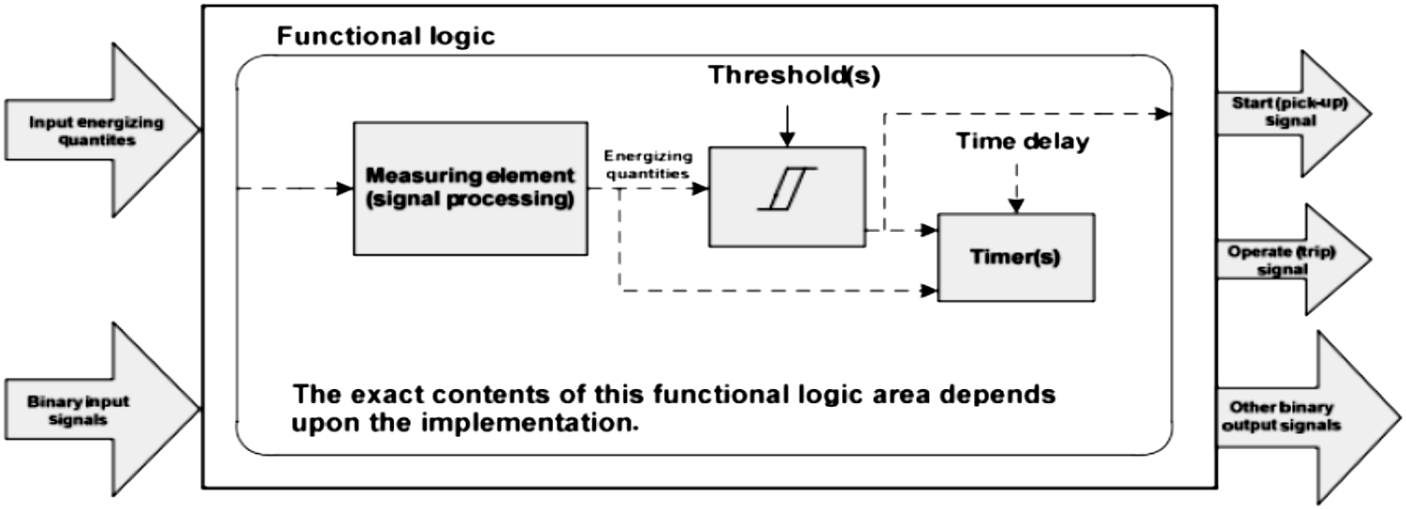
Relay

- Satu komponen perlindungan yang berfungsi untuk menentukan pada tahap kerosakan tertentu yang memerlukan pemutus litar terpelantik.
- Tahap kerosakan adalah nilai tatahan yang di tetapkan terlebih dahulu.
- Trip contact akan tertutup dan menyalurkan bekalan kepada shunt trip coil untuk membuka pemutus litar.

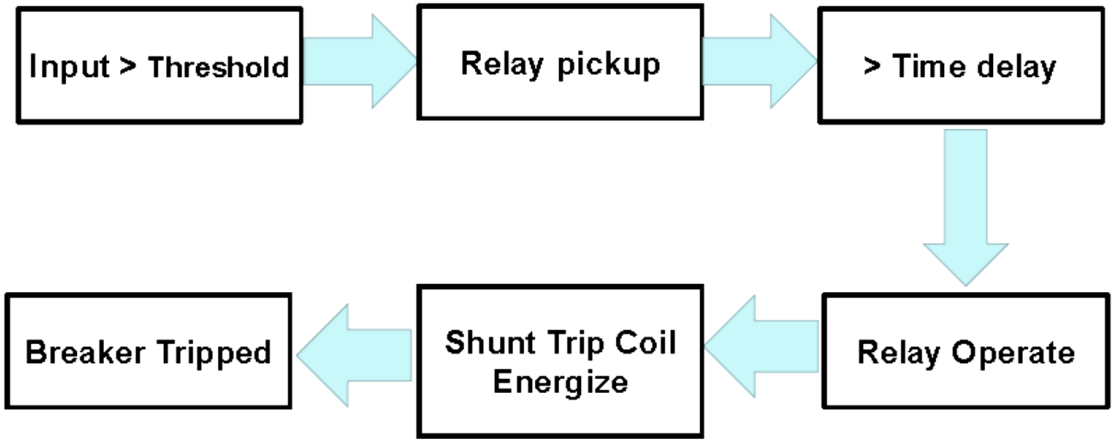
Over Load Relay

- Selalunya digunakan untuk motor. Biasanya mempunyai dua ciri-ciri yang berbeza dimana ia boleh menampung beban lebih yang tinggi semasa motor masih sejuk.
- Cold or starting curve – during starting
- Hot or running curve – when motor is hot, usually after being on full load for more than 30 minutes

What are the process before breaker tripped?

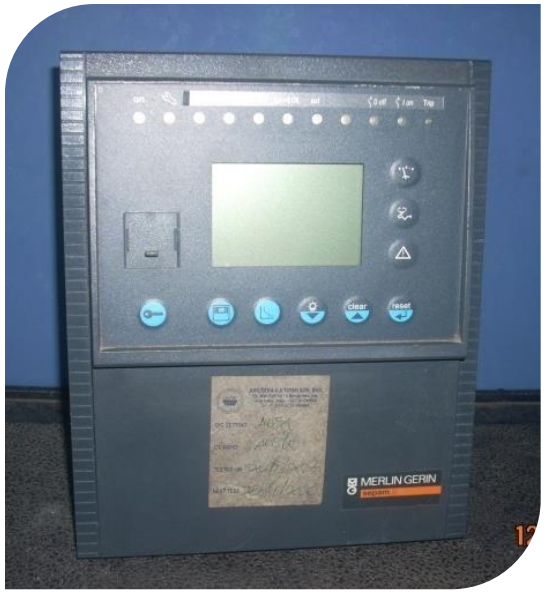


Simplified protection function block diagram.



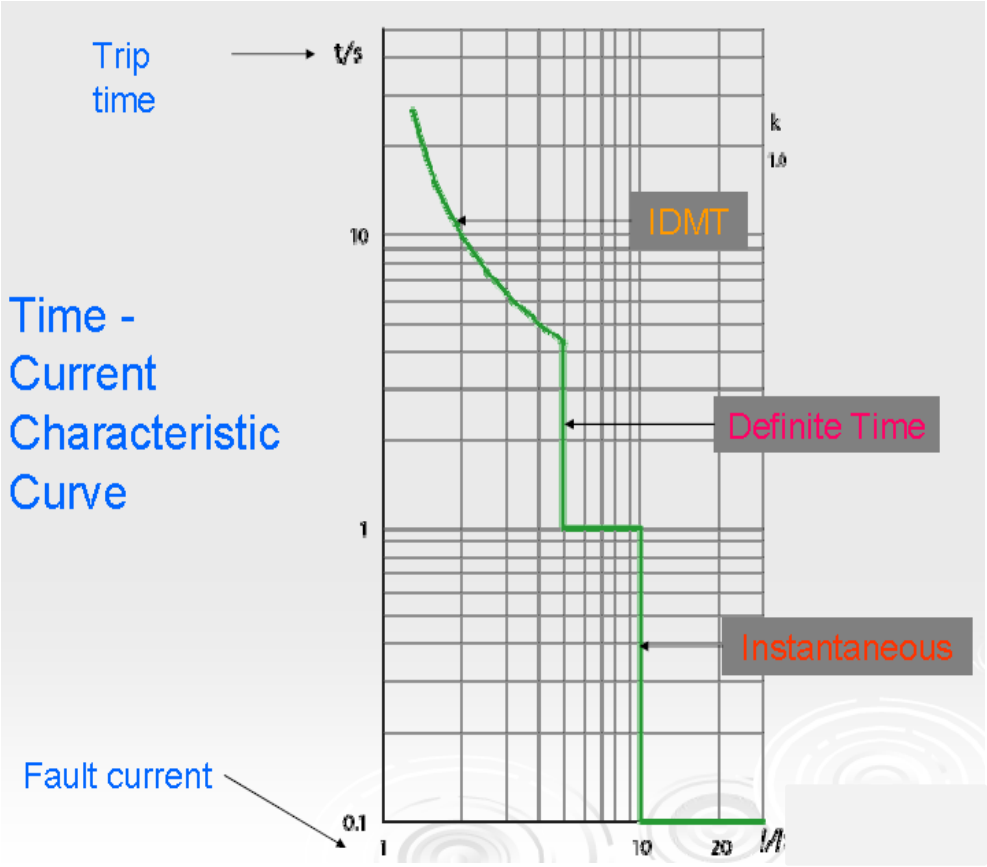
What Does LS-1 Specified?

- **5.6** Microprocessor based protection relay shall be housed in robust panel flush mounting case to IP54
  - **5.6.1** shall be of combined 3phase OC and EF protection with characteristics of :
    a) instantaneous,
    b) definite time and
    c) inverse time
  - ***5.6.1*** Time / Current characteristic of IDMT OC and EF relays shall be of standard inverse curve (3/10)
  - **5.6.2** The relays shall include a serial communication port for external connection to facilitate external reading, setting and recording of relay data and parameters by a PC
  - **5.6.4** Shall make available current & voltage measurements for local display. Measurements shall include:
    a) phase currents,
    b) phase-to-phase voltages &
    c) phase-to neutral voltages.



Type of Operating Characteristics

- ***These are different types of overcurrent relay:***
  1. Instantaneous Overcurrent Relay *(Define Current Relay or High-Set Relay (I_o >>))*
  2. Define Time Overcurrent Relay
  3. Inverse Time Overcurrent Relay (*IDMT Relay or low-set (I_o >))*
     a) Standard/Normal Inverse
     b) Very Inverse Time
     c) Extremely Inverse
     d) Long Time Inverse
  4. Directional Overcurrent Relay



1. Instantaneous Overcurrent relay (Define Current)

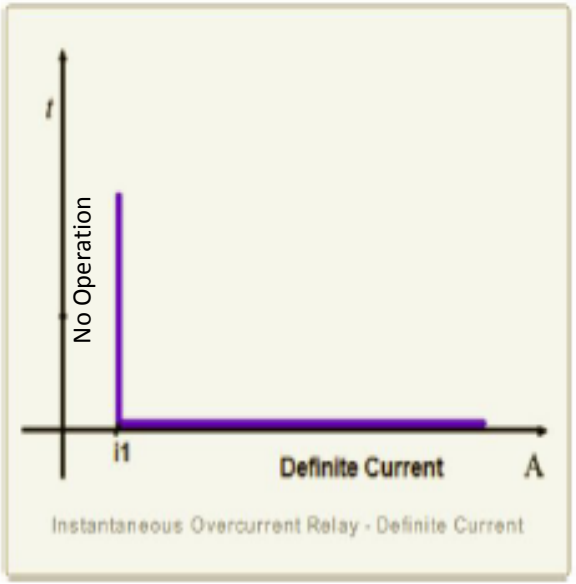
INSTANTANEOUS AND ITS DEFINITIONS

- Some relays are "instantaneous" or "high speed", and others have adjustable time delay.
- The term "instantaneous" means "having no intentional time delay" and is applied to relays that operate in a minimum time of approximately 0.1s.
- The term "high speed" connotes operation in less than approximately 0.1s and usually in $\leq$0.05s. The operating time of high-speed relays is usually expressed in cycles based on the power-system frequency; for example, "one cycle" would be 1/50 second in a 50-cycle system (50Hz), ie 0.02s.
- Originally, only the term "instantaneous" was used, but, as relay speed was increased, the term "high speed" was felt to be necessary in order to differentiate such relays from the earlier, slower types.

ITS OPERATION

- Operate instantaneously when the current reaches a predetermined value.
- Operates in a definite time when current exceeds its Pick-up value.
- Its operation criterion is only current magnitude (*without time delay*).
- Operating time is constant.
- There is no intentional time delay.
- Operates in 0.1s or less

Application: This type is applied to the outgoing feeders.

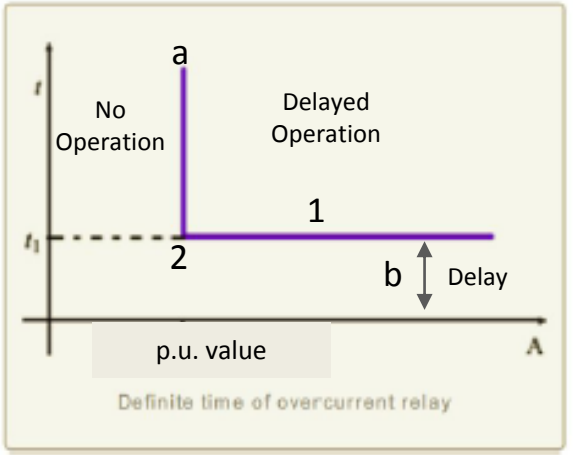


2. Definite Time Overcurrent Relays

In this type, two conditions must be satisfied for operation (*tripping*):-

a) current must exceed the setting value

b) the fault must be continuous at least a time equal to time setting of the relay.



Definite time of overcurrent relay

Modern relays may contain more than one stage of protection. Each stage includes each own current and time setting.

ITS OPERATION

1. Operating time is constant
2. Independent of the magnitude of current above the pick-up value.
3. It has pick-up and time dial settings, desired time delay can be set with the help of an intentional time delay mechanism.
4. Easy to coordinate.

Drawback of Relay:

1. The continuity in the supply cannot be maintained at the load end in the event of fault.
2. Time lag is provided which is not desirable in on short circuits.
3. It is difficult to co-ordinate and requires changes with the addition of load.
4. It is not suitable for long distance transmission lines where rapid fault clearance is necessary for stability.
5. Relay have difficulties in distinguishing between Fault currents at one point or another when fault impedances between these points are small, thus poor discrimination ie not suitable for huge cascaded system.

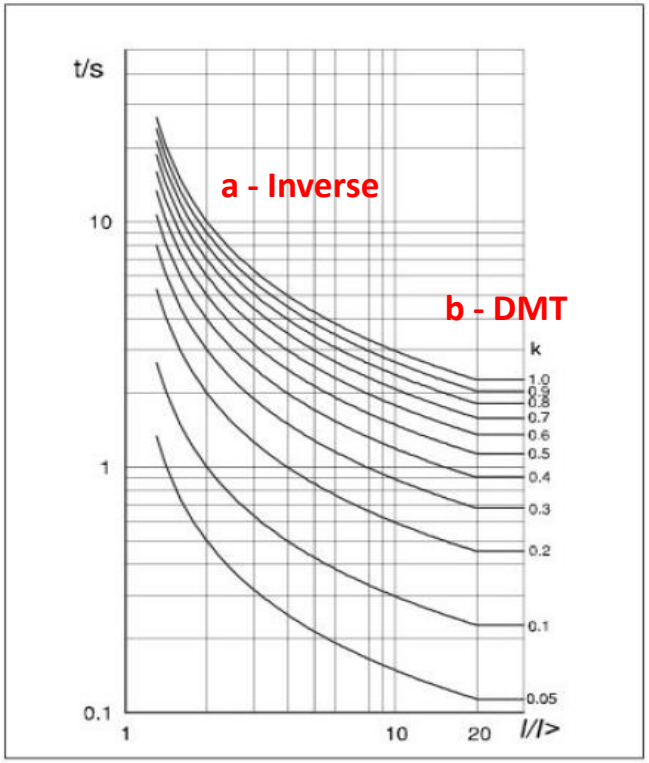
Application - *Definite time overcurrent relay is used as:*

1. Back up protection of distance relay of transmission line with time delay.
2. Back up protection to differential relay of power transformer with time delay.
3. Main protection to outgoing feeders and bus couplers with adjustable time delay setting.

3. Inverse Time Overcurrent Relays (IDMT Relay)

- Inverse Time relays are also referred to as Inverse Definite Minimum Time (IDMT) relay.
- In this type of relays, operating time is inversely changed with current. So, high current will operate overcurrent relay faster than lower ones.
- ***Discrimination by both 'Time' and 'Current'. The relay operation time is inversely proportional to the fault current.***
- The operating time can be moved up (made slower) by adjusting. The lowest time dial setting (*fastest operating time*) is generally 0.05 and the slowest is 1.0.
- Operates when current exceeds its pick-up value.
- Operating time depends on the magnitude of current.
- It gives (a) inverse time current characteristics at lower values of fault current and (b) definite time characteristics at higher values
- An inverse characteristic is obtained if the value of plug setting multiplier is below 10, for values between 10 and 20 characteristics tend towards definite time characteristics.
- Widely used for the protection of distribution lines.

Based on the inverseness it has four different types.



What is IDMT Curve?

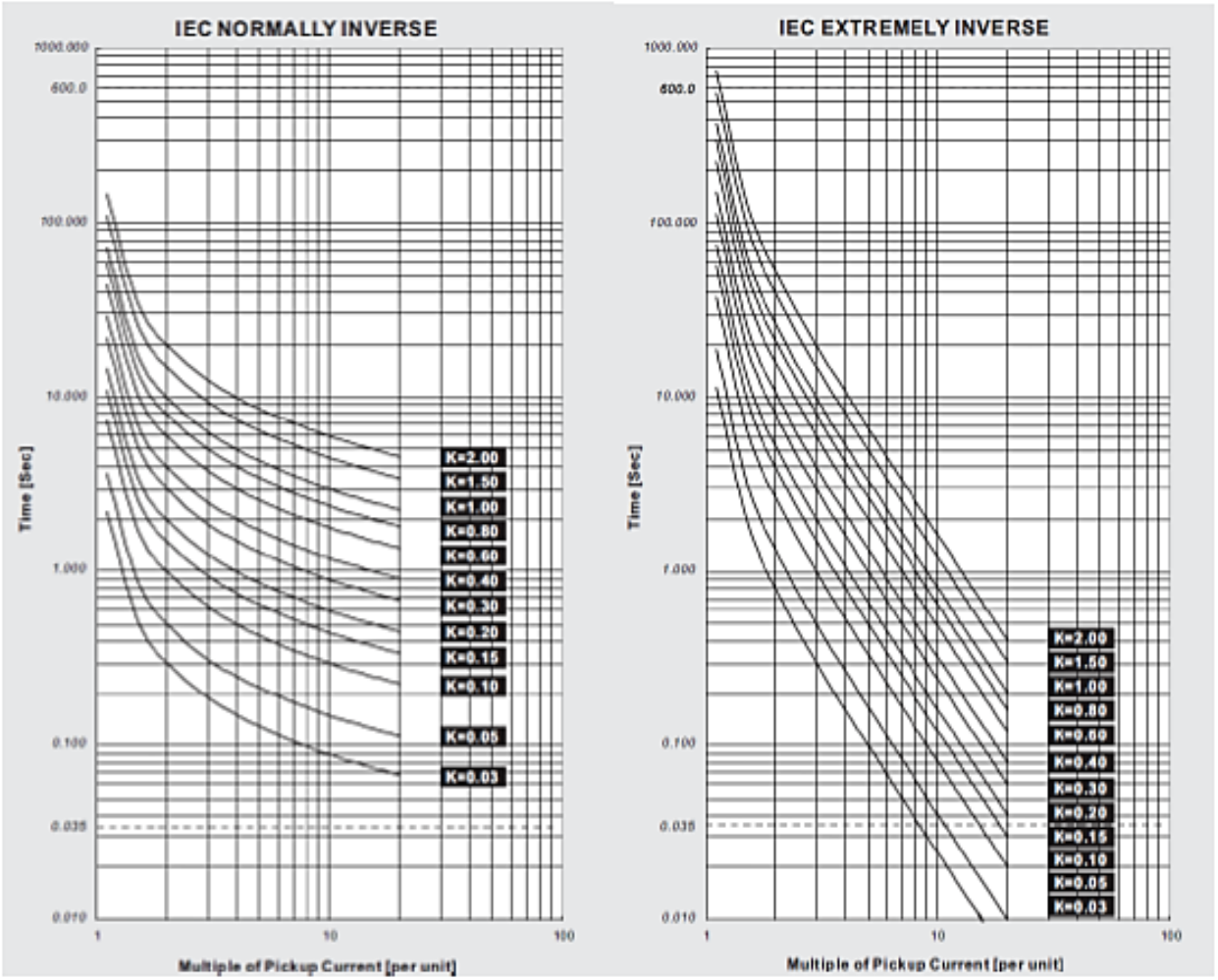
IEC 60255-151 IDMTL Curve

Table A.1 – Constants for dependent time operating and reset characteristics

Curve type	Operating time $t(G) = TMS\left[\frac{k}{\left(\frac{G}{G_S}\right)^{\alpha} - 1} + c\right]$			Reset time $t_r(G) = TMS\left(\frac{t_r}{1-\left(\frac{G}{G_S}\right)^{\alpha}}\right)$		Commonly used name
	k s	c s	α	t_r s	α	
A	0,14	0	0,02	*	*	Inverse
B	13,5	0	1	*	*	Very inverse
C	80	0	2	*	*	Extremely inverse
D	0,0515	0,1140	0,02	4,85	2	IEEE Moderately inverse
E	19,61	0,491	2	21,6	2	IEEE Very inverse
F	28,2	0,1217	2	29,1	2	IEEE Extremely inverse

* For curves A, B and C, the manufacturer shall declare if dependent time reset characteristic is implemented and provide the appropriate information.

What is IDMT Curve?

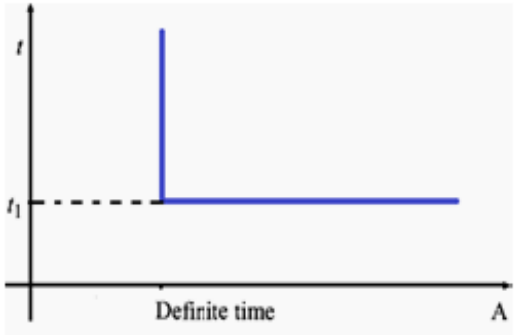


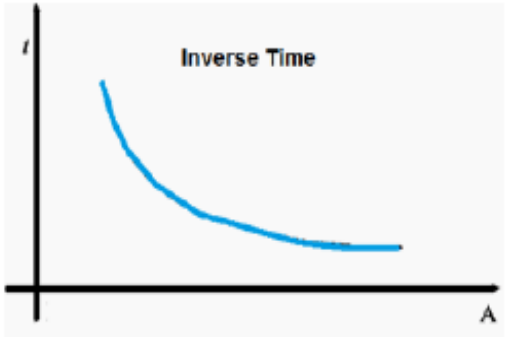
- Choice of Curve determined by Utility / Design engineer
- Set PickUp Current (Ipu) according to fault level
- Set Time Multiplier Setting (K), based on coordination study
- IEC Curve Formula:

$$T = K * \left(\frac{\beta}{\left(\frac{I}{Ipu} \right)^{\alpha} - 1} \right)$$

IEC Curve Constants	α	β
Normally Inverse	0.02	0.14
Very Inverse	1	13.5
Extremely Inverse	2	80
Short time	0.04	0.05
1.3 (Normally Inverse)	0.02	0.064

Summary of difference between DT vs IDMT





DTL scheme (EF and OC)

1. Fixed time & current function
2. Suitable for medium & small board (250A to 630A) where Short Circuit Current Stress is Lower.
3. Not suitable for large MSB where high short-circuit current require immediate tripping action.
4. For small DB (below 250A), ELR is used for protection.

IDMTL scheme (EF and OC)

1. Decreasing Time over Current
2. Trip curve specified under ANSI/IEC 60255 math formula
3. Suitable for both large and medium board (above 630A) where Short Circuit-Current is high.
4. Ability to distinguish heavy vs light fault and Reduce the Trip Time with Increasing Fault Current

Summary of difference between DT vs IDMT

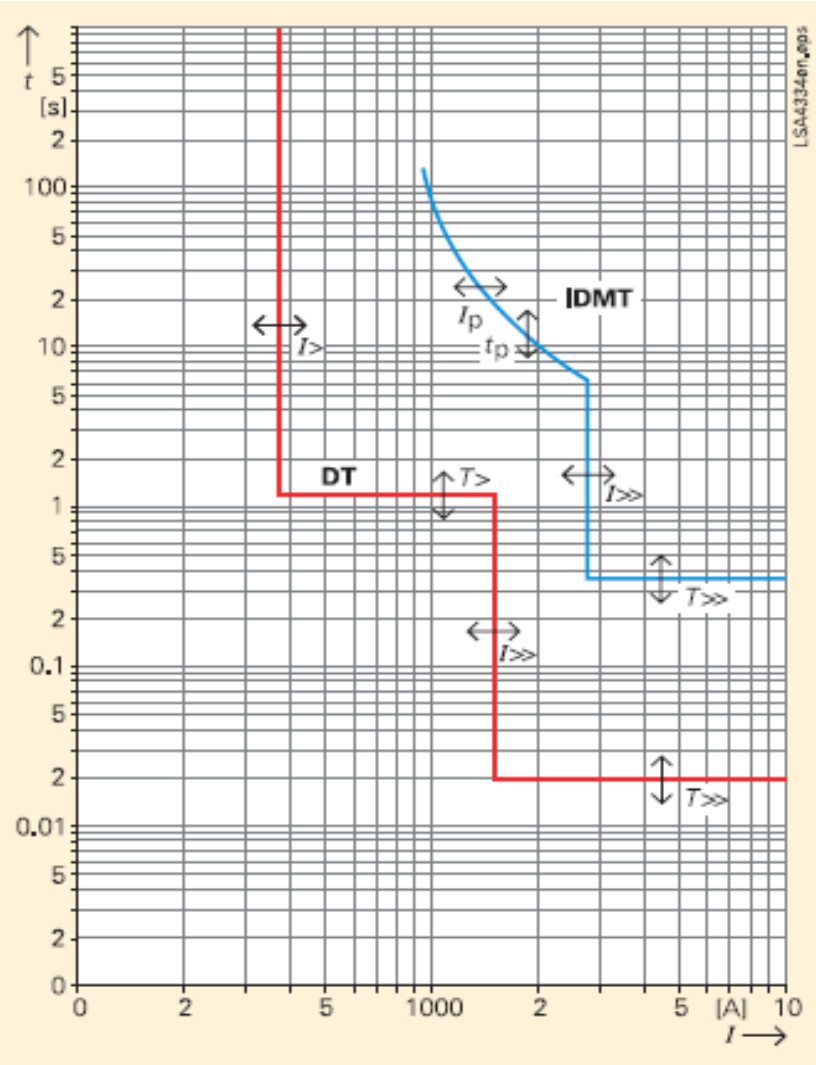
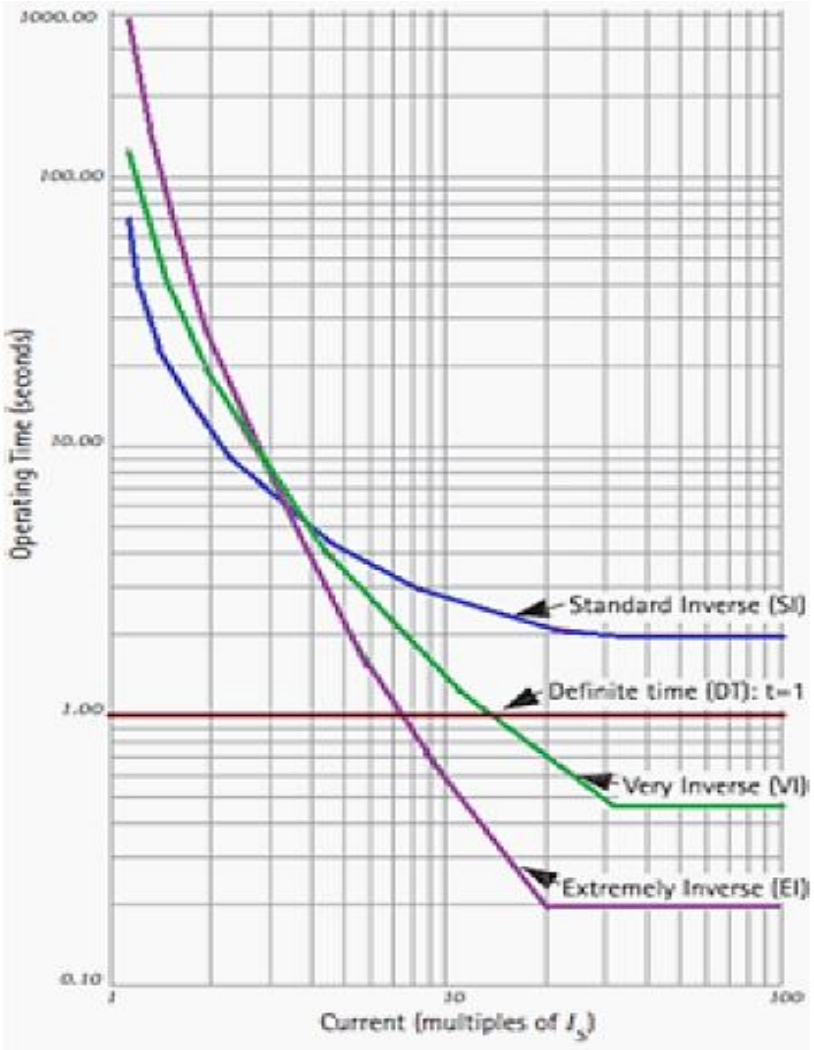


Figure shows the basic characteristics of definite and inverse-time overcurrent protection.

- *I*> overcurrent stage always work with definite tripping time.
- *I*>> high-set overcurrent stage
- *I*p inverse-time overcurrent stage, the tripping time depends on the magnitude of the short-circuit current.
- *I*p stages: various tripping characteristics can be set:-
  a) Normal inverse (NI)
  b) Very inverse (VI)
  c) Extremely inverse (EI)
  d) Long time inverse (LI)

Comparison Between Types of IDMT Curves : NI-VI-EI-DT



IEC 60255 IDMT relay characteristics; TMS=1.0

Normal Inverse / Standard Inverse (NI / SI)

- Most commonly used.

Very Inverse (VI)

- Suitable if there is a substantial reduction of fault current as the fault distance from the power source increases.
- Suitable for protection of motor load with peak currents on switching in.

Extreme Inverse (EI)

- Suitable for protection of motor load with peak currents on switching in.

Normal Inverse Characteristics

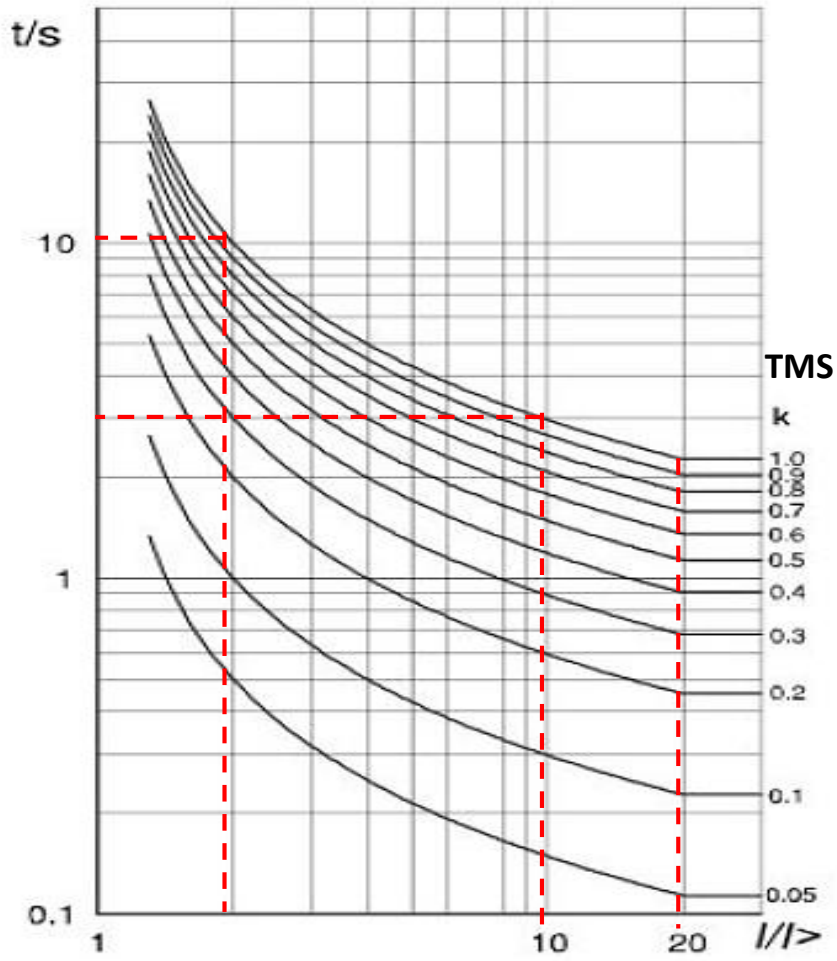
- Usual choice for end-users
- The uncertainty of the operating time (t_{op}) and the necessary operating time may require **a grading margin of 0.4 to 0.5 seconds.**
- Normal inverse time Overcurrent Relay is **relatively small change** in time per unit of change of current.

Application

- Used in utility and industrial circuits
- Applicable where the fault magnitude is mainly dependent on the system generating capacity at the time of fault

What is Timer Multiplier Setting (TMS)?

- When there is a requirement for upstream and downstream protection, we want both relays **to have the same characteristic curve.**
- The downstream relay protection should always be faster in tripping time then the upstream. This is achieved by setting the TMS. Setting the time multiplier to a smaller value causes the relay to trip faster.

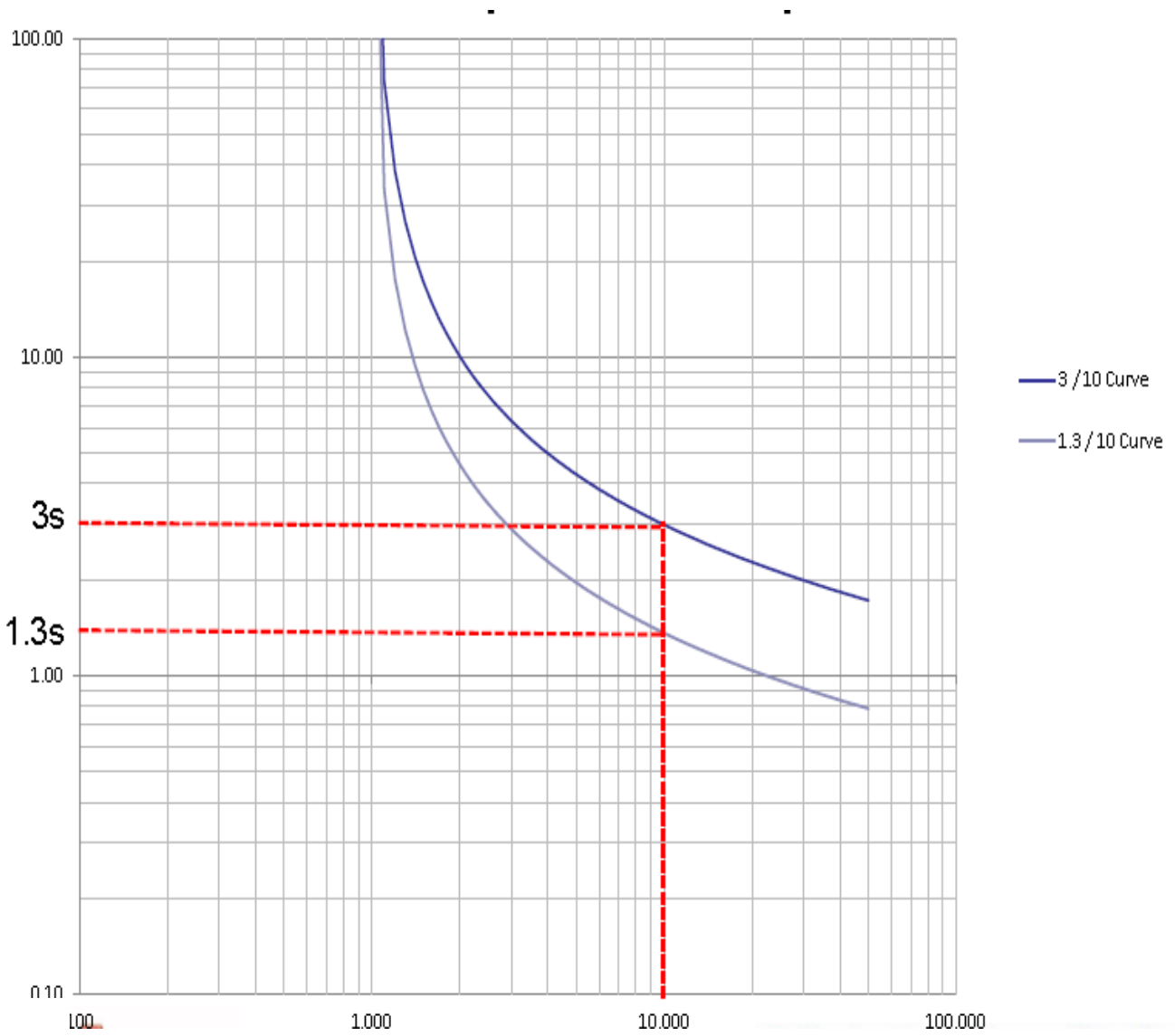


Observe for TMS=1

- at PSM=2; t_{op} = 10s
- at PSM=10; t_{op} = 3s
- for PSM > 20 t_{op} = t_{op} at PSM =20

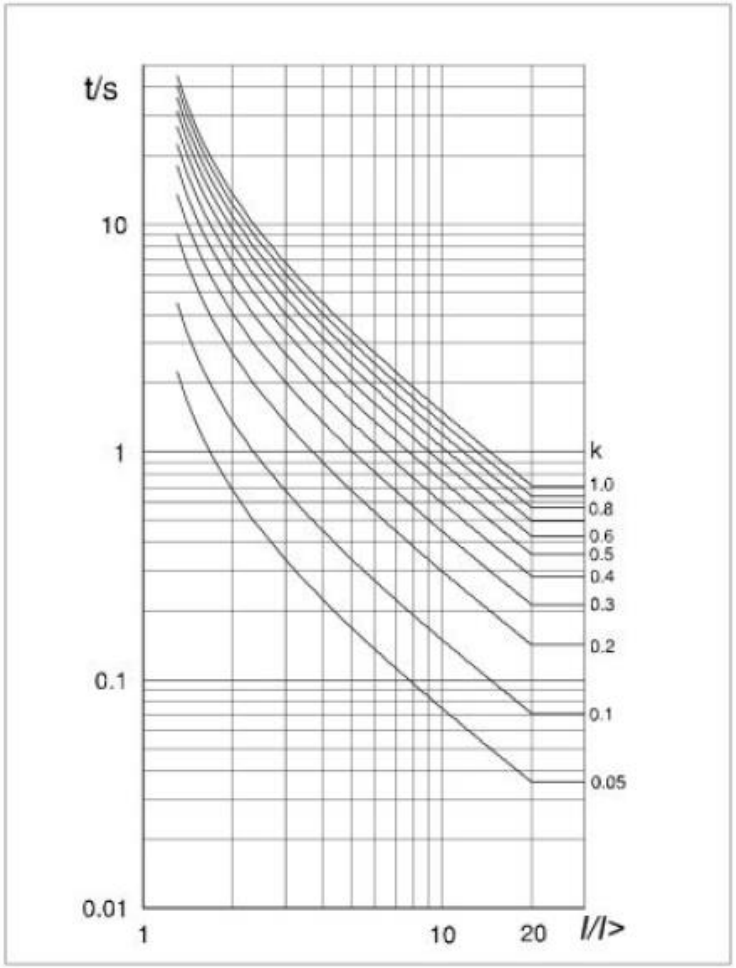
This the characteristic of an IDMT curve

Difference of NI 1.3/10 Curve Vs. NI 3/10 Curve



Very Inverse Characteristics

- Used where there is a reduction in fault current, as the distance from the source increases
- Particularly effective with ground faults because of their steep characteristics



Application

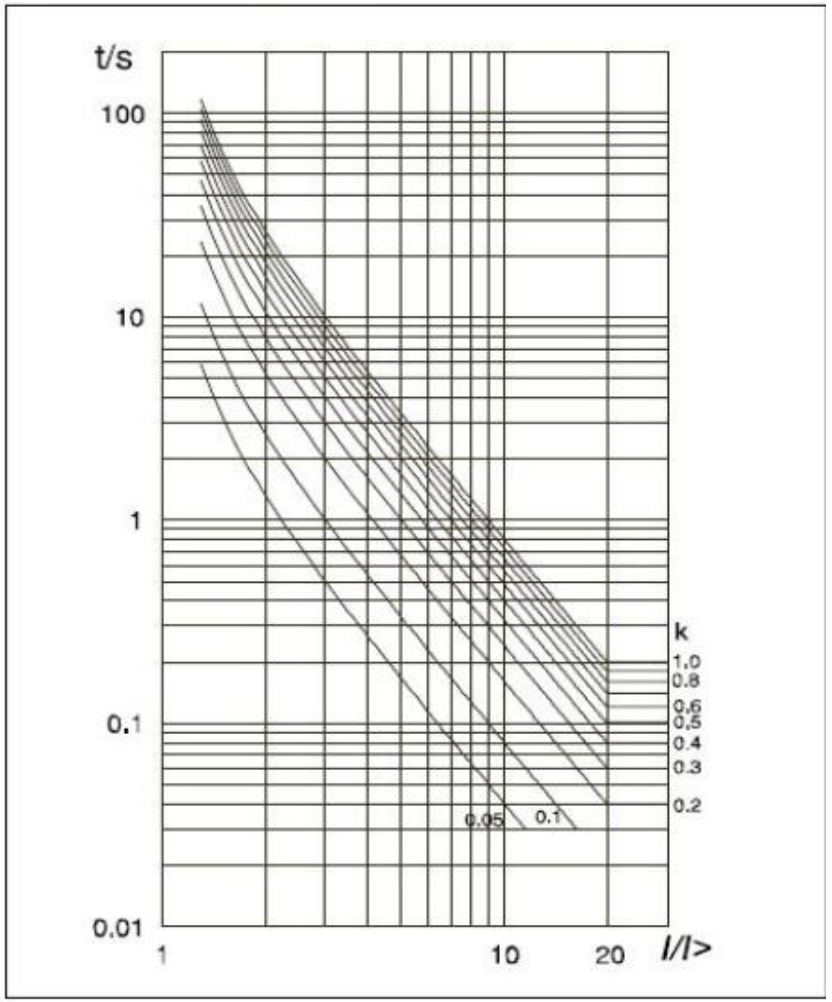
- Suitable if there is a substantial reduction of fault current as the fault distance from the power source increases
- Suitable if short circuit current drops rapidly with the distance from the substation
- Provides better coordination with LV breakers or a back-up with other relays

Extremely Inverse Characteristics

- Suitable for protection of machines against overheating
- Protection of distribution feeders with peak current on switching

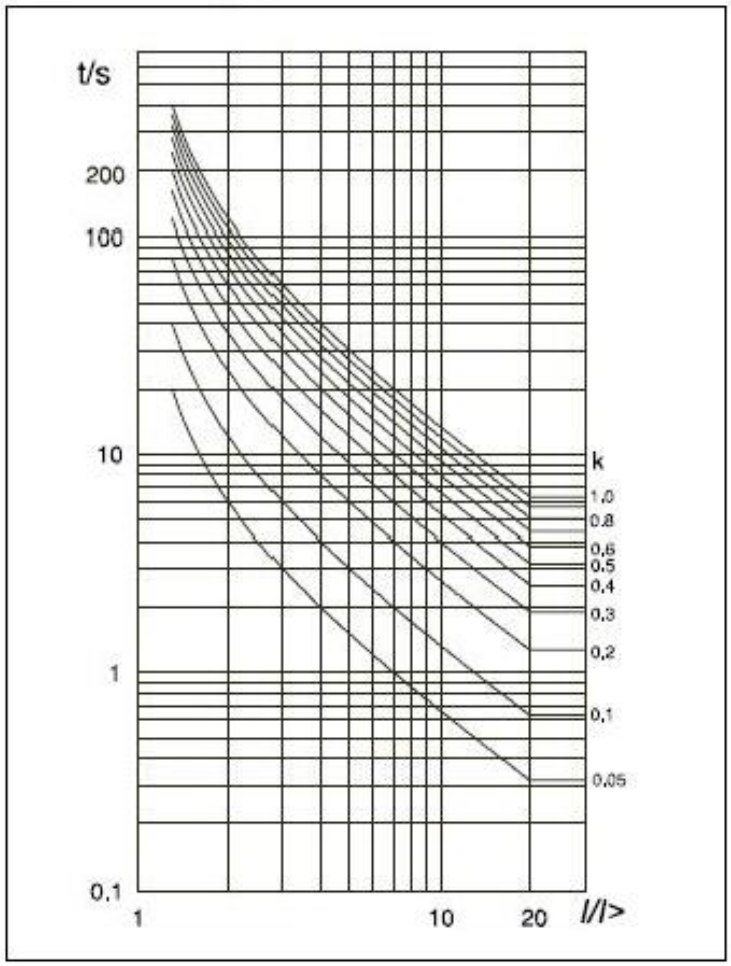
Applications

- Suitable for grading and coordinates with fuse, MCCB and reclosers
- Protection of alternators, transformers, expensive cables, etc.
- Suitable for protection of distribution feeders with peak currents on switching in (refrigerators, pumps, water heaters and so on).



Long Time Inverse Characteristics

- As backup to earth-fault protection
- Can be used for Thermal Protection
- Used to protect transformer neutral earthing resistors
- Override motor starting circuits.



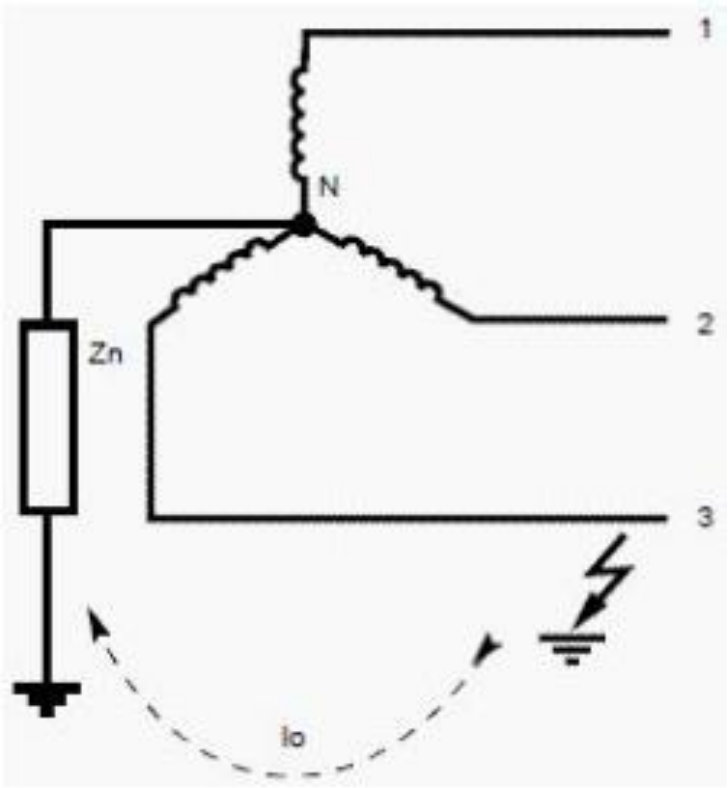
Earth Fault Element

- OCEF Relay earth fault element have two settings which is:-

  a) low-set Io > and,

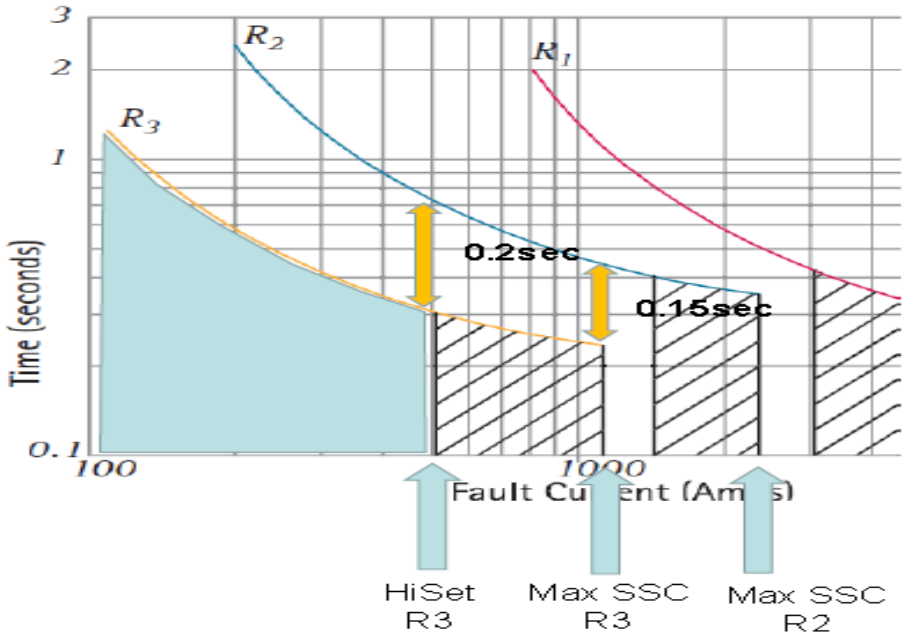
  b) high-set Io >>

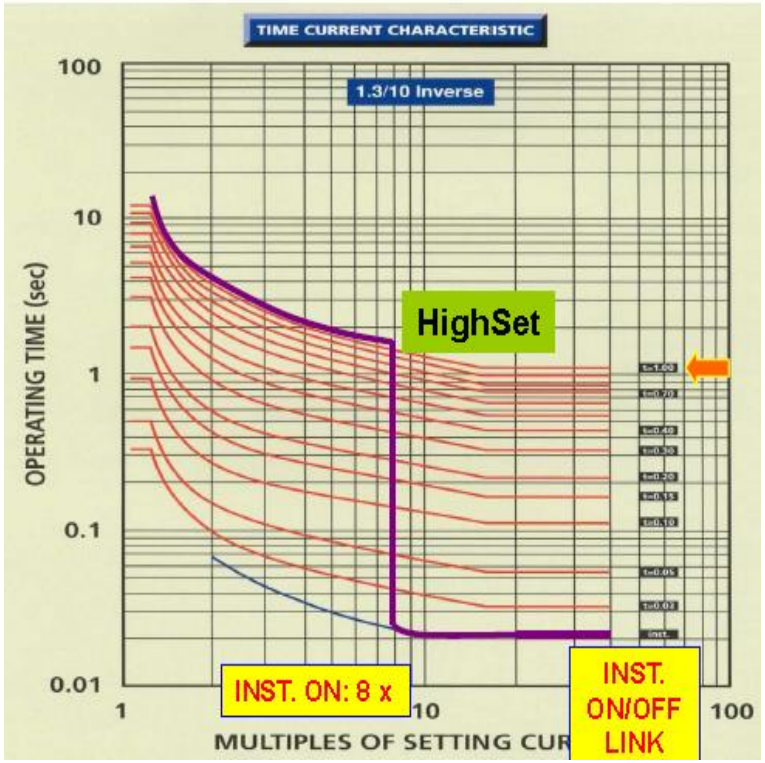
- The low-set Io > and high-set Io >> earth fault element can also be configured as Definite Time (Instantaneous) settings



Low-Set & High-Set

- Low Set : IEC 60255 inverse time-current characteristic curve
- High-set : Instantaneous tripping or definite time (a.s.a.p) for high-set. Can be disabled if required.



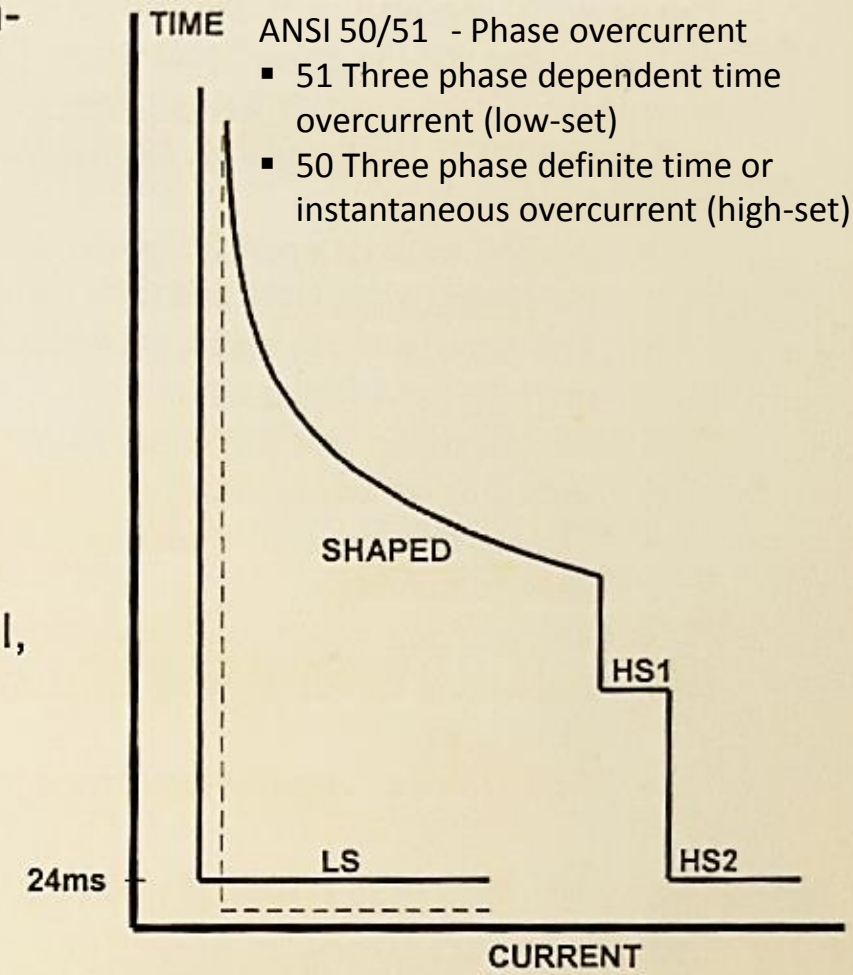


Hi Set for Increasing Time Segregation

- For network where many layers of IDMT relay or Main Incoming has low initial TMS value
- Where 2 or more levels having same trip value.
- To force the levels to trip at preset value
- To increase time segregation by “chop-off” of trip curve
- To create higher certainty in trip coordination with large fault current
- For network layers where Discrimination Margin is very close
- To increase the effective discrimination time.

Characteristics of ARGUS 1 Relay

- Applies to phase-fault and earth-fault elements
- 4 Independent stages:
- 1 transient free LOWSET
  - Level: 0.1–52.5 xIn
  - Delay: 0–20 sec
- 1 SHAPED characteristic
  - Level: 0.1–2.5 xIn
  - Time Multiplier: 0.025x–1.6x
  - Characteristics: NI, EI, VI, LTI, DTL
- 2 transient free HIGHSETs
  - Level: 0.1–52.5 xIn
  - Delay: 0–20 sec



ANSI 50/51 - Phase overcurrent

- 51 Three phase dependent time overcurrent (low-set)
- 50 Three phase definite time or instantaneous overcurrent (high-set)

OCEF Relay Characteristics

FEATURES				MK2200L	MK2200	MK1000
Detection method				Fundamental	Fundamental	Fundamental
Breaker Failure				Y	Y	N
Trip Circuit Supervision				Y	N	N
Thermal Overload Protection				Y	N	N
Earth Fault, Io	Highset Element, Io>>	Definite time		Y	Y	Y
	Lowset Element, Io>	Definite time		Y	Y	Y
		IDMT Curves	NI, VI, EI, LTI	Y	Y	Y
			NI (1.3/10)	Y	N	Y
Overcurrent, I	Highset Element, I>>>	Definite time		Y	N	N
		Sampling		Y	N	N
	Highset Element, I>>	Definite time		Y	Y	Y
	Lowset Element, I>	Definite time		Y	Y	Y
		IDMT Curves	NI, VI, EI, LTI	Y	Y	Y
			NI (1.3/10)	Y	N	Y
Relay Start time Display				Y	Y	N
No. of Outputs				4	5	2
Internal Relay Failure				Y	Y	N
Modbus RTU				Y	Y	N
Detect Frequncy [Hz]				50 and 60	50 and 60	50 or 60
Binary Input				Y(2 inputs)	Y(1 input)	N
Fault Record				Y(50 records)	Y(9 records)	N
Event Record				Y(250 records)	N	N
Alarm Record				Y(30 records)	N	N
Password Protection				Y	N	N
Rated Input Current				1 and 5Amp	1 and 5Amp	5Amp
Display				LCD Char. Base	7Segment	7Segment
Mounting				Panel W129 H139	Panel W129 H139	Panel W91 H91

What Is ANSI?

1. In the design of electrical power systems, the **ANSI Standard Device Numbers** denote what features a protective device supports (such as a relay or circuit breaker).

2. These types of devices **protect** electrical systems and components from damage when an unwanted event occurs, such as an electrical fault.

3. ANSI numbers are used to **identify the functions of medium voltage microprocessor devices.**

4. ANSI facilitates the development of American National Standards (ANS) by accrediting the procedures of standards developing organizations (SDOs). These groups work cooperatively to develop voluntary national consensus standards.

5. Accreditation by ANSI signifies that the procedures used by the standards body in connection with the development of American National Standards meet the Institute's essential requirements for openness, balance, consensus and due process.

ANSI Codes

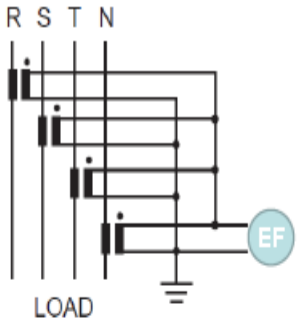
Category of Current protection functions

- ANSI 50/51 - Phase overcurrent
  - 51 Three phase dependent time overcurrent (low-set)
  - 50 Three phase definite time or instantaneous overcurrent (high-set)
- ANSI 50N/51N or 50G/51G - Earth fault or sensitive earth fault
- ANSI 50BF - Breaker failure
- ANSI 46 - Negative sequence / unbalance
- ANSI 49RMS - Thermal overload

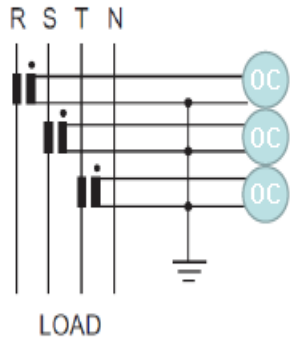
ANSI DEVICE NUMBERS/DESCRIPTION

2 Time-delay	37 Undercurrent or underpower	50 Instantaneous overcurrent	67 AC directional overcurrent	79 AC reclosing
21 Distance	38 Bearing	51 AC time overcurrent	68 Blocking	81 Frequency
25 Synchronism-check	40 Field	59 Overvoltage	69 Permissive	85 Carrier or pilot-wire
27 Undervoltage	46 Reverse-phase	60 Voltage balance	74 Alarm	86 Lock out
30 Annunciator	47 Phase-sequence voltage	63 Pressure	76 DC overcurrent	87 Differential
32 Directional power	49 Thermal	64 Apparatus ground	78 Out-of-step	94 Tripping

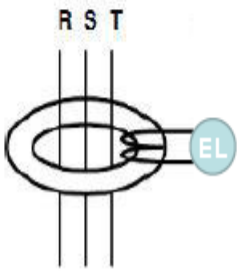
Protection Relay Fault Detection Method



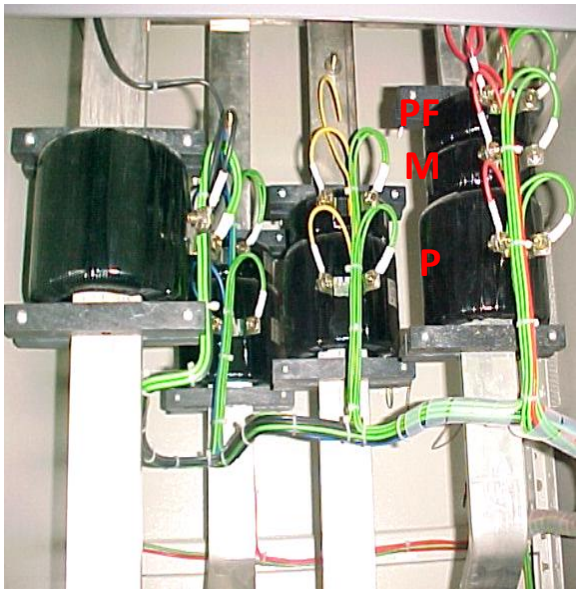
- Earth Fault (EF)
  - Phase to Earth fault condition
  - Detection by Zero Sequence Current flow (high level typically 40A-120A)
  - 4 CT measurement

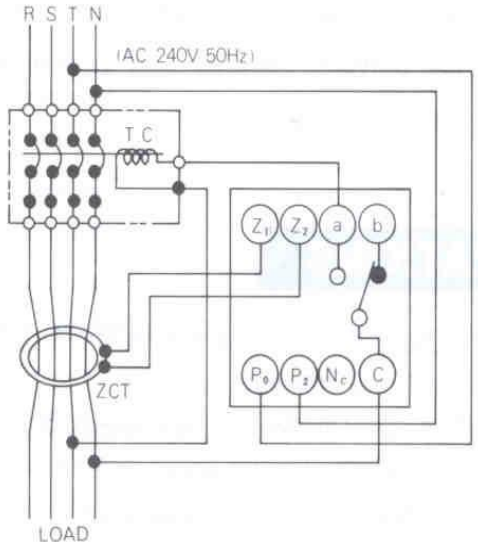


- Over Current (OC)
  - Exceed current limit of system capacity
  - Detection by Margin of Current flow (high level >100A)
  - 3 CT measurement

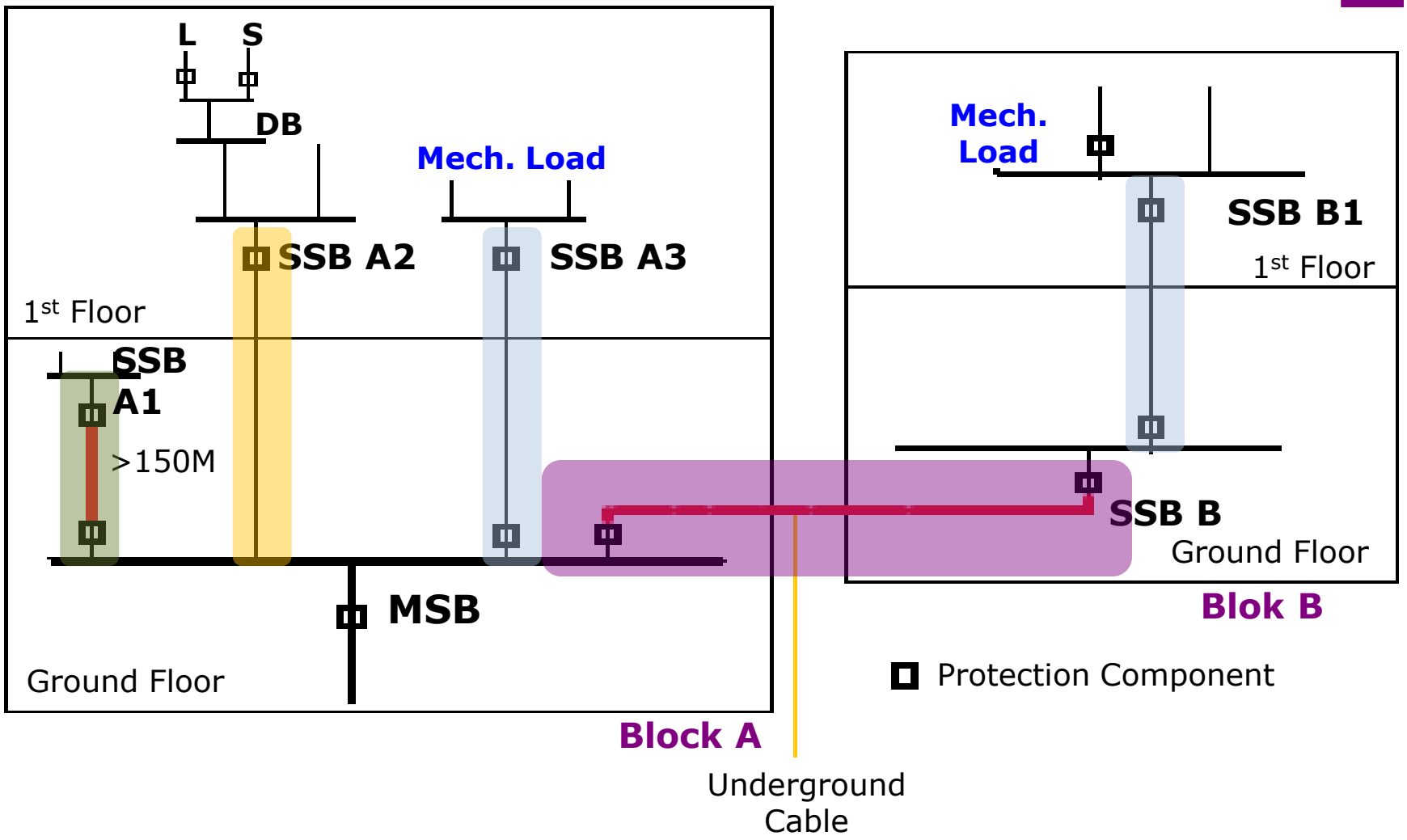


- Earth Leakage (EL)
  - Human Safety protection IEC 60479
  - Detection by Zero Sequence Current Flow (very low level mA)
  - Must use Z-CT High Sensitivity
  - 1 CT measurement

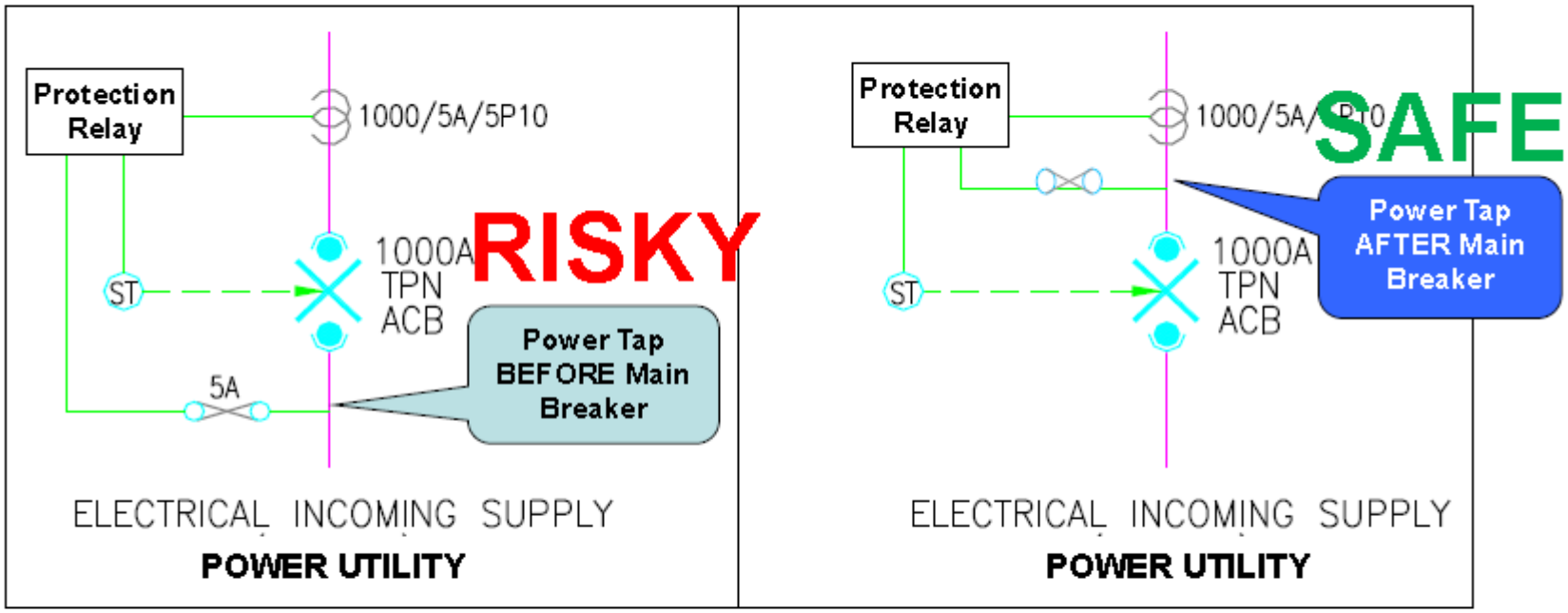




Positioning The Protection Component



Downstream Power Tapping



Power Tap BEFORE CB

- Potential risks to upstream Utility circuits

Power Tap AFTER CB

- Ensure complete isolation of specific discrimination zone upon CB trip
- System safety is maintained

Modbus Communication

- SCADA
- Substation automation