Power System Protection
ECE 456

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Overcurrent Co-ordination

Contents

Overcurrent Coordination

- Systematic application of current-actuated protective devices in the electrical power system, which, in response to a fault or overload, will remove only a minimum amount of equipment from service.
- The coordination study of an electric power system consists of an organized time-current study of all devices in series from the utilization device to the source.
- This study is a comparison of the time it takes the individual devices to operate when certain levels of normal or abnormal current pass through the protective devices.

Objective of Coordination

- To determine the characteristics, ratings, and settings of overcurrent protective devices.
  - To ensure that the minimum unfaulted load is interrupted when the protective devices isolate a fault or overload anywhere in the system.
  - At the same time, the devices and settings selected should provide satisfactory protection against overloads on the equipment and interrupt short circuits as rapidly as possible.
- Minimize the equipment damage and process outage costs,
- To protect personnel from the effects of these failures.

Advantages Of Coordination

- Provides data useful for the selection of
  - instrument transformer ratios
  - protective relay characteristics and settings
  - fuse ratings
  - low-voltage circuit breaker ratings, characteristics, and settings.
- Also provides
  - other information pertinent to the provision of optimum protection and selectivity in coordination of these devices

Coordination Study

- Primary Considerations
  - Short Circuit currents
    - Maximum and minimum momentary (first cycle) short-circuit current
    - Maximum and minimum interrupting duty (5 cycle to 2 s) short-circuit current
    - Maximum and minimum ground-fault current

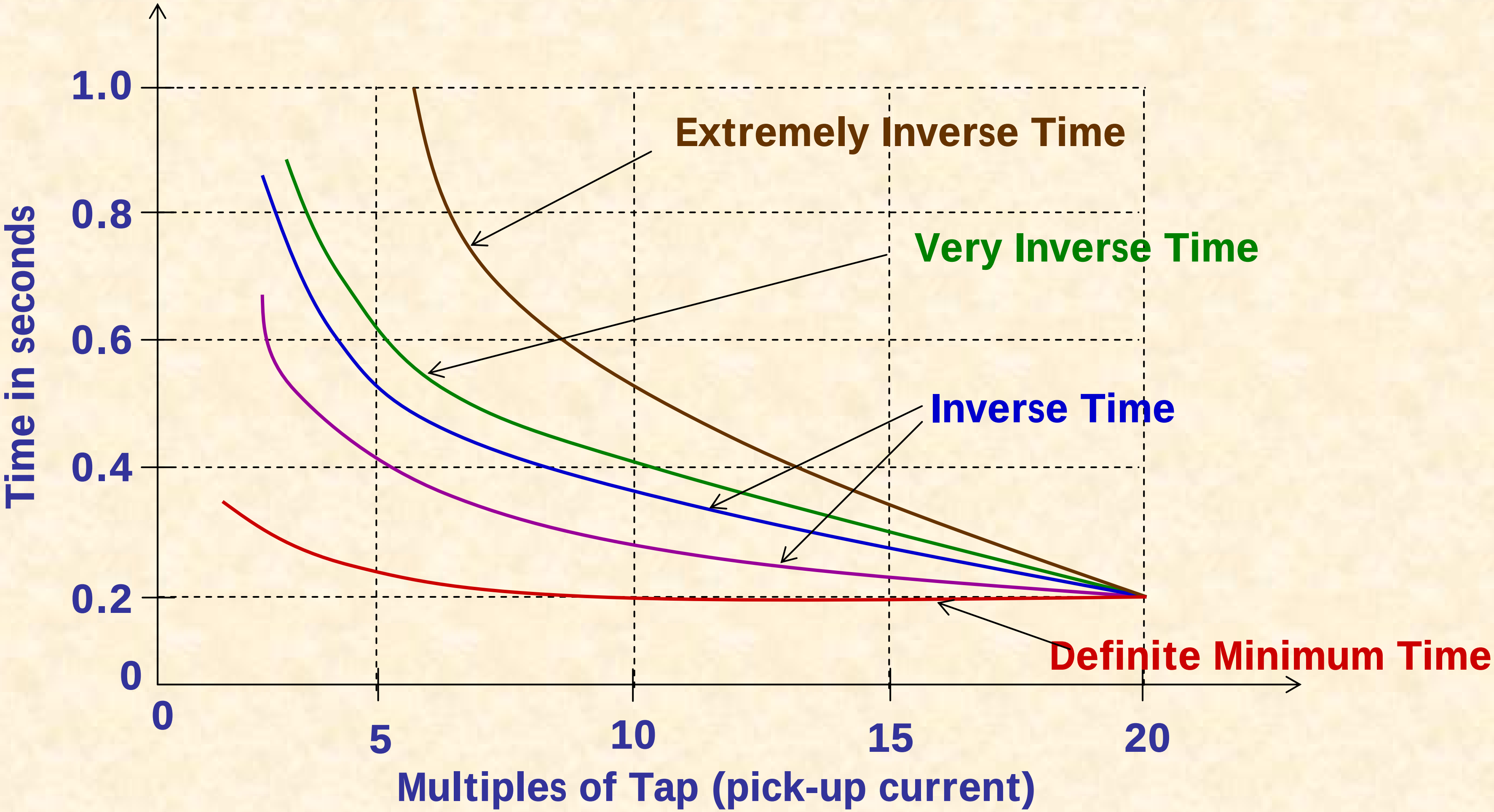
Coordination Study

- Primary Considerations
  - Coordination time intervals
    - circuit breaker opening time (5 cycles) 0.08 s
    - relay over travel   0.10 s
    - safety factor for CT saturation, setting errors, etc
      0.22 s

Coordination Study

- Pick-up current
  - pickup is defined as that minimum current that starts an action.
  - pickup current of an overcurrent relay is the minimum value of current that will cause the relay to close its contacts.
  - For an induction disk overcurrent relay, pickup is the minimum current that will cause the disk to start to move and ultimately close its contacts.
  - For solenoid-actuated devices, tap or current settings of these relays usually correspond to pickup current.

Multiples of Tap (Pick up Current)



Time Multiplier Setting(TMS)

- Time Multiplier Setting (TMS) or Time Dial Setting (TDS)
- Means of adjusting the time taken by the relay to trip once the current exceeds the set value

$$T.M.S. = \frac{T}{T_m}$$

Where,

T - is the required time of operation

Tm - is the time obtained from the relay characteristics curve at TMS 1.0 and using the Plug Setting Multiplier (PSM) equivalent to the maximum fault current

Instantaneous Setting

$$IT = \frac{(1.1)(I_{MAX})(A.F.)}{(TXMR - RATIO)(C.T.RATIO)}$$

Where,

IT is the Instantaneous Trip (Amperes)

1.1 is the Safety Factor

I_{max} is Maximum Fault Current Seen (Amperes)

A.F. is Asymmetric Factor

TXMR Ratio is Transformer Ratio

C.T. Ratio is Current Transformer Ratio

IEEE Standard Inverse Time Characteristic

Reset Time of an Inverse -Time Overcurrent Relay

$$\text{For } 0 < M < 1 \quad t(I)_{reset\ time} = TD\left(\frac{t_r}{M^2 - 1}\right) \qquad (1)$$

Pickup Time of an Inverse - Time Overcurrent Relay

$$\text{For } M > 1 \quad t(I)_{trip\ time} = TD\left(\frac{A}{M^P - 1} + B\right) \qquad (2)$$

Where,

t(I) is the reset time in equation (1) and the trip time in equation (2) in seconds

TD is the time dial setting

M is the I_{input}/I_{pickup} (I_{pickup} is the relay current set point)

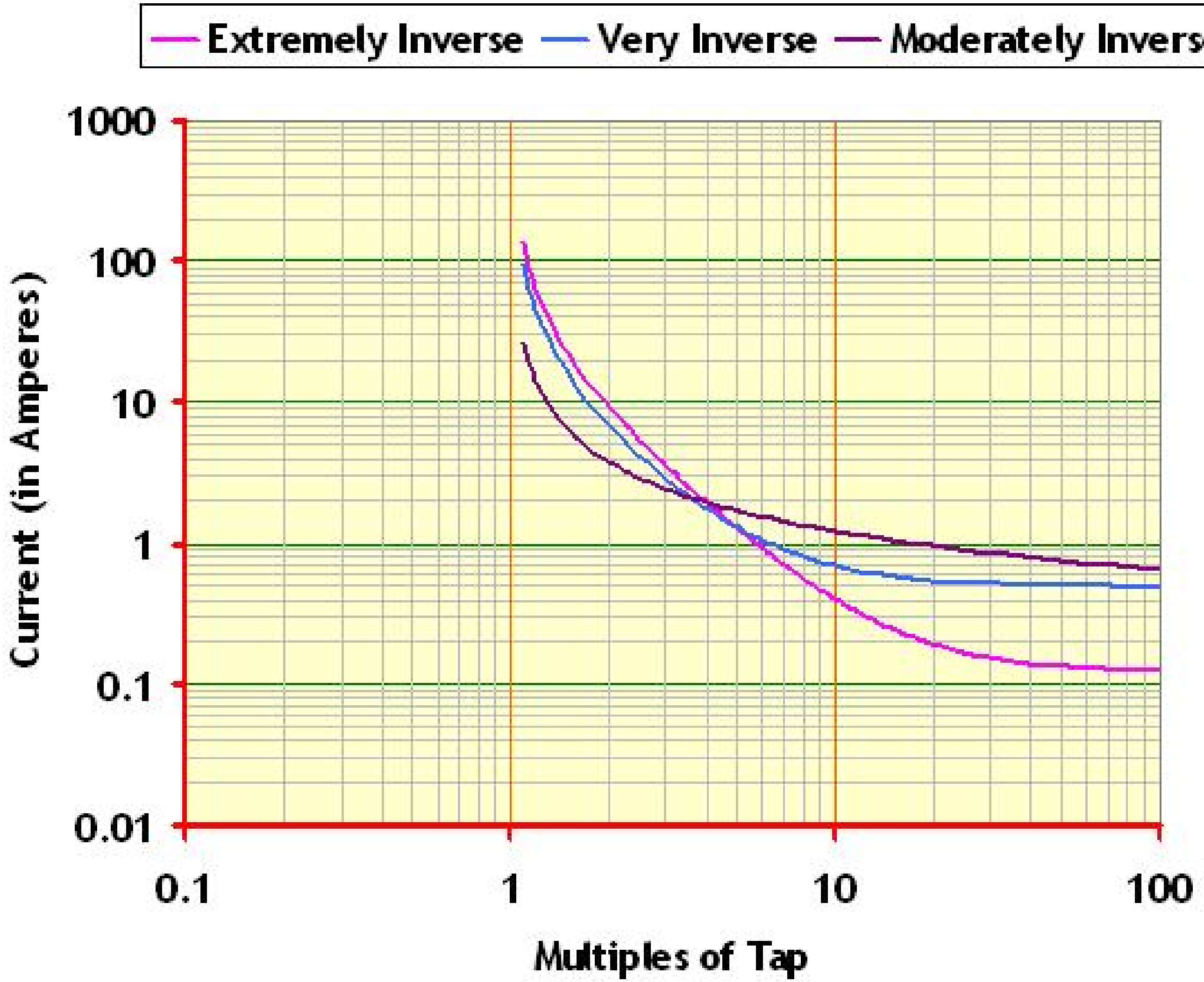
t(r) is the reset time (for M=0)

A, B, p constants to provide selected curve characteristics

Constants & Exponents

Characteristics	A	B	p	t_r
Moderately Inverse	0.0515	0.1140	0.02000	4.85
Very Inverse	19.61	0.491	2.0000	21.6
Extremely Inverse	28.2	0.1217	2.0000	29.1

Relay Characteristics



Coordination Between Devices

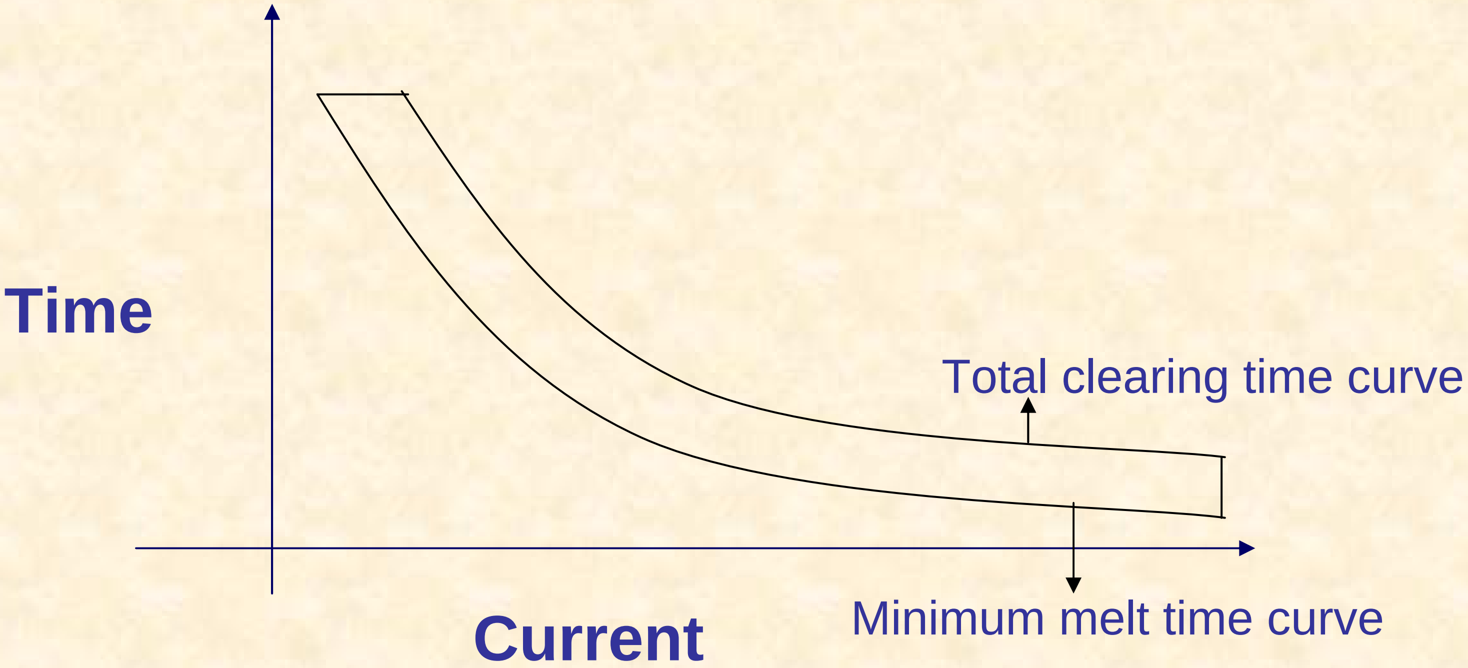
- Fuses
- Sectionalizers
- Reclosers
- Instantaneous over current
- Inverse time overcurrent relays
- Directional overcurrent relays

Fuses

- Different Types of fuses
- Basic Characteristics
  - Consists of one or more silver-wire or ribbon elements called fusible element suspended in an envelope
  - When high currents flows, the fusible element melts almost instantaneously disconnecting the protected element.
  - The time current characteristics of a fuse has two curves
    - Minimum melt curve
    - Total clearing time

Fuses

Fuse Time Vs Current characteristics



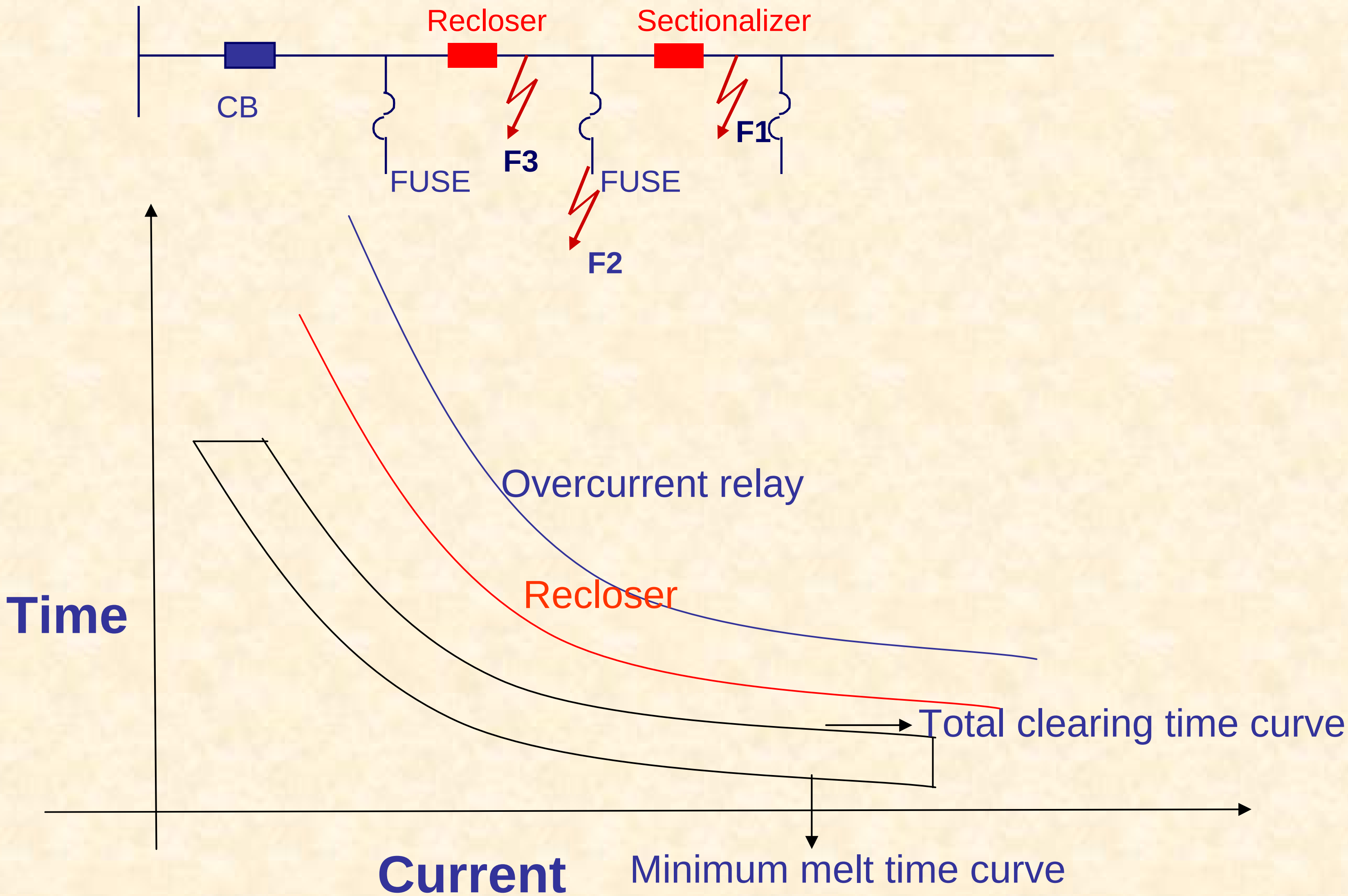
Fuses

- Selection criteria
  - Melting curves
  - Load carrying capabilities
  - Continuous current
  - Hot load pick up
  - Cold load pickup

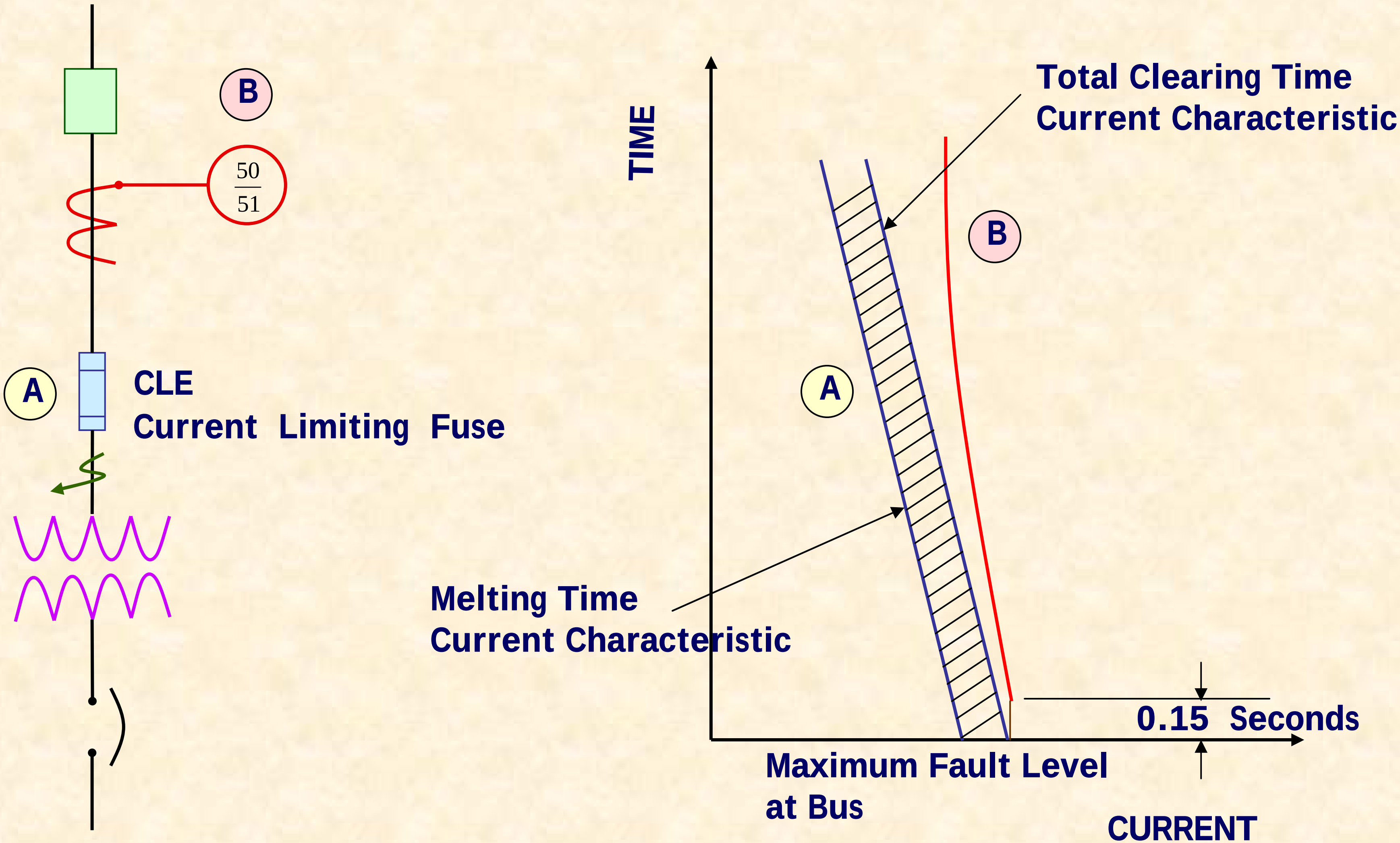
Sectionalizers & Reclosers

- Sectionalizers:
  - It cannot interrupt a fault
  - Counts number of time it sees the fault current and opens after a preset number while the circuit is de energized
- Reclosers
  - Limited fault interrupting capability
  - Recloses automatically in a programmed sequence

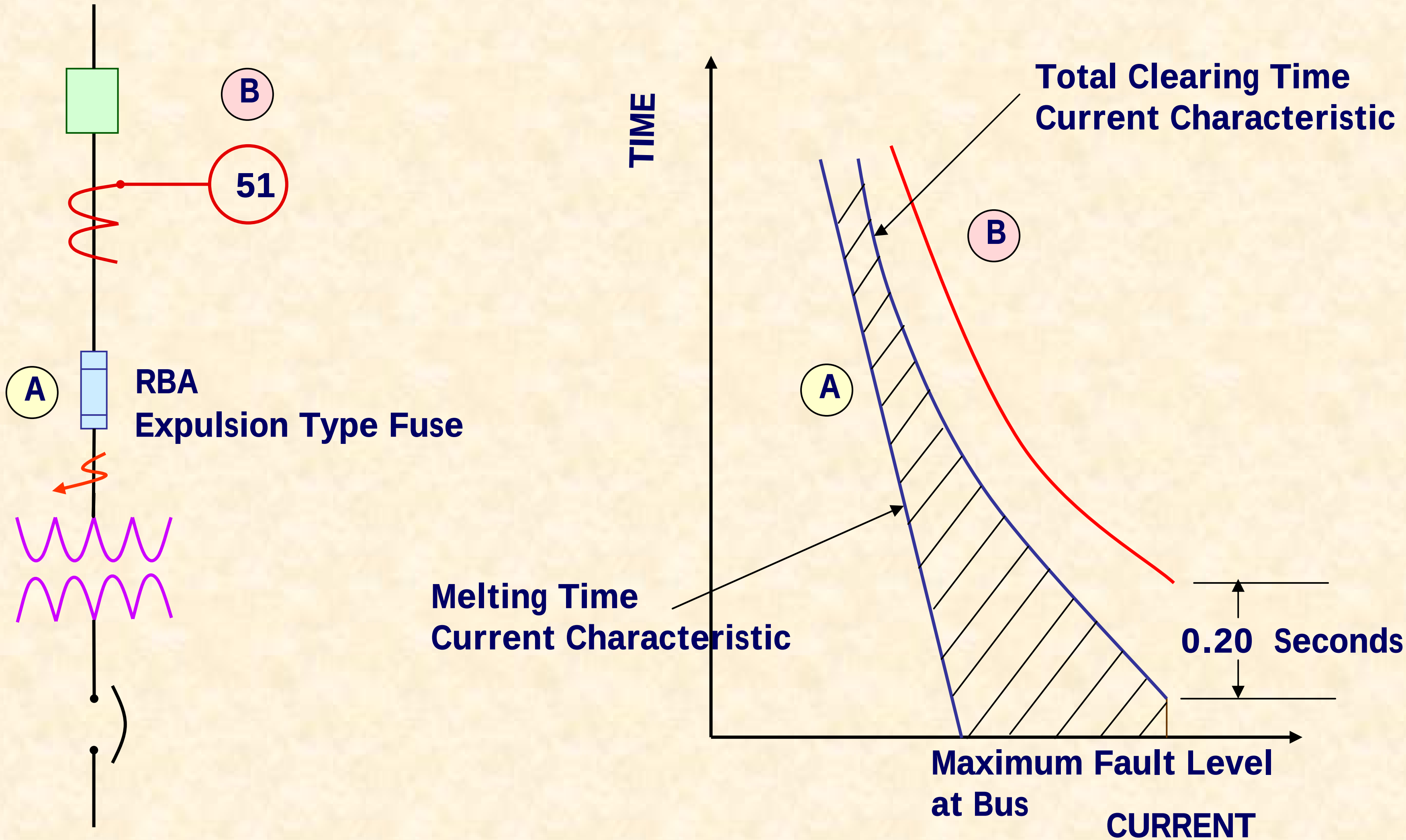
Coordination of protective devices



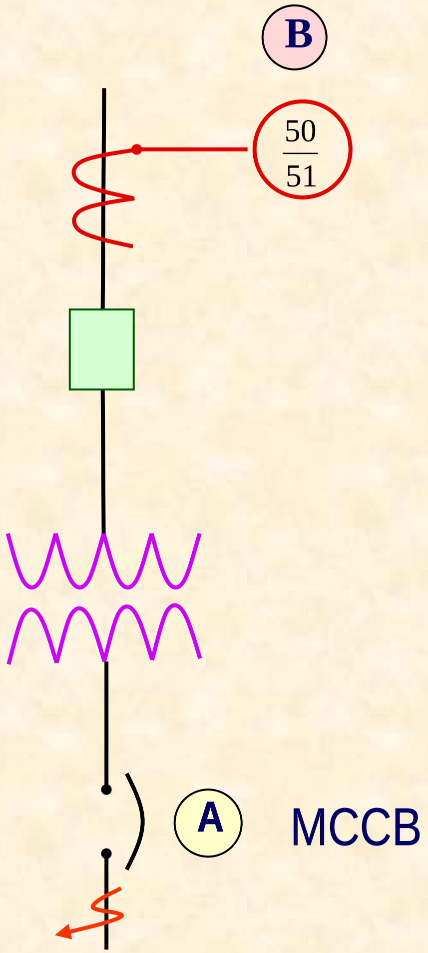
Fuse - Relay Interval

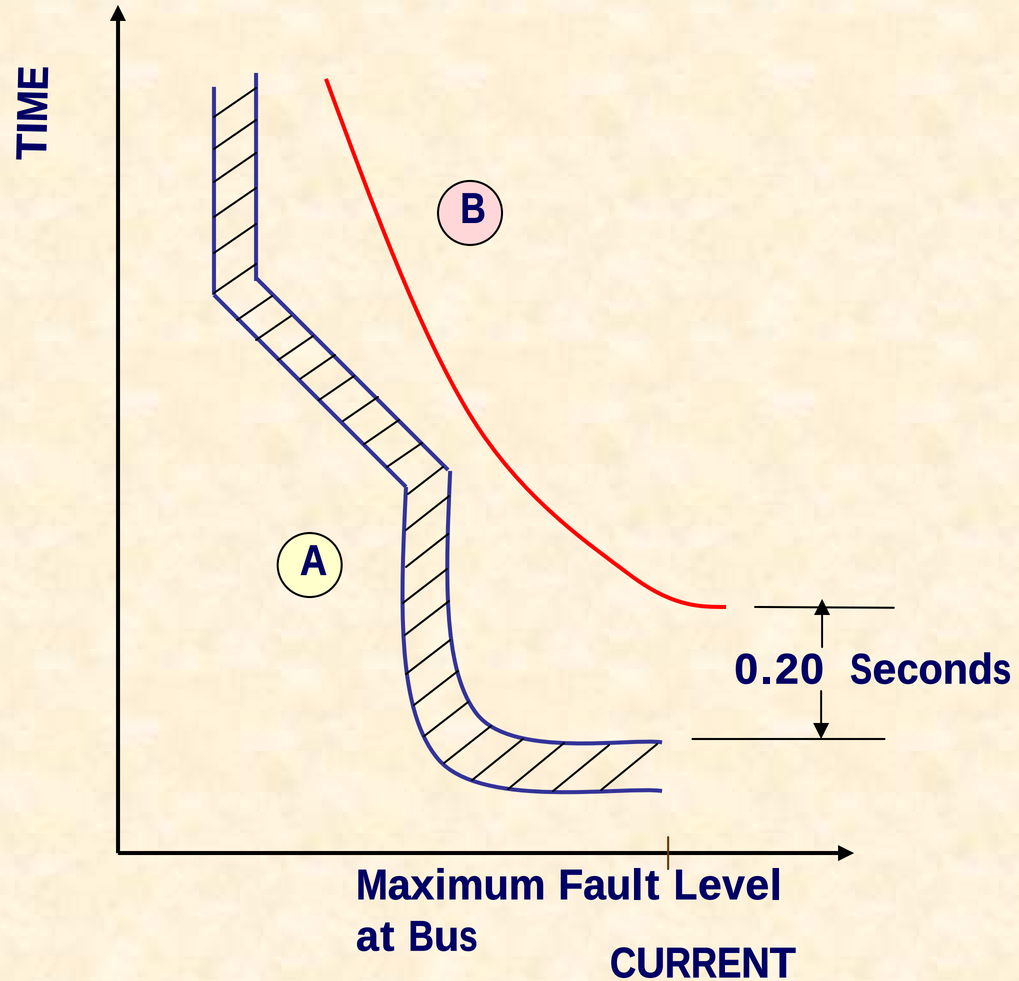


Fuse-Relay Interval

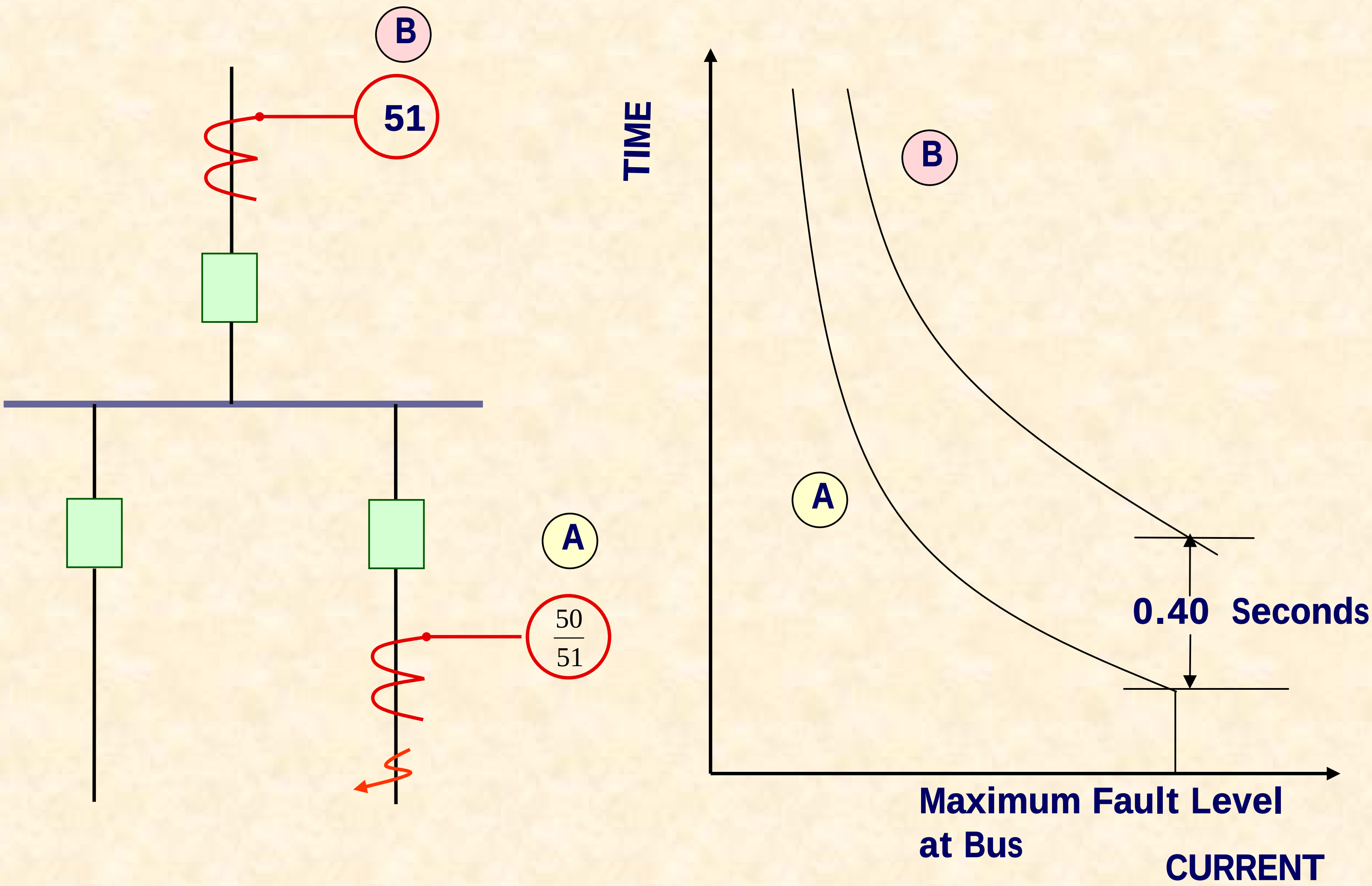


Breaker-Relay Interval

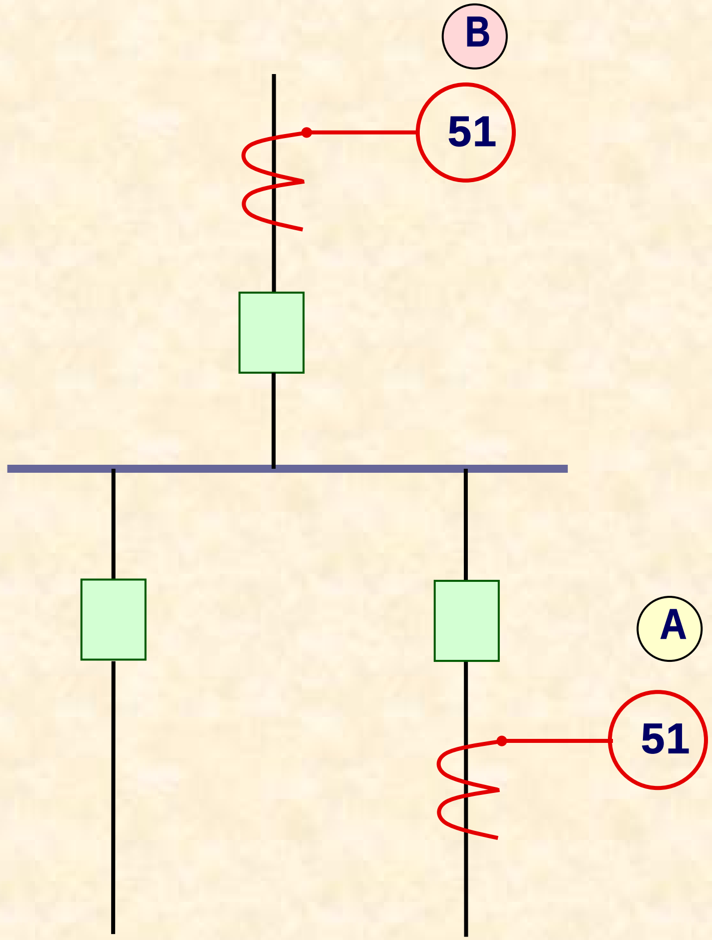


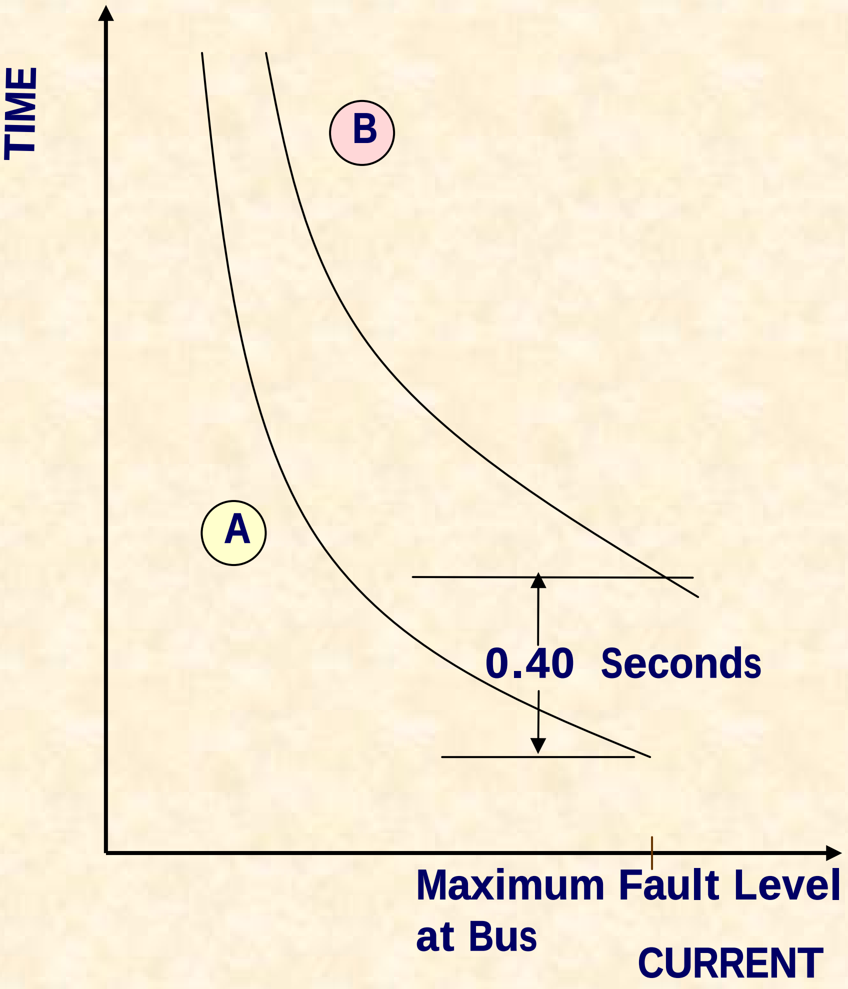


Relay- Relay Interval

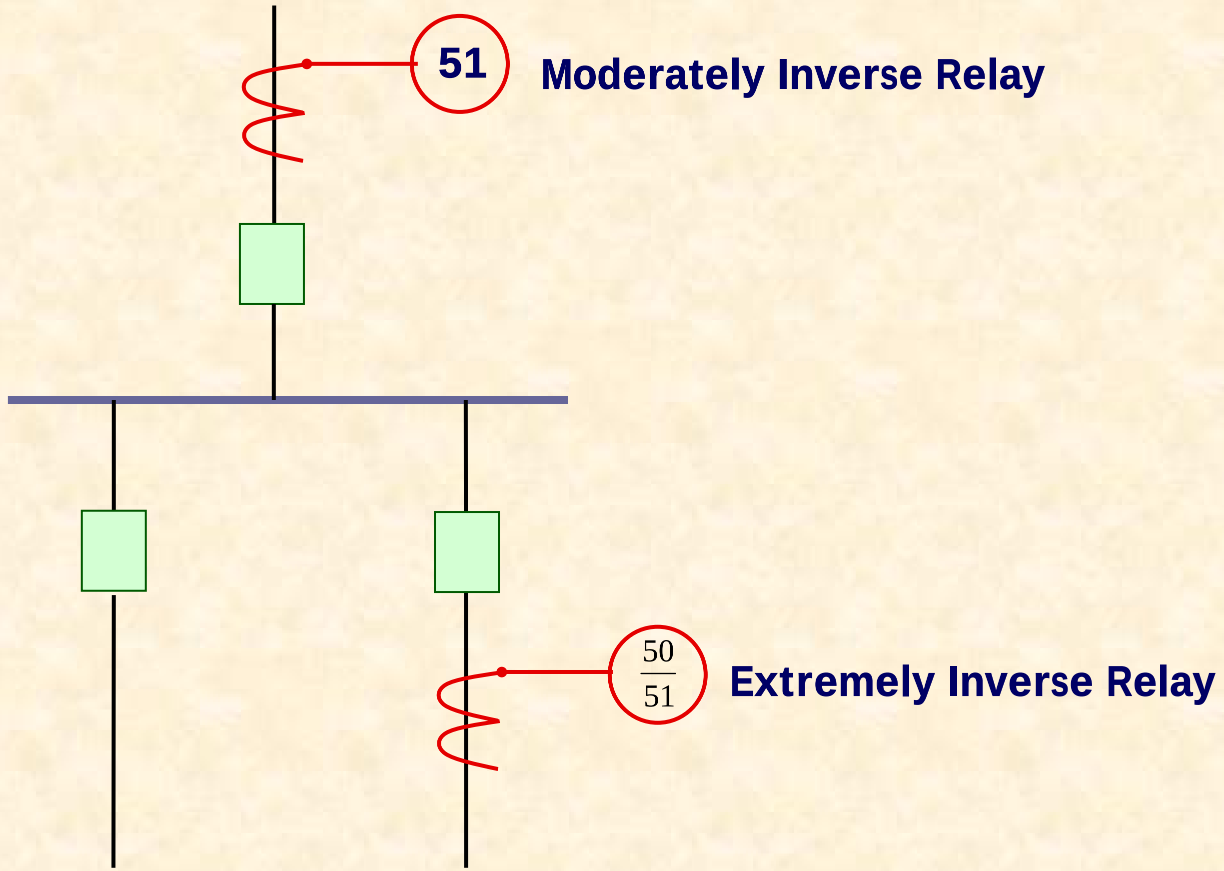


Relay- Relay Interval

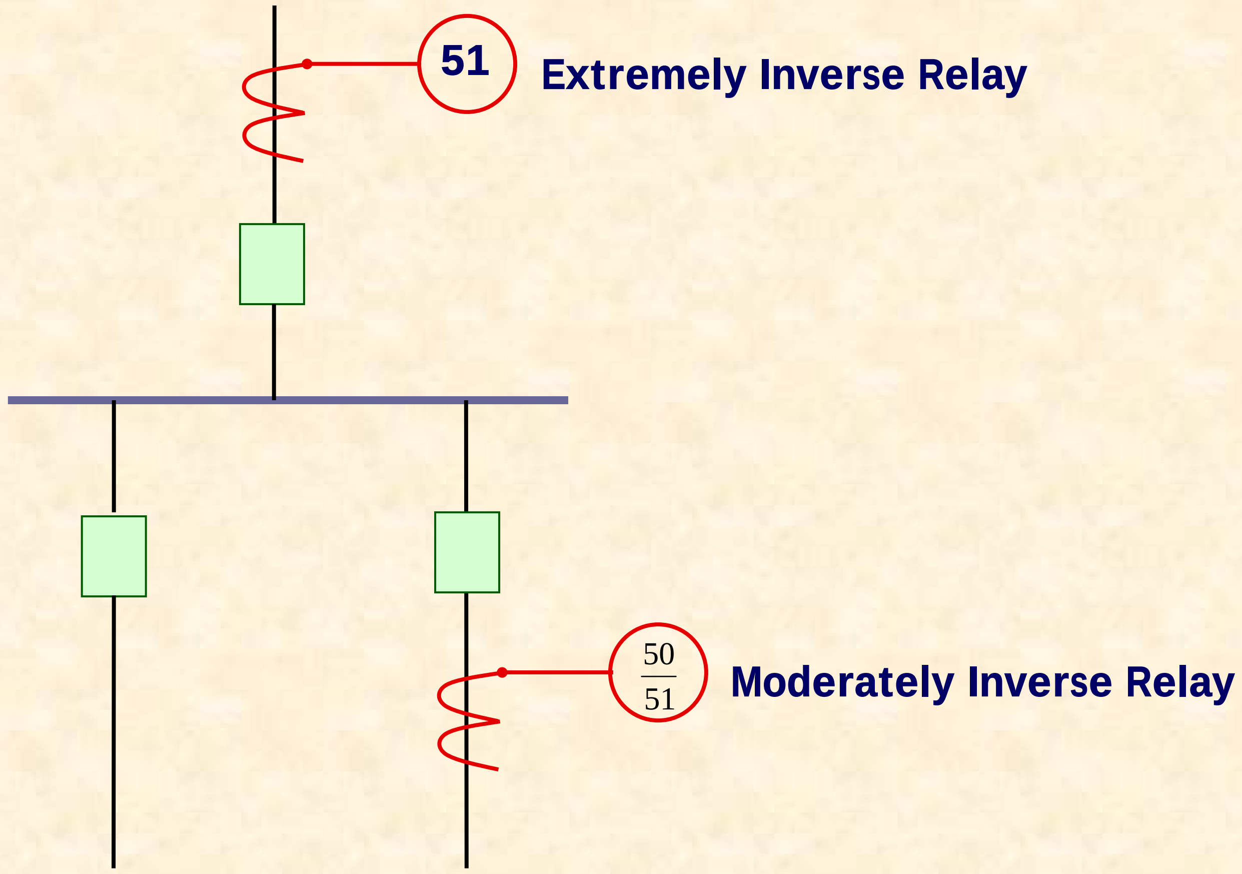




Relay Characteristic Selection



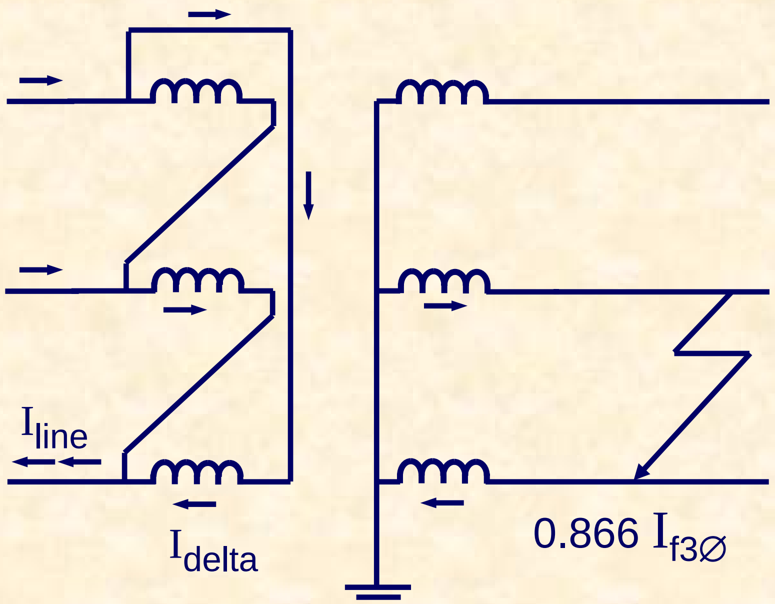
Relay Characteristic Selection



Overcurrent Protection
Transformer Protection – 2:1:1 Fault Current

- A phase-phase fault on one side of transformer produces 2:1:1 distribution on other side
- Use an overcurrent element in each phase (cover the 2x phase)
- 2∅ & EF relays can be used provided fault current > 4x setting

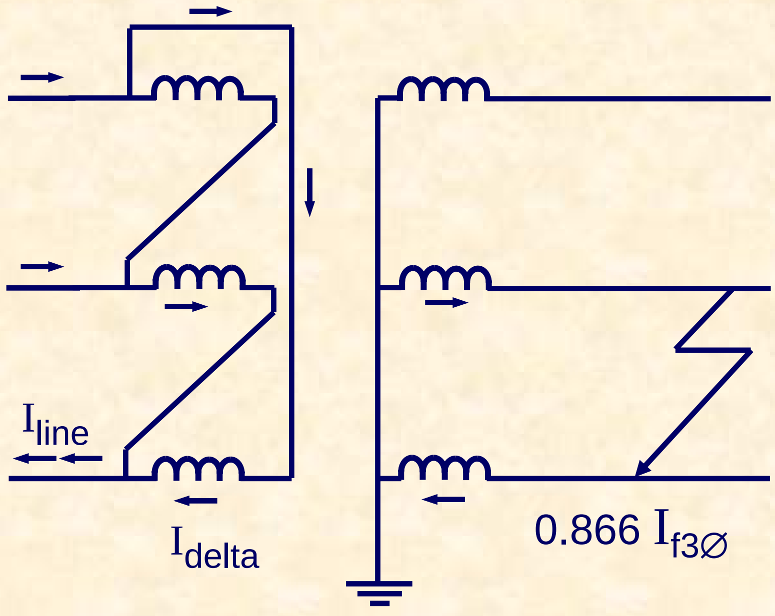
Turns Ratio = $\sqrt{3}$:1



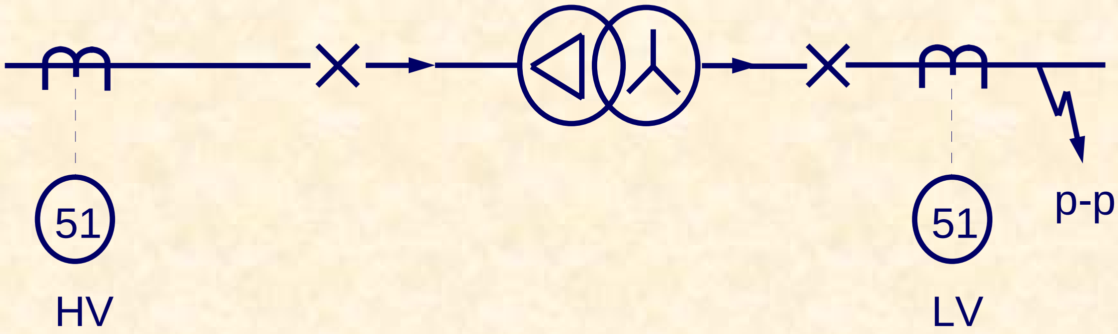
Overcurrent Protection
Transformer Protection – 2:1:1 Fault Current

- Istar = Ep-p/2Xt = √3 Ep-n/2Xt
- Istar = 0.866 Ep-n/Xt
- Istar = 0.866 If3∅
- Idelta = Istar/√3 = If3∅ /2
- Iline = If3∅

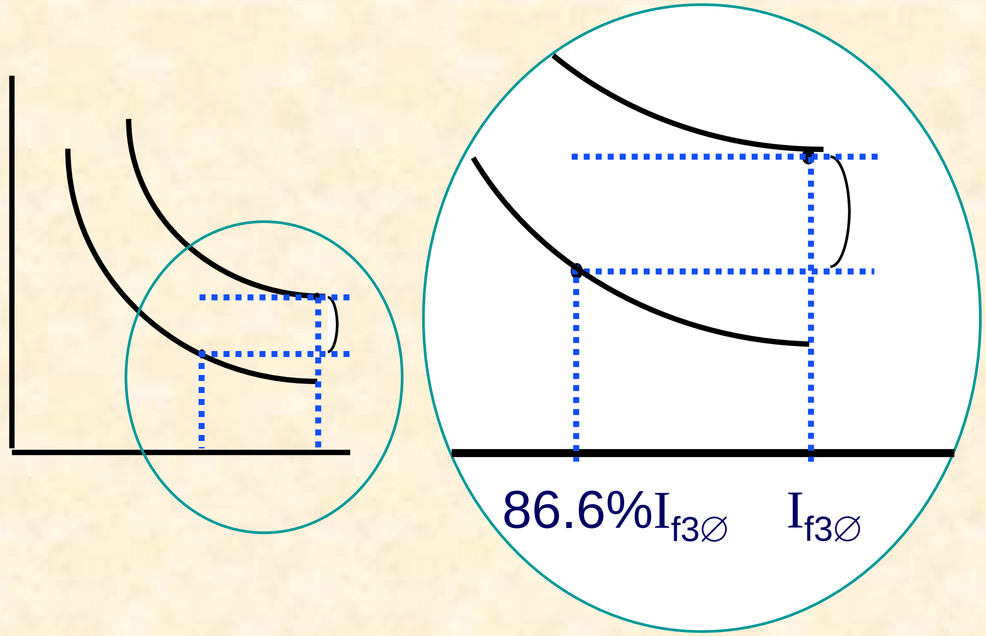
Turns Ratio =
√3 :1



Overcurrent Protection
Transformer Protection – 2:1:1 Fault Current



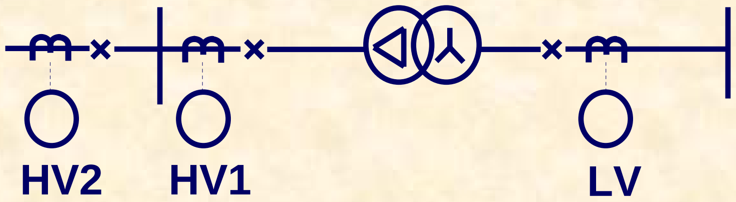
- Grade HV relay with respect to 2:1:1 for p-p fault
- Not only at max fault level

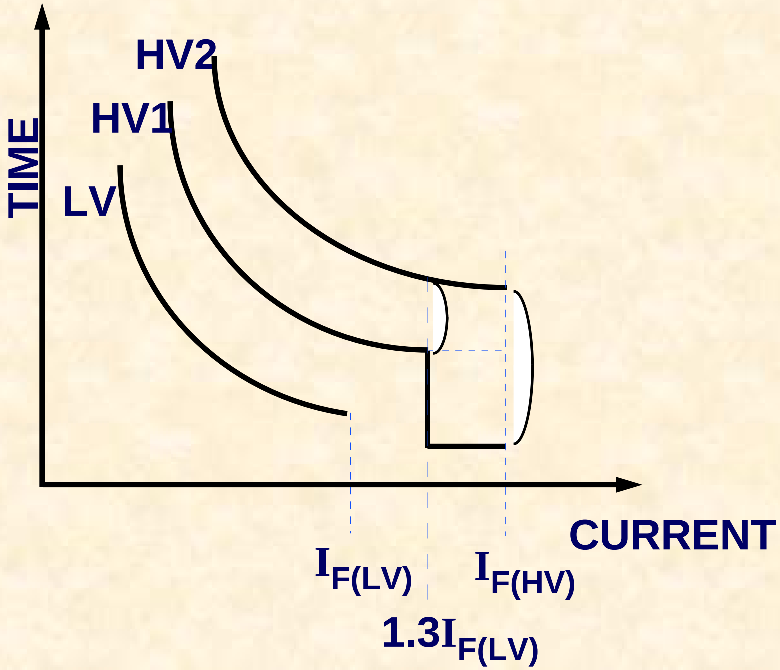


Overcurrent Protection
Instantaneous Protection

- Fast clearance of faults
  - Ensure good operation factor, If >> Is
- Current setting must be co-ordinated to prevent overtripping
- Used to provide fast tripping on HV side of transformers
- Used on feeders with auto reclose, prevents transient faults becoming permanent
  - AR ensures healthy feeders are re-energised
- Consider operation due to DC offset - transient overreach

Overcurrent Protection
Instantaneous OC on Transformer Feeders

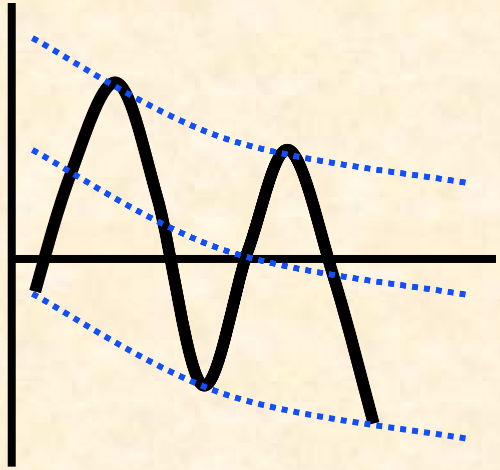




- Set HV inst 130% IfLV
- Stable for inrush
- No operation for LV fault
- Fast operation for HV fault
- Reduces op times required of upstream relays

Overcurrent Protection Transient Overreach

- Should have ability to ignore DC offset

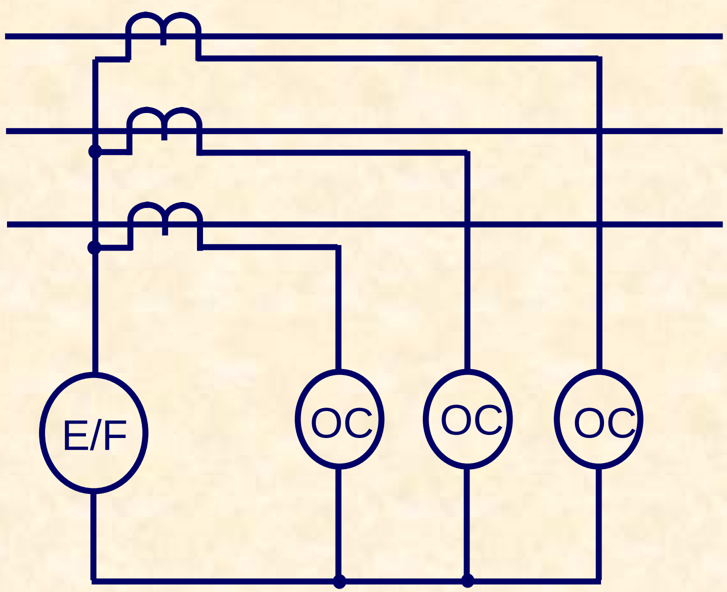


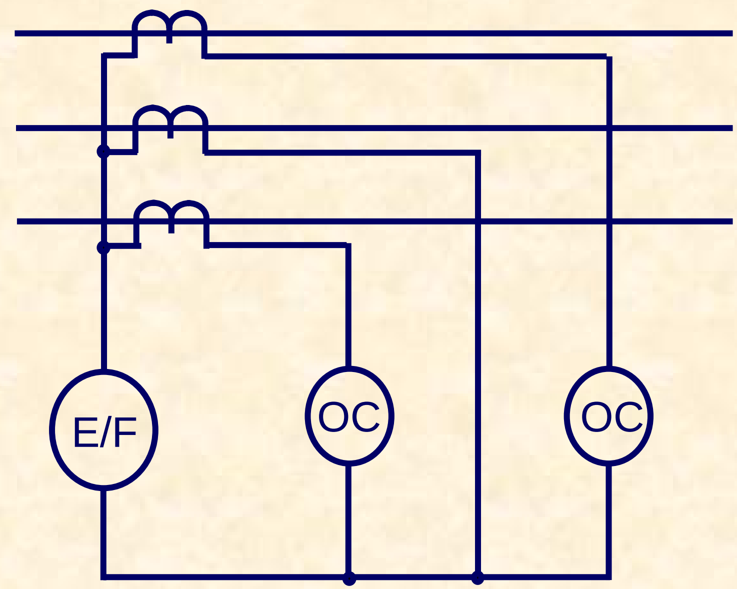
- Low overreach allows low Inst setting to be used
  - high operation factor
  - immunity to LV transformer faults

Overcurrent Protection
Earth Fault Protection

- Earth fault current may be limited
- Sensitivity and speed requirements may not be met by overcurrent relays
  - Use dedicated EF protection relays
- Connect to measure residual (zero sequence) current
  - Can be set to values less than full load current
- Co-ordinate as for OC elements
  - May not be possible to provide co-ordination with fuses

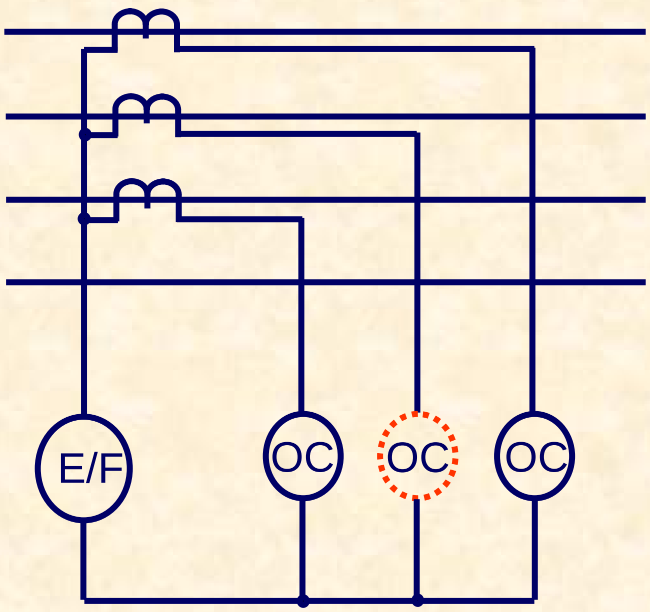
Overcurrent Protection
Earth Fault Relay Connection - 3 Wire System

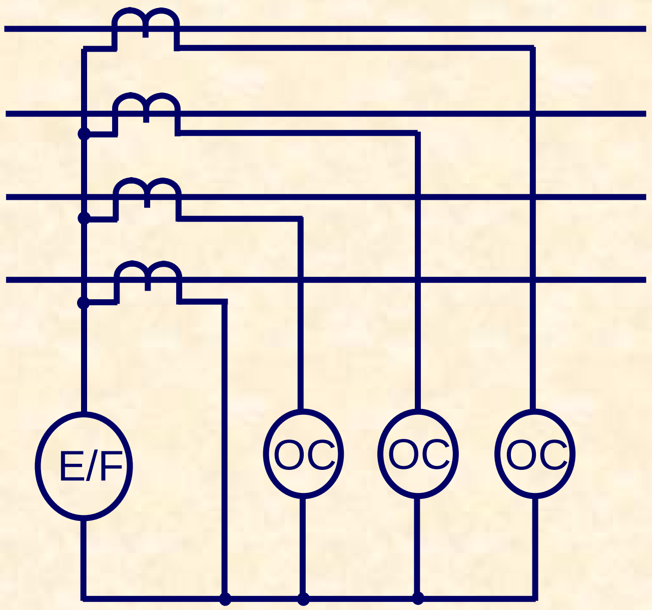




- Combined with OC relays
- Economise using 2x OC relays

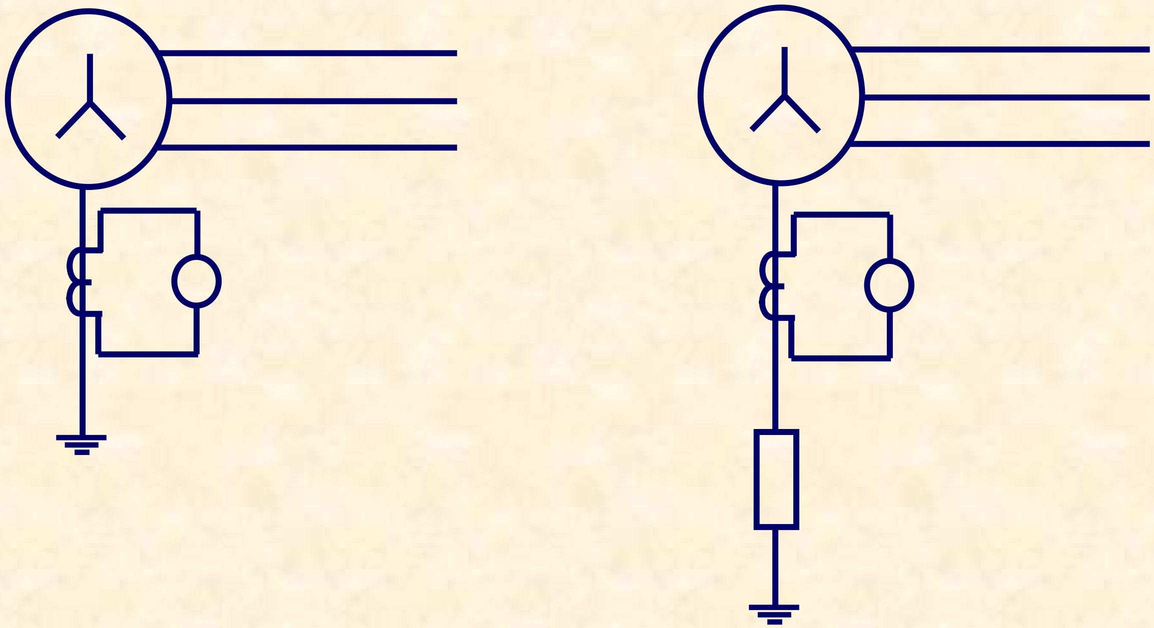
Overcurrent Protection
Earth Fault Relay Connection - 4 Wire System





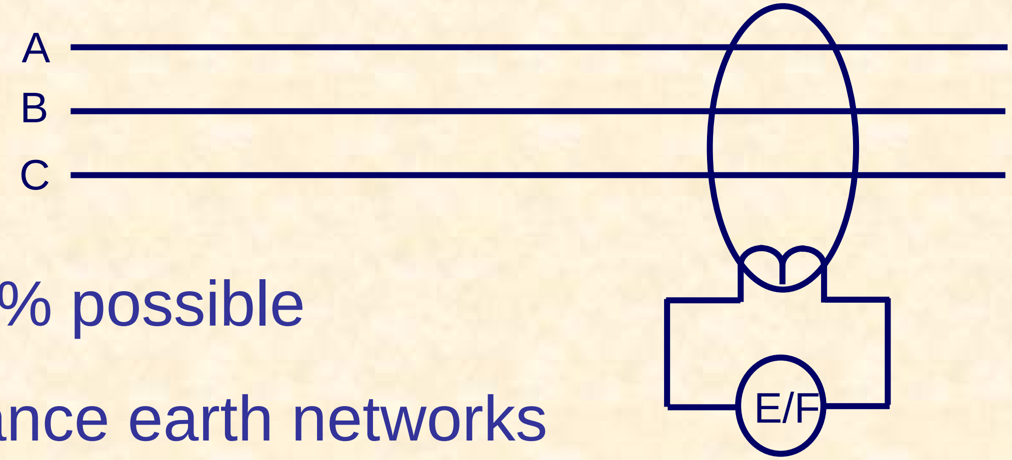
- EF relay setting must be greater than normal neutral current
- Independent of neutral current but must use 3 OC relays for phase to neutral faults

Overcurrent Protection
Earth Fault Relays Current Setting



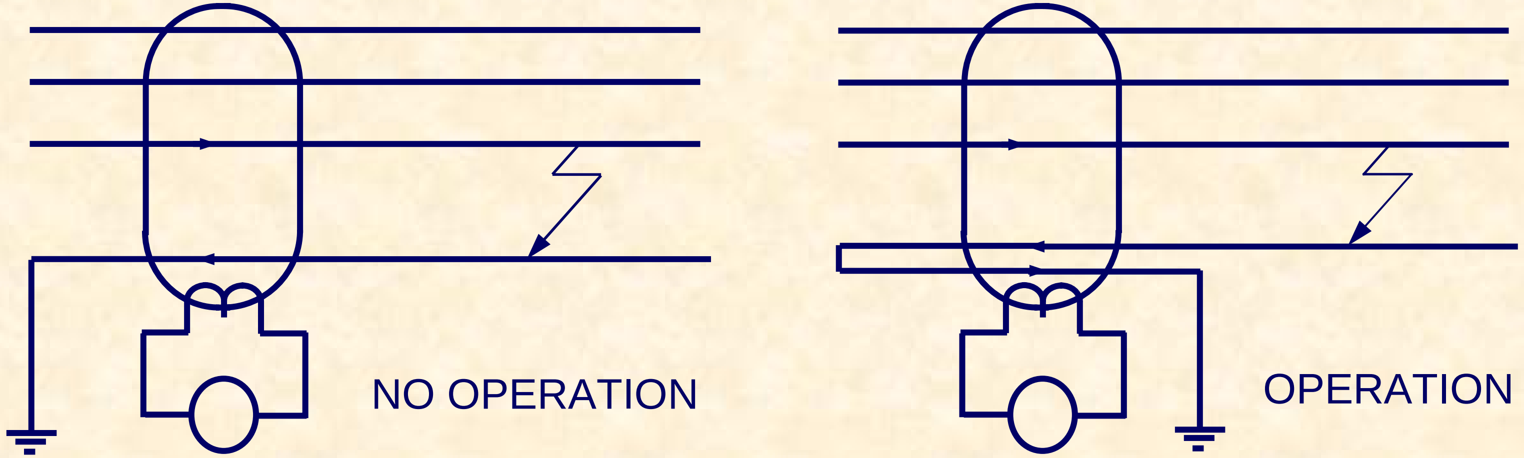
- ❑ Solid earth
  - ❑ 30% Ifull load adequate
- ❑ Resistance earth
  - ❑ setting w.r.t earth fault level
  - ❑ special considerations for impedance earthing

Overcurrent Protection
Sensitive Earth Fault Relays

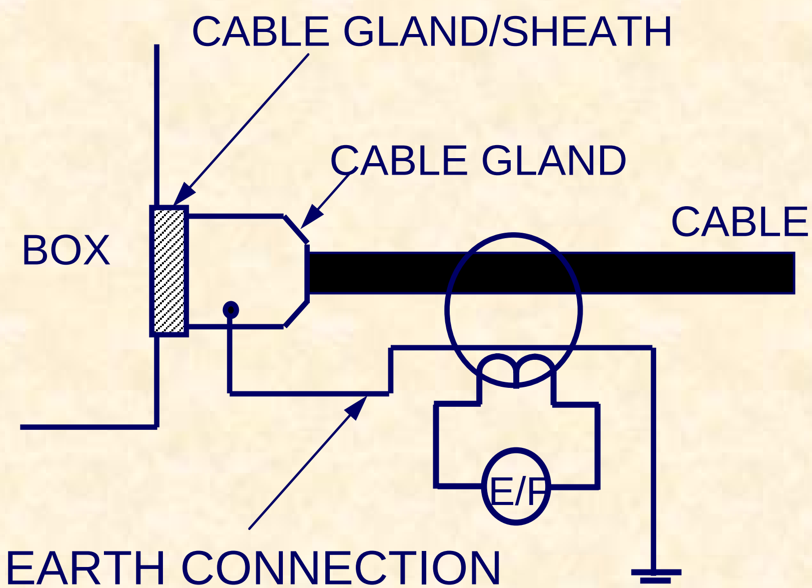


- Settings down to 0.2% possible
- Isolated/high impedance earth networks
- For low settings cannot use residual connection, use dedicated CT
- Advisable to use core balance CT
- CT ratio related to earth fault current not line current
- Relays tuned to system frequency to reject 3rd harmonic

Overcurrent Protection
Core Balance CT Connections



- Need to take care with core balance CT and armoured cables
- Sheath acts as earth return path
- Must account for earth current path in connections - insulate cable gland



Contents

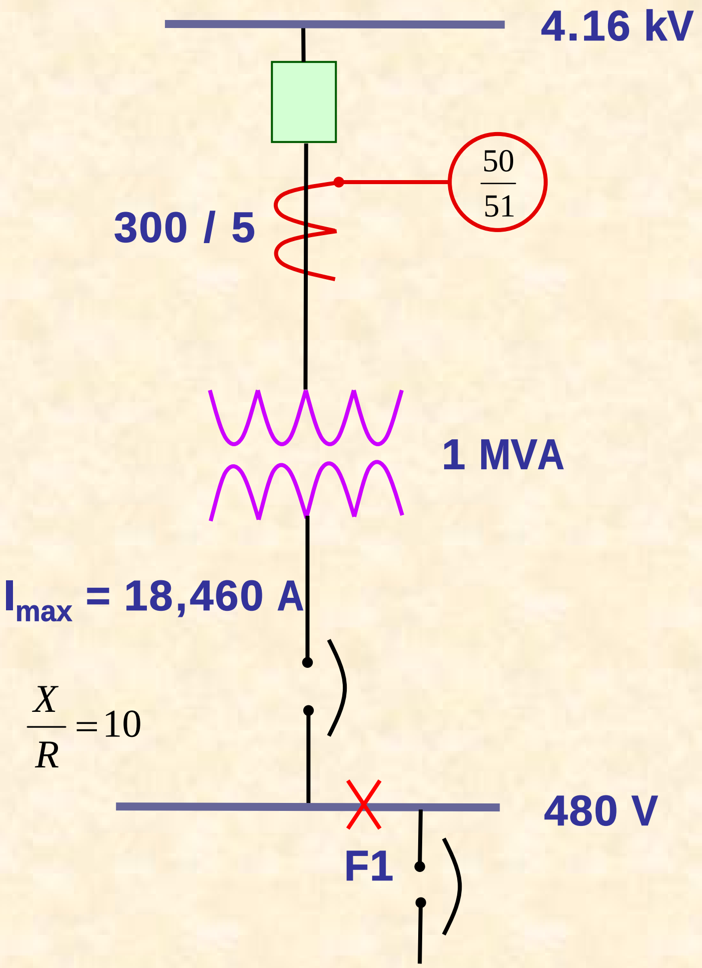
Example 1

Calculate the instantaneous element setting for the relay shown. The asymmetry factor is given as 1.45

$$IT = \frac{(1.1)(18{,}460)(1.45)}{(4.16/0.48)(300/5)}$$

$$= 56.6 \text{ A}$$

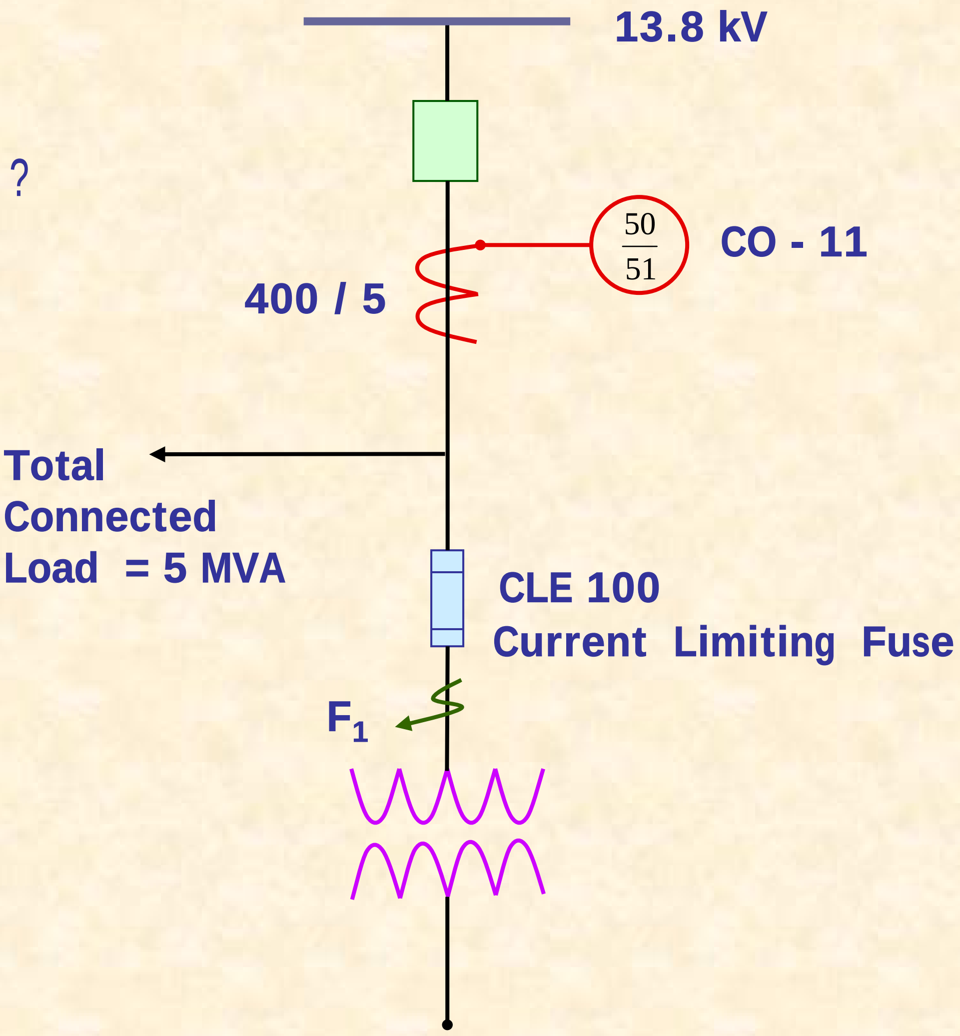
Set IT 56.6 A on the relay



Example 3

Calculate the relay setting and plot its characteristics

- Is the CT Ratio acceptable ?
- What kind of relay do we need ?
- What is the tap setting ?



Example 3 - Solution

Step 1 Fault at F_1

Current drawn by load, $I_{load} = \frac{5 \times 10^3}{\sqrt{3} \times 13.8} = 210\ A$

CT selected is acceptable as its primary is more than the load current

Step 2 Use an extremely inverse relay as we are coordinating with a current limiting fuse

Step 3 Draw Melting time and Total Clearing time fuse characteristics for CLE 100

Melting Current for CLE 100 = 2500 A

Total Clearing Current for CLE 100 = 3210 A

Example 3 - Solution

Step 4 $IT = \frac{(1.1)(3210)}{(400/5)} = 44\ A$ Use an IT of 50 A

IT in primary of CT = 50 × 80 = 4000 A

Load current in primary of CT $= 210 + 100 = 310A$

Load current in secondary of CT $= 310 \times \frac{5}{400} = 3.875\ A$

Fault current in primary of CT $= 3210\ A$

Fault current in secondary of CT $= 3210 \times \frac{5}{400} = 40.125\ A$

Example 3 - Solution

Step 4 Set TAP = 5

Pickup current in secondary of CT = Relay coil current = 5 A

Pickup current in primary of CT $= \mathbf{5} \times \dfrac{\mathbf{400}}{\mathbf{5}} = \mathbf{400}\ A$

Step 5 Trip time of relay

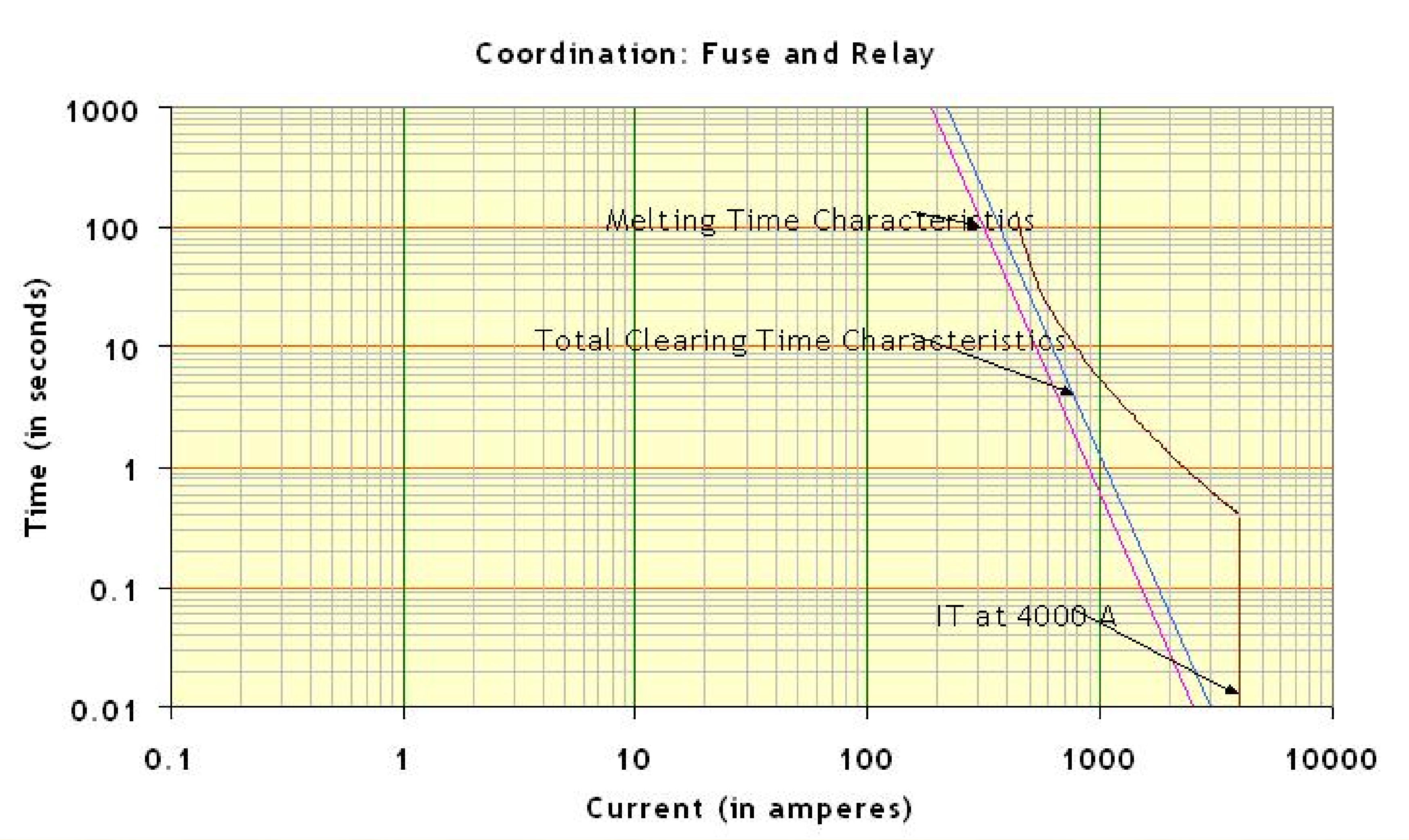
$$M = \frac{I_{input}}{I_{pickup}} = \frac{\mathbf{40}}{\mathbf{5}} = \mathbf{8}$$

$$For \;\; M > 1$$

$$t(I)_{trip\ \ time} = TD\left(\frac{A}{M^{P} - 1} + B\right)$$

$$= 1\left(\frac{28.2}{8^{2} - 1} + 0.1217\right) = 0.5693 \cong 0.6 \sec$$

Example 3 - Solution

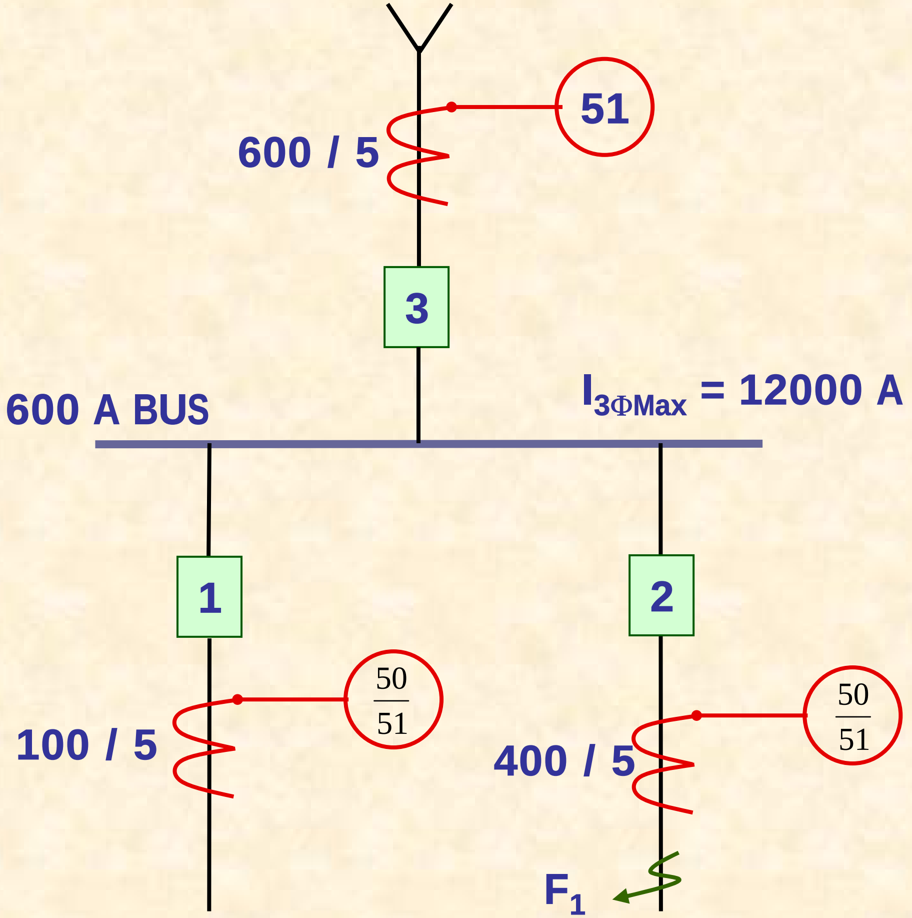


Example 4

Calculate the settings for relay on feeder 3 to co-ordinate with relays on feeder 1 and 2.

The feeder relays are as follows:

Feeder 1	Feeder 2
Extremely Inverse Relay	Extremely Inverse Relay
Tap - 2	Tap - 5
TD - 2	TD - 3
IT - 20	IT - 40



Example 4 - Solution

Step 1 Feeder 1

TAP = 2 MEANS THAT

Pickup current in secondary of CT = Relay coil current = 2 A

Pickup current in primary of CT $= \mathbf{2} \times \frac{\mathbf{100}}{\mathbf{5}} = \mathbf{40}\ A$

IT in secondary of CT = Relay coil current = 20 A

IT in primary of CT $= \mathbf{20} \times \frac{\mathbf{100}}{\mathbf{5}} = \mathbf{400}\ A$

Example 4 - Solution

Step 2 Feeder 2

TAP = 5 MEANS THAT

Pickup current in secondary of CT = Relay coil current = 5 A

Pickup current in primary of CT $= \mathbf{5} \times \dfrac{\mathbf{400}}{\mathbf{5}} = \mathbf{400}\ A$

IT in secondary of CT = Relay coil current = 40 A

IT in primary of CT $= \mathbf{40} \times \dfrac{\mathbf{400}}{\mathbf{5}} = \mathbf{3200}\ A$

Example 4 - Solution

Step 3 Plot curve for Relay at feeder 1 with TAP = 2 and TDS = 2

Plot curve for Relay at feeder 2 with TAP = 5 and TDS = 3

Step 4 Feeder 3

Load current in primary of CT $= \mathbf{600}\ A$

Load current in secondary of CT $= \mathbf{600} \times \frac{\mathbf{5}}{\mathbf{600}} = \mathbf{5}\ A$

Fault current in primary of CT $= \mathbf{12000}\ A$

Fault current in secondary of CT $= \mathbf{12000} \times \frac{\mathbf{5}}{\mathbf{600}} = \mathbf{100}\ A$

Example 4 - Solution

Step 5 Select pickup setting as 7A, that is TAP = 7

Pickup current in secondary of CT = Relay coil current = 7 A

Pickup current in primary of CT $= 7 \times \dfrac{600}{5} = 840\ A$

Step 6 Trip time of relay

$$M = \frac{I_{input}}{I_{pickup}} = \frac{100}{7} = 14.29$$

The required operating time of the feeder 3 relay for this current should be 0.4s+ instantaneous operating time of feeder 2 relay. Assume instantaneous operating time = 0.01s. Therefore required operating time = 0.01+0.4 = 0.41s

Example 4 - Solution

Step 7 The TD setting to get an operating time of 0.41s at M=14.29 is

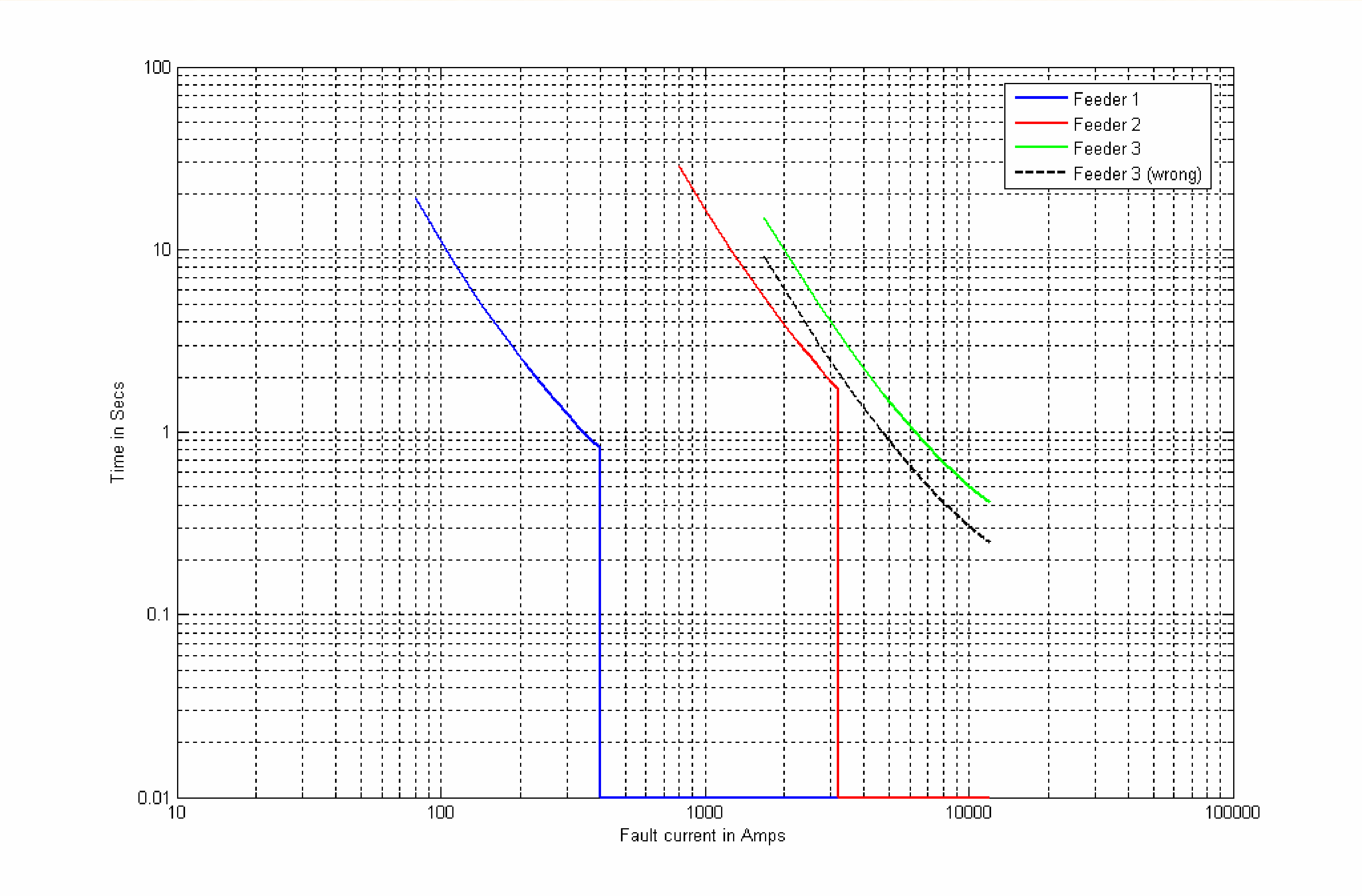
$$For \quad M > 1$$

$$0.41 = TD\left(\frac{A}{M^{P} - 1} + B\right) = TD\left(\frac{28.2}{14.29^{2} - 1} + 0.1217\right)$$

$$TD = 1.57$$

Select closet available higher TD

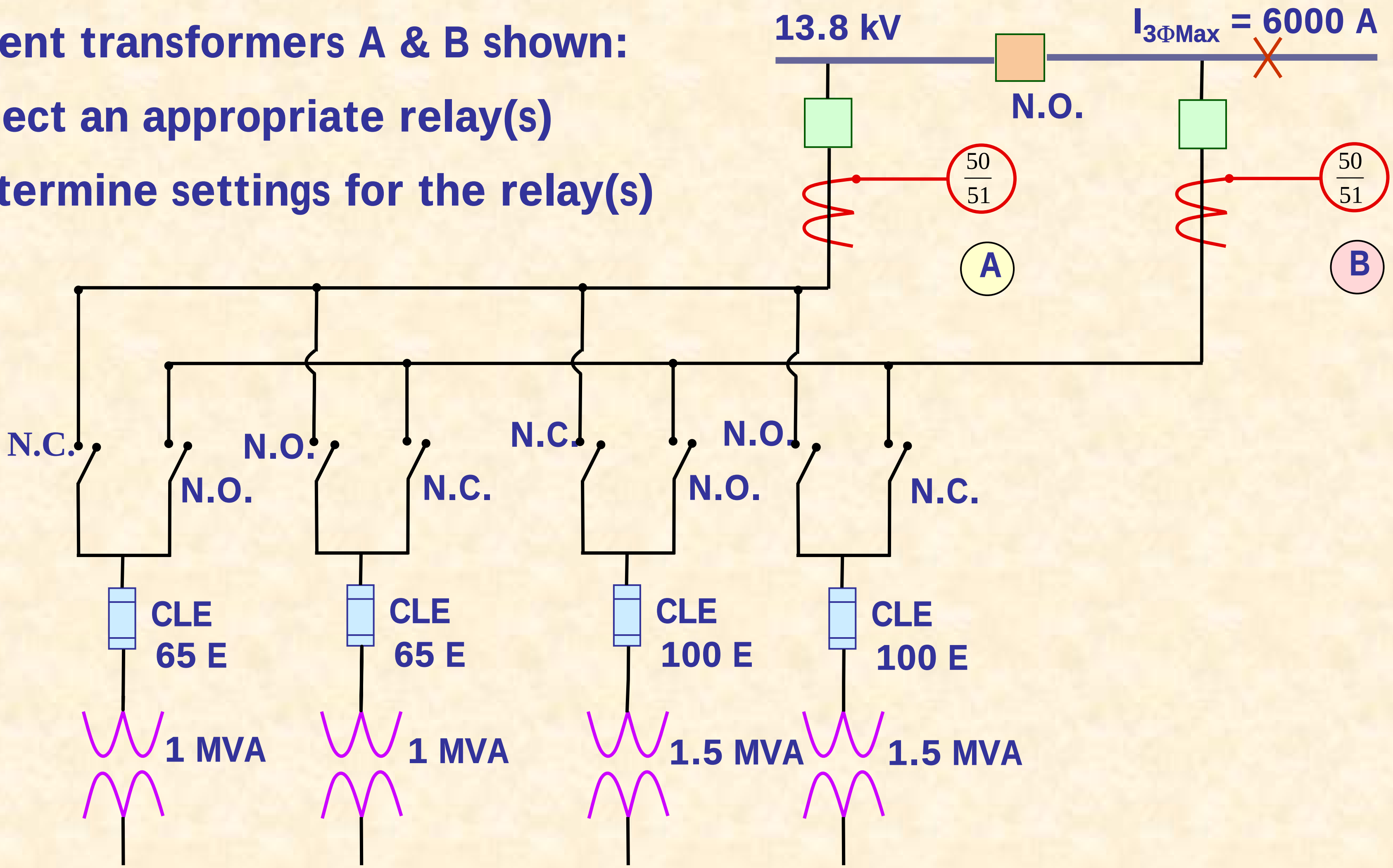
Example 4 - Solution



Example 5

Select the appropriate CT Ratio for the two current transformers A & B shown:

- Select an appropriate relay(s)
- Determine settings for the relay(s)



Example 5 - Solution

Step 1 Total Load = 1 + 1 + 1.5 + 1.5 = 5 MVA

Maximum load on the feeder, $I_{load} = \dfrac{5 \times 10^3}{\sqrt{3} \times 13.8} = 209.18\ A \approx 209\ A$

Step 2 SELECT CT RATIO : $1.5 \times 209 = 320\ A$

Select a CT Ratio of 400 / 5 A

Step 3 $IT = \dfrac{(1.1)\,(6000)}{(400/5)} = 82.5\ A$ Use an IT of 90 A

IT in primary of CT = 90 × 80 = 7200 A

Example 5 - Solution

Load current in primary of CT = 209 A

Load current in secondary of CT $= 209 \times \frac{5}{400} = 2.6125\ A$

Fault current in primary of CT = 6000A

Fault current in secondary of CT $= 6000 \times \frac{5}{400} = 75\ A$

Step 4 Minimum Tap = 3.0 Select Tap = 7.0

TAP = 7 MEANS THAT

Pickup current in secondary of CT = Relay coil current = 7 A

Pickup current in primary of CT $= 7 \times \frac{400}{5} = 560\ A$

Example 5 - Solution

Step 5 Trip time of relay

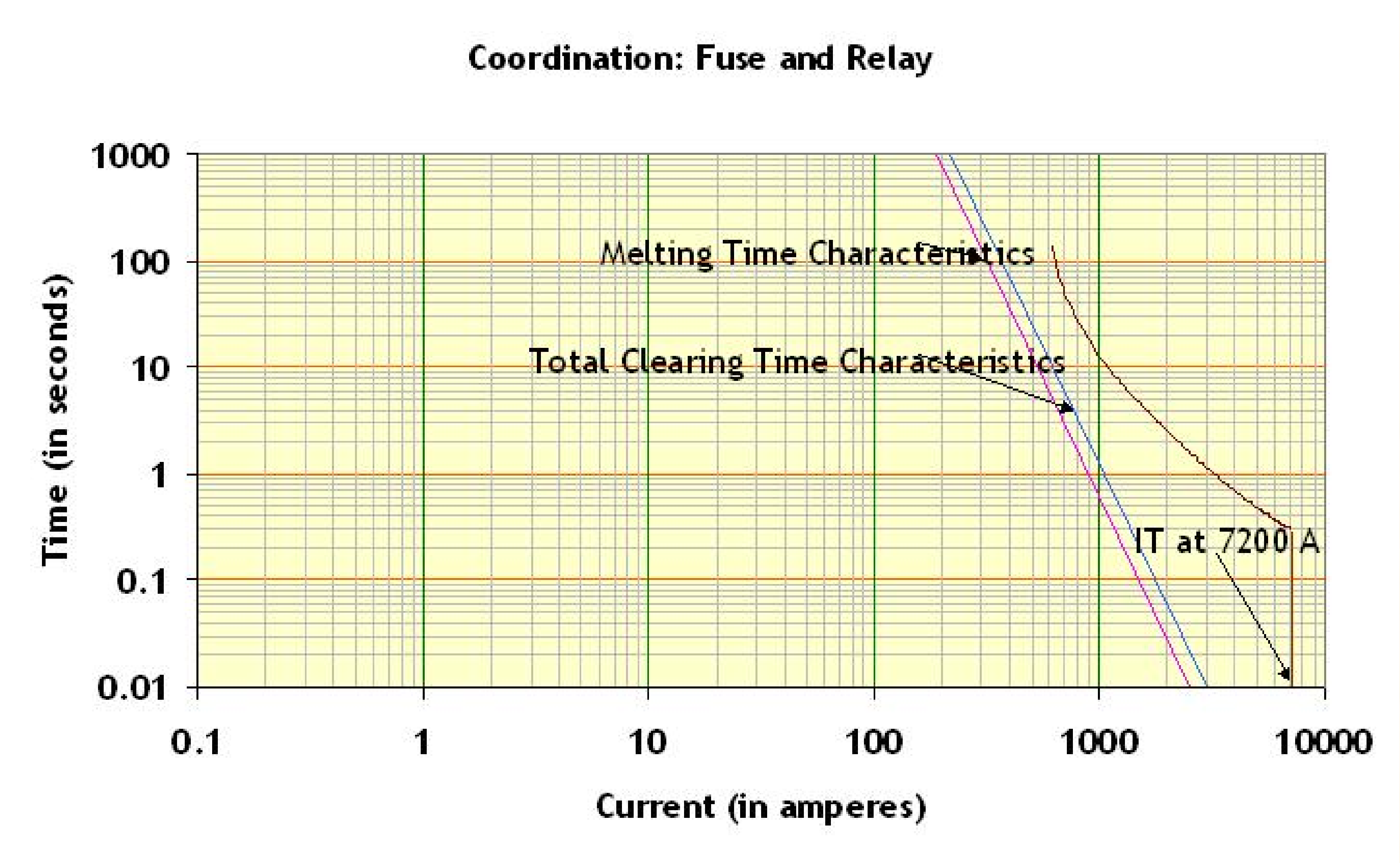
$$M = \frac{I_{input}}{I_{pickup}} = \frac{75}{7} = 10.71$$

$$For \;\; M > 1$$

$$t(I)_{trip \;\; time} = 1\left(\frac{A}{M^{P} - 1} + B\right)$$

$$= 1\left(\frac{28.2}{10.71^{2} - 1} + 0.1217\right) = 0.3697 \cong 0.4 \sec$$

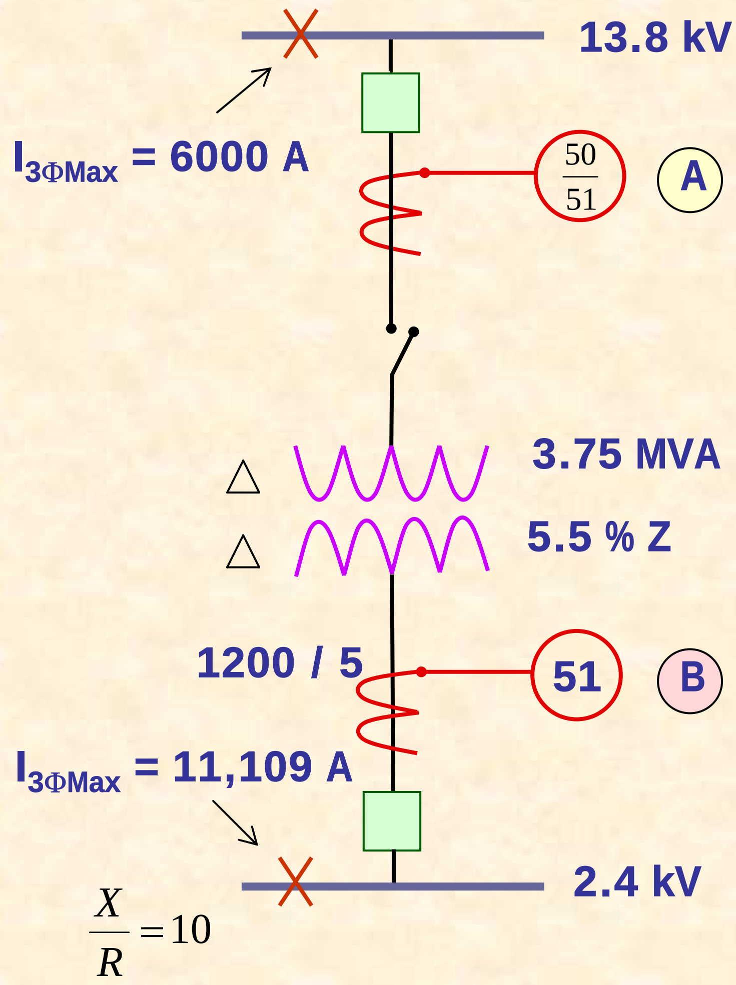
Example 5 - Solution



Example 6

Select the appropriate ratio for the current transformers shown and

- Select an appropriate relay
- Determine settings for the relay



51 Tap 5

Time Dial - 1.0

Use Very Inverse Relay

Example 6 - Solution

RELAY AT 'B'

Step 1 TAP = 5 MEANS THAT

Pickup current in secondary of CT = Relay coil current = 5 A

Pickup current in primary of CT $= 5 \times \frac{1200}{5} = 1200\ A$

RELAY AT 'A'

Step 2 Current on 13.8 kV side of Transformer, $I = \frac{3.75 \times 10^3}{\sqrt{3} \times 13.8} = 157\ A$

Step 3 SELECT CT RATIO : $1.5 \times 157 = 236\ A$

Select a CT Ratio of 300 / 5

Example 6 - Solution

Step 4 Load current in primary of CT = 157 A

Load current in secondary of CT $= 157 \times \frac{5}{300} = 2.6167\ A$

Fault current in primary of CT $= 11{,}109 \times \frac{2.4}{13.8} = 1932\ A$

Fault current in secondary of CT $= 1932 \times \frac{5}{300} = 32.2\ A$

Step 5 Select Tap = 3 TAP = 3 MEANS THAT

Pickup current in secondary of CT = Relay coil current = 3 A

Pickup current in primary of CT $= 3 \times \frac{300}{5} = 180\ A$

Example 6 - Solution

Step 6 $IT = \frac{(1.1)(11{,}109)(1.45)}{(13.8/2.4)(300/5)} = \mathbf{51.359}\ A$ Use an IT of 60 A

IT in primary of CT = 60 × 60 = 3600 A

Step 7 Required operating time of RA for fault current of 1932A (HV)

Top of RB for 11,109A = $1\left(\frac{28.2}{(11109/1200)^2-1} + 0.1217\right)$

$= 0.4546 \cong 0.46\ \text{sec}$

Therefore t_{req} of relay RA = 0.46+0.4 = 0.86s

Example 6 - Solution

Step 8 Time dial setting of relay RA is

$$M = \frac{I_{input}}{I_{pickup}} = \frac{32.2}{3} = 10.73$$

$$0.86 = TD\left(\frac{28.2}{10.73^2 - 1} + 0.1217\right)$$

$$TD = 2.3$$

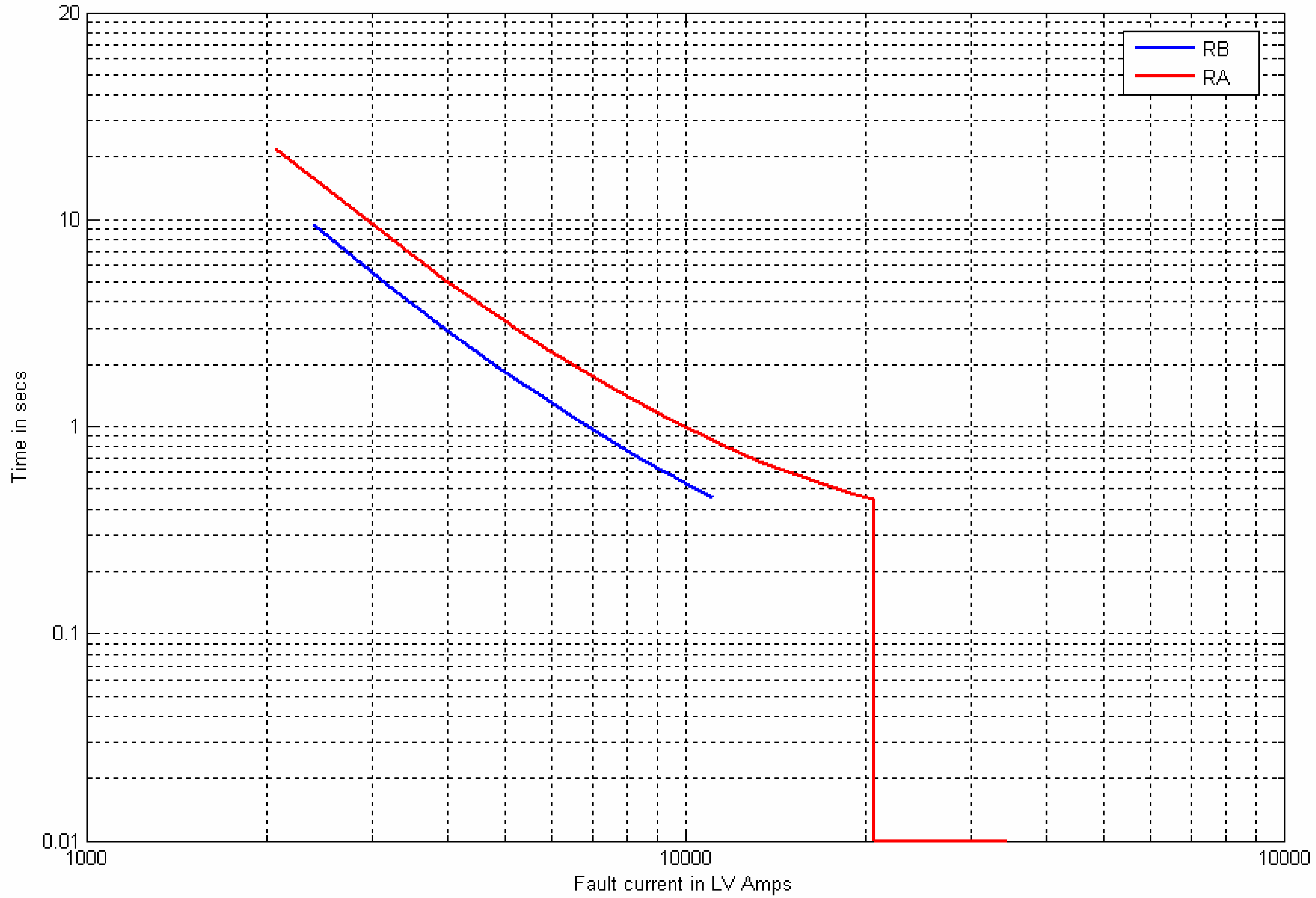
<u>The setting of relay RA is</u>

Pickup = 3A

Time dial = 2.3

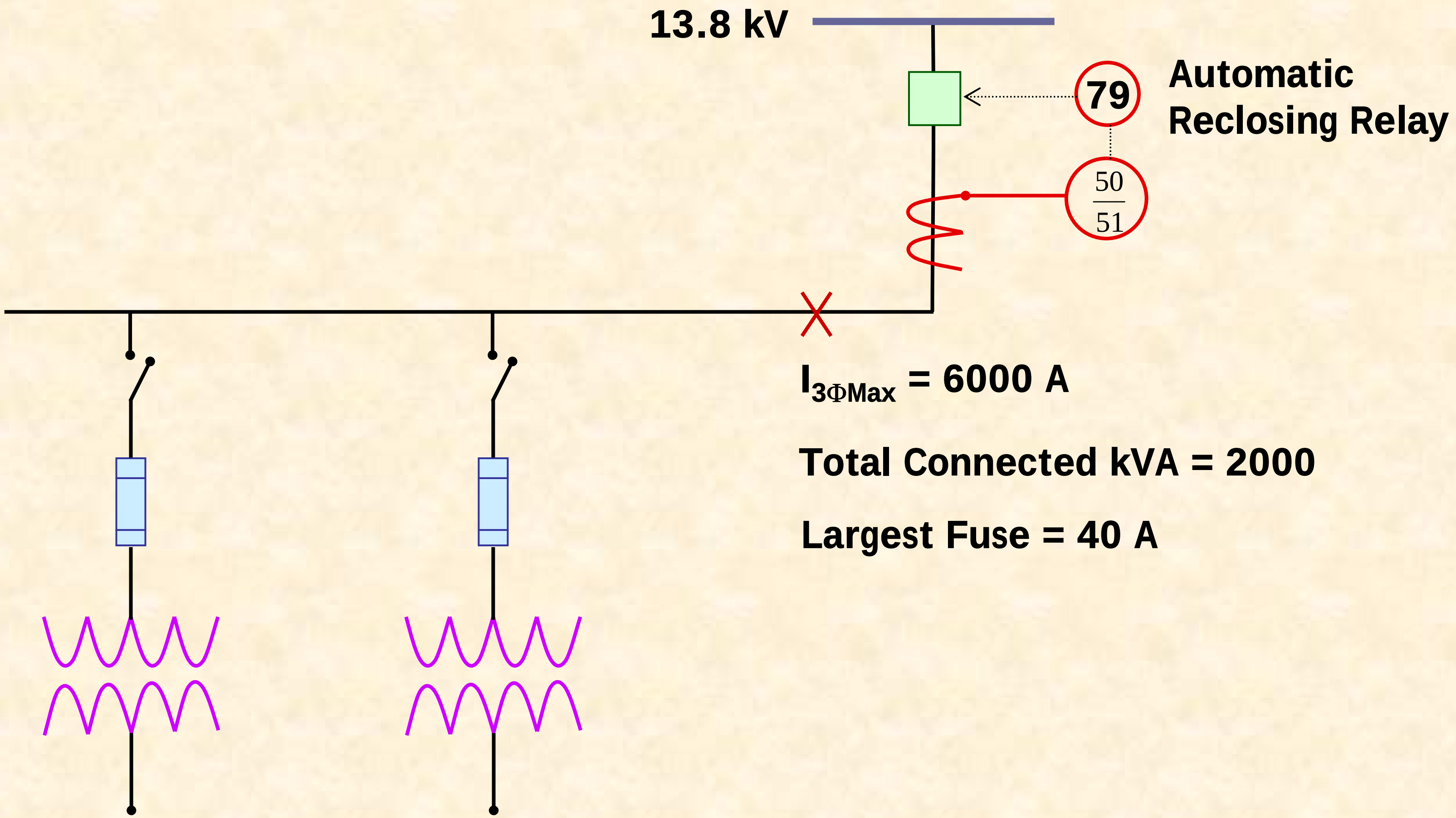
Instantaneous = 60A

Example 6 - Solution



Example 7

Select and apply the appropriate relay for the circuit.



Example 7 - Solution

Step 1 Maximum load on the feeder, $I_{load} = \frac{2000}{\sqrt{3} \times 13.8} = 84\ A$

Step 2 SELECT CT RATIO : $1.5 \times 84 = 126\ A$

Select a CT Ratio of 200 / 5 A

Step 3 Load current in primary of CT $= 84\ A$

Load current in secondary of CT $= 84 \times \frac{5}{200} = 2.1\ A$

Fault current in primary of CT $= 6000\ A$

Fault current in secondary of CT $= 6000 \times \frac{5}{200} = 150\ A$

Example 7 - Solution

Step 4 $$IT = \frac{(1.1)(1200)}{(200/5)} = 33\,A$$ Use an IT of 40A

Where fuse clearing current = 1200A

IT in primary of CT = $40 \times 200/5 = 1600$ A

Step 5 Select Tap = 5.0

TAP = 5 MEANS THAT

Pickup current in secondary of CT = Relay coil current = 5 A

Pickup current in primary of CT $= \mathbf{5} \times \frac{\mathbf{200}}{\mathbf{5}} = \mathbf{200}\,A$

Example 7 - Solution

Step 6 Trip time of relay

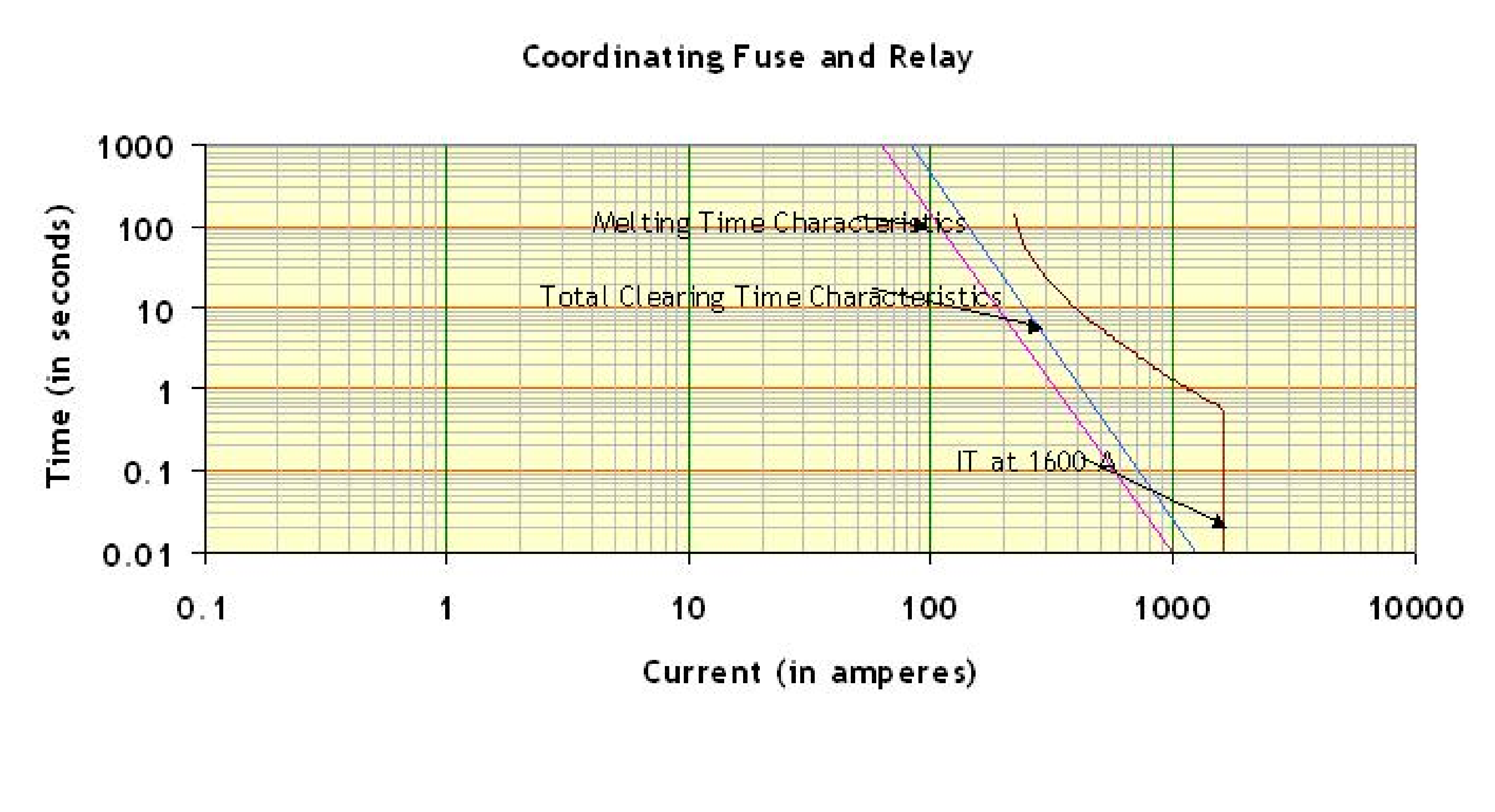
$$M = \frac{I_{input}}{I_{pickup}} = \frac{150}{5} = 30$$

$$For \;\; M > 1$$

$$t(I)_{trip\ \ time} = 1\left(\frac{A}{M^{P} - 1} + B\right) = 1\left(\frac{28.2}{30^{2} - 1} + 0.1217\right)$$

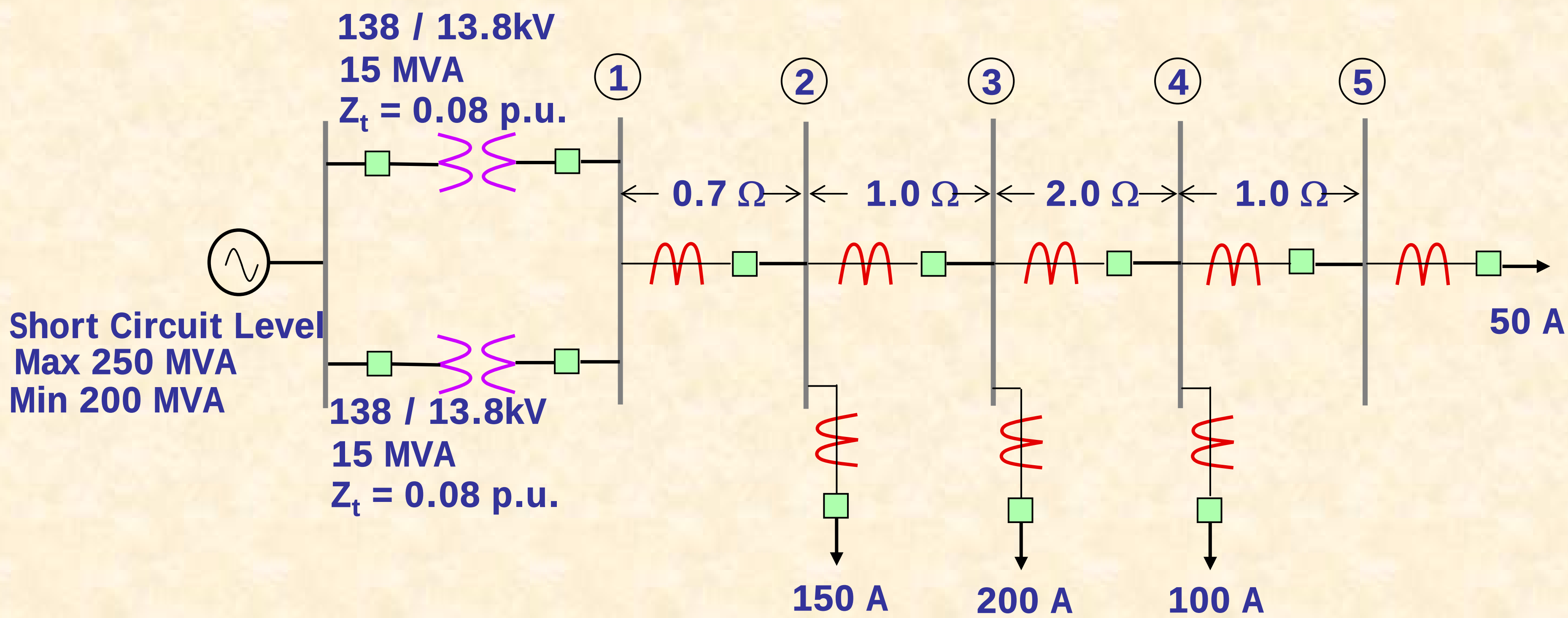
$$= 0.1530 \cong 0.2 \sec$$

Example 7 - Solution



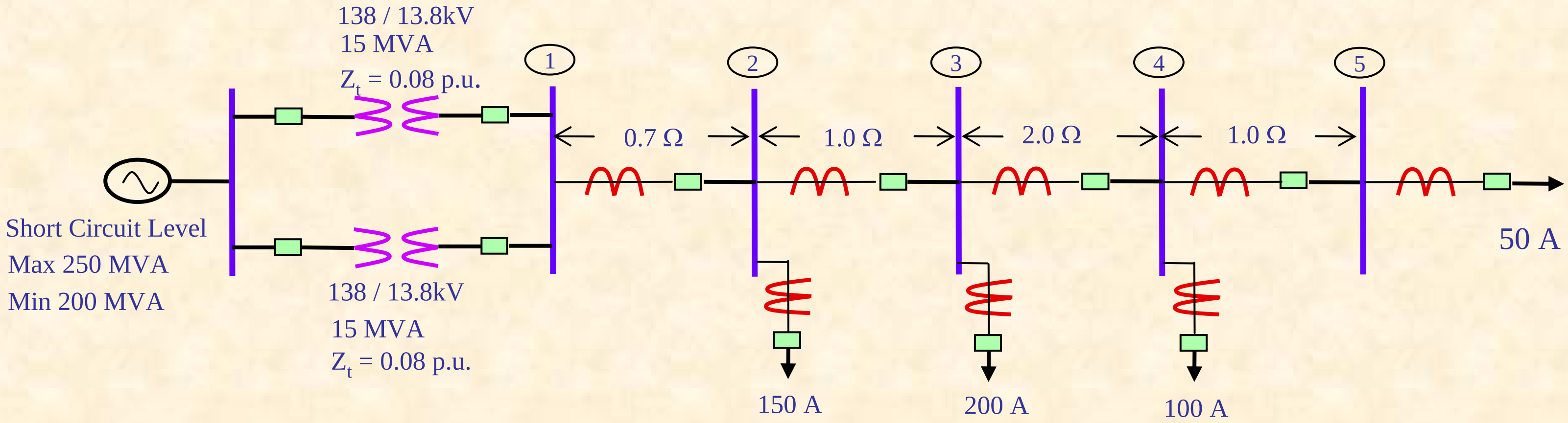
Example 8

Relay coordination on radial feeders



Use Extremely Inverse Relay Characteristics

Example 8



Line Parameters		
Bus		Impedance Ohms Ω
From	To	
1	2	0.70
2	3	1.00
3	4	2.00
4	5	1.00

Example 8 - Solution

Select Base Capacity = 25 MVA

Select Base Voltage on Bus 1 = 13.8 kV

Base Current, $I_b = \frac{25 \times 1000}{\sqrt{3} \times 13.8} = 1046 A$

Base Impedance,

$$Z_b = \frac{(Base\ Voltage\ in\ kV)^2}{Base\ Capacity\ in\ MVA}$$

$$= \frac{(13.8)^2}{25}$$

$$= 7.618\ \Omega$$

Line Parameters		
Bus		Impedance p.u.
From	To	
1	2	0.0919
2	3	0.1313
3	4	0.2625
4	5	0.1313

Example 8 - Solution

Maximum short circuit current - Fault on Source Bus $= \frac{250}{25} = 10.0 \; p.u.$

Source Impedance $= \frac{1}{10} = 0.1 \; p.u$

Minimum short circuit current - Fault on Source Bus $= \frac{200}{25} = 8.0 \; p.u.$

Source Impedance $= \frac{1}{8} = 0.125 \; p.u.$

Transformer Impedance on 15 MVA and 13.8 kV base = 0.08

Transformer Impedance on 25 MVA and 13.8 kV base

$$Z_t = 0.08 \times \frac{25 \times (13.8)^2}{15 \times (13.8)^2} = 0.1333 \; p.u.$$

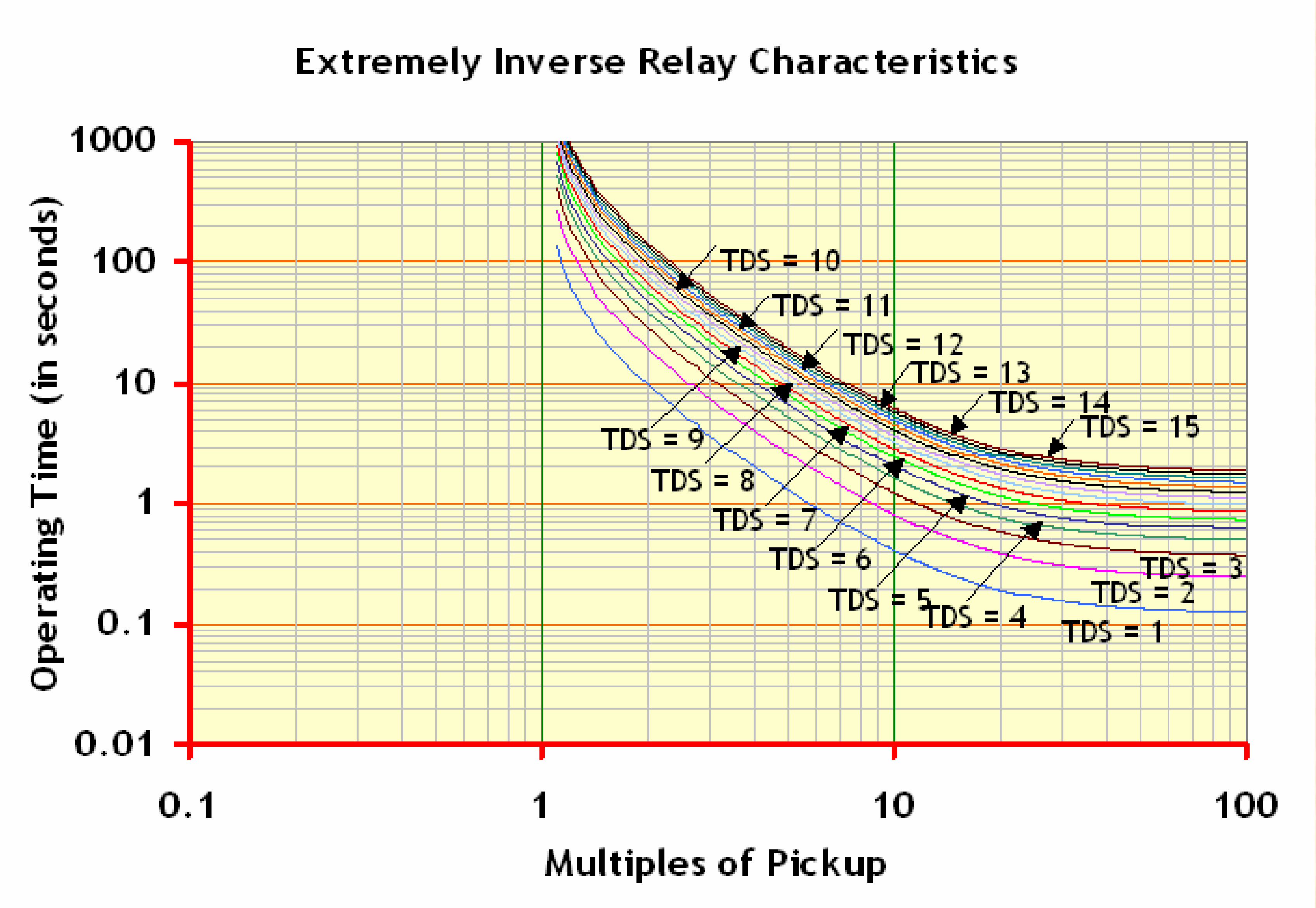
Example 8 - Solution

Selection Of CT Ratios and Current Settings				
Relay Location Bus	Maximum Load Current (A)	CT Ratio Selected	Relay Current Setting	
			Percent	Primary Current (A)
1	500	800/5	75	600
2	350	500/5	100	500
3	150	200/5	100	200
4	50	100/5	75	75
5	50	100/5	75	75

Example 8 - Solution

Fault Current Calculations				
Location of Fault Bus	Total Impedance to Fault p.u.		Fault Current (A)	
	Maximum (One Transformer in Circuit)	Minimum (Two transformers in circuit)	Minimum (One Transformer in circuit)	Maximum (Two Transformers in circuit)
1	0.2583	0.1667	4049	6274
2	0.3502	0.2586	2986	4045
3	0.4815	0.3899	2172	2683
4	0.7440	0.6524	1406	1603
5	0.8753	0.7837	1195	1335

Example 8 - Solution

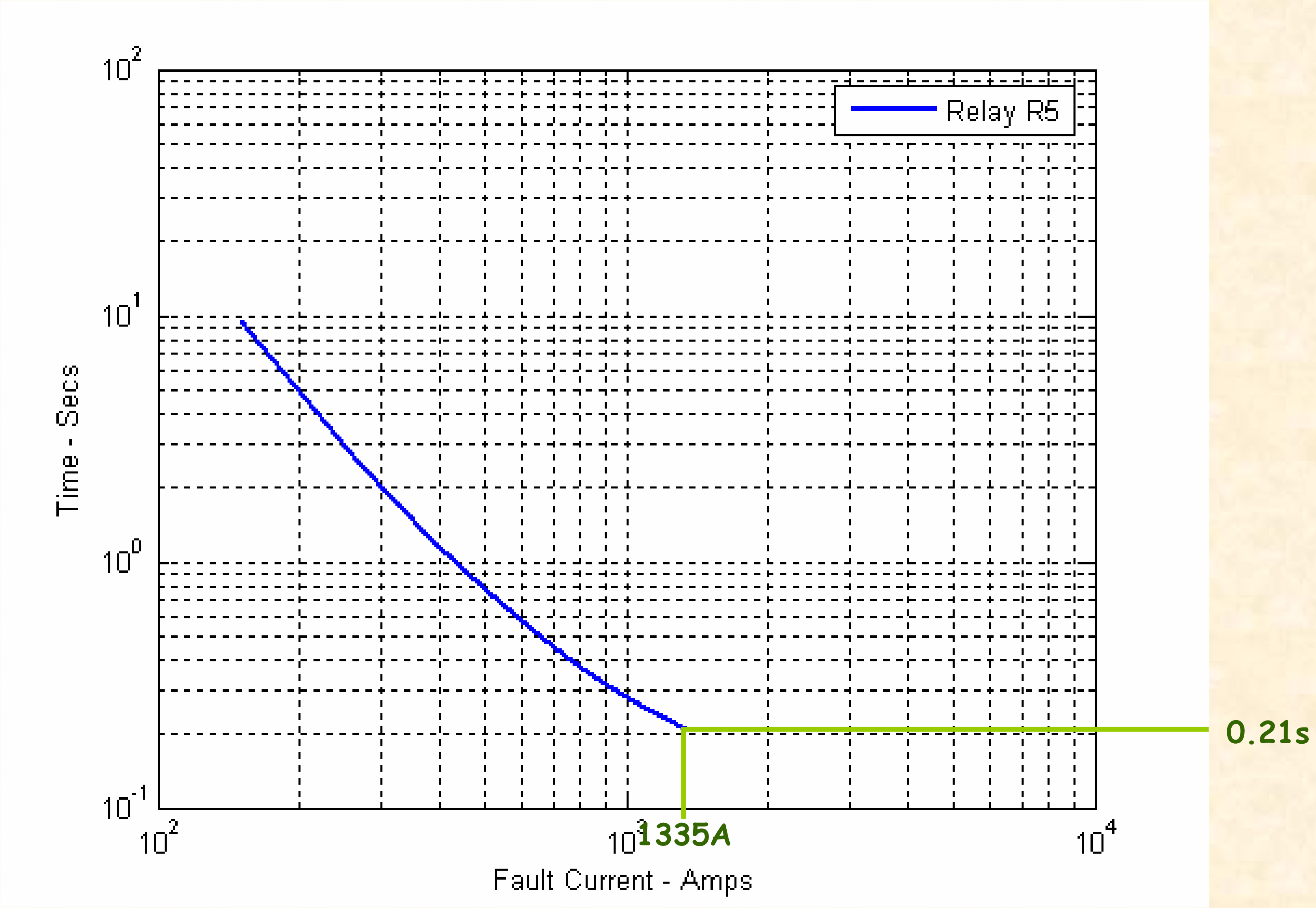


Example 8 - Solution

Choosing relay 5 parameters

Relay at Bus	Coordination parameters – Fault at Bus 5		
	Current in Multiples of Relay Setting	TMS	Relay Operating Time
5	17.800	1	0.21

Example 8 - Solution

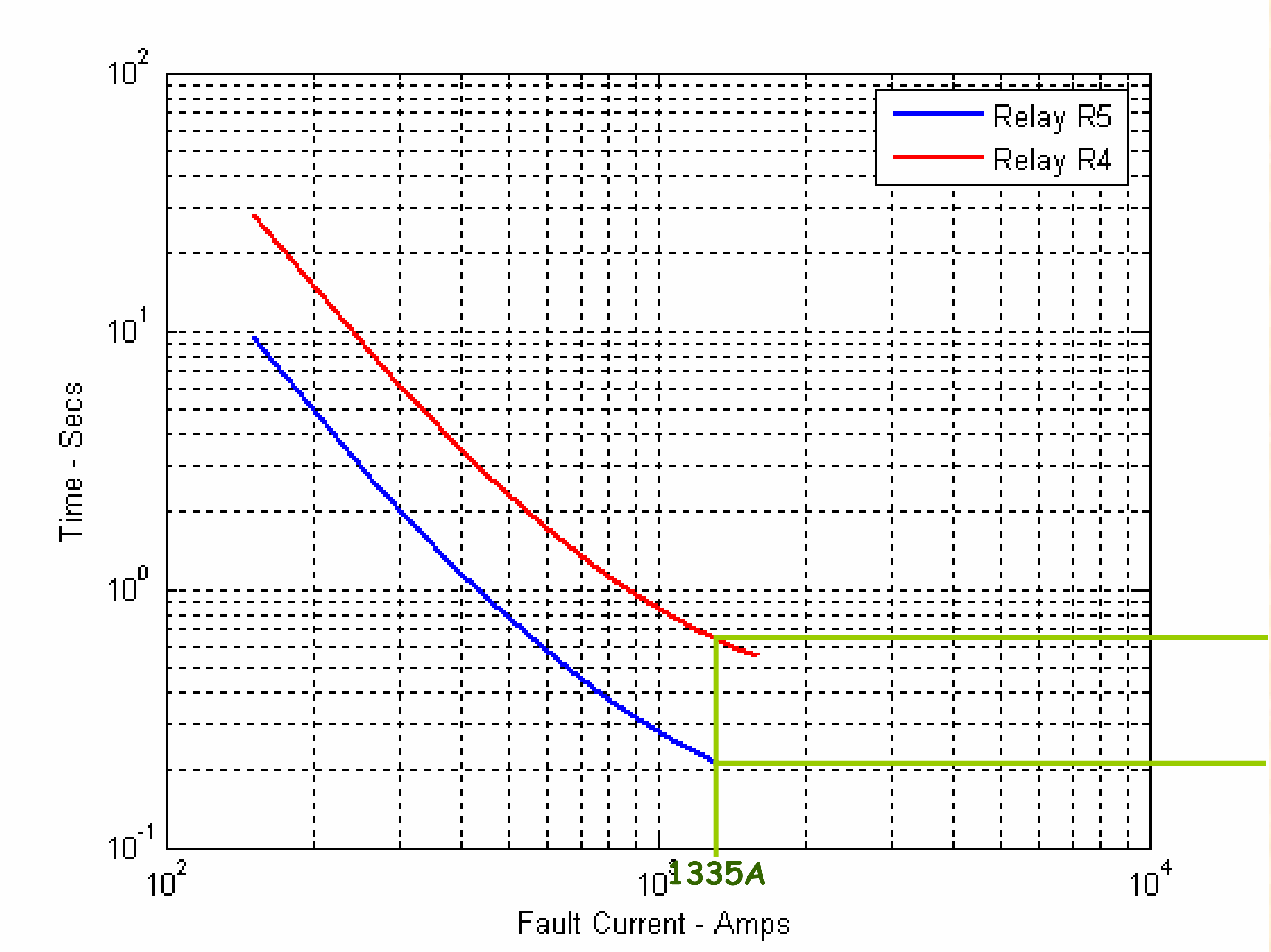


Example 8 - Solution

Choosing relay 4 parameters

Relay at Bus	Coordination parameters – Fault at Bus 5		
	Current in Multiples of Relay Setting	TMS	Relay Operating Time
5	17.800	1	0.21
4	17.800	3	0.63

Example 8 - Solution

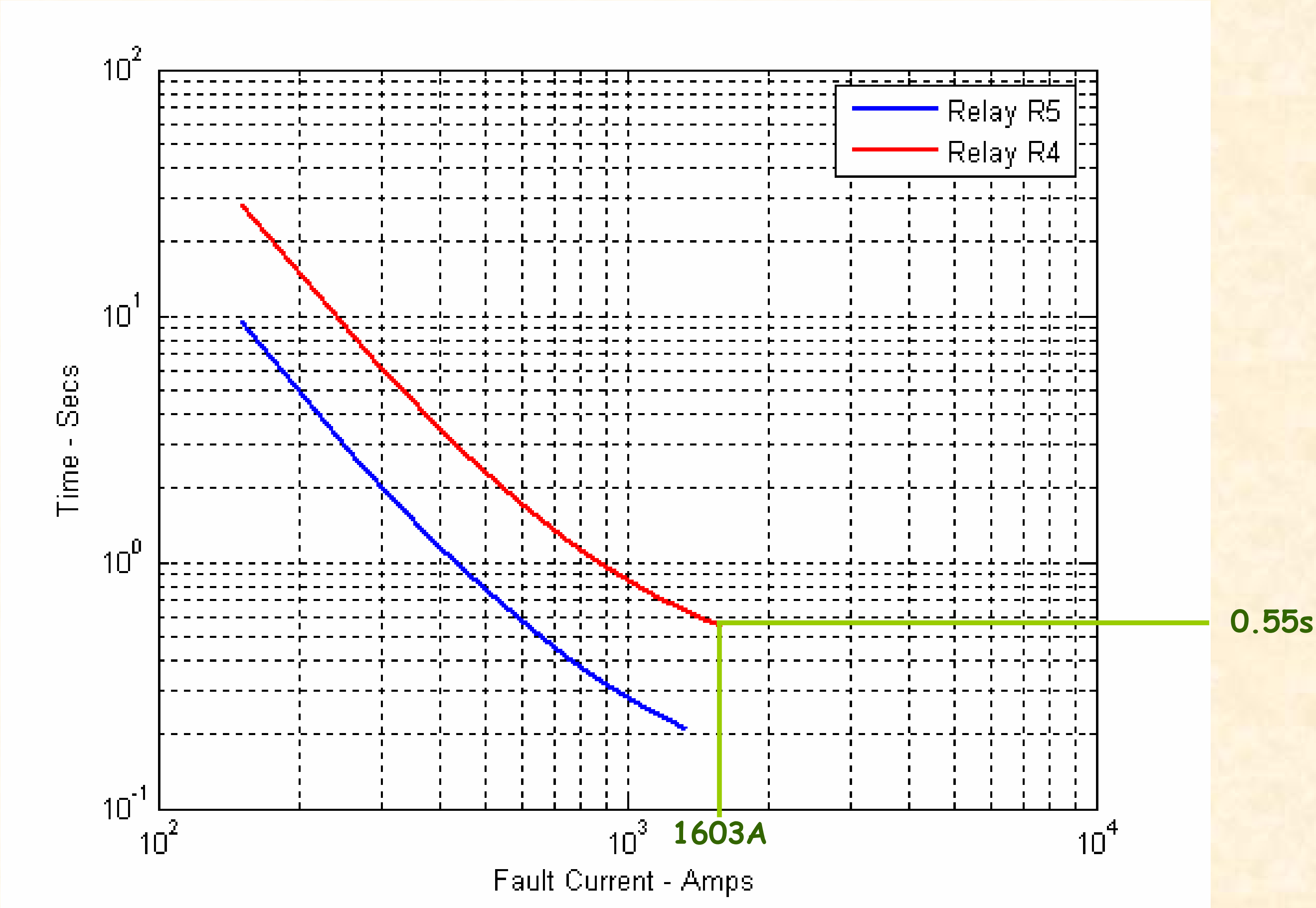


Example 8 - Solution

Checking relay 4 parameters

Current	Coordination parameters – Fault at Bus 4		
	Current in Multiples of Relay Setting	TMS	Relay Operating Time
1603	21.373	3	0.55
1406	18.75	3	0.6

Example 8 - Solution

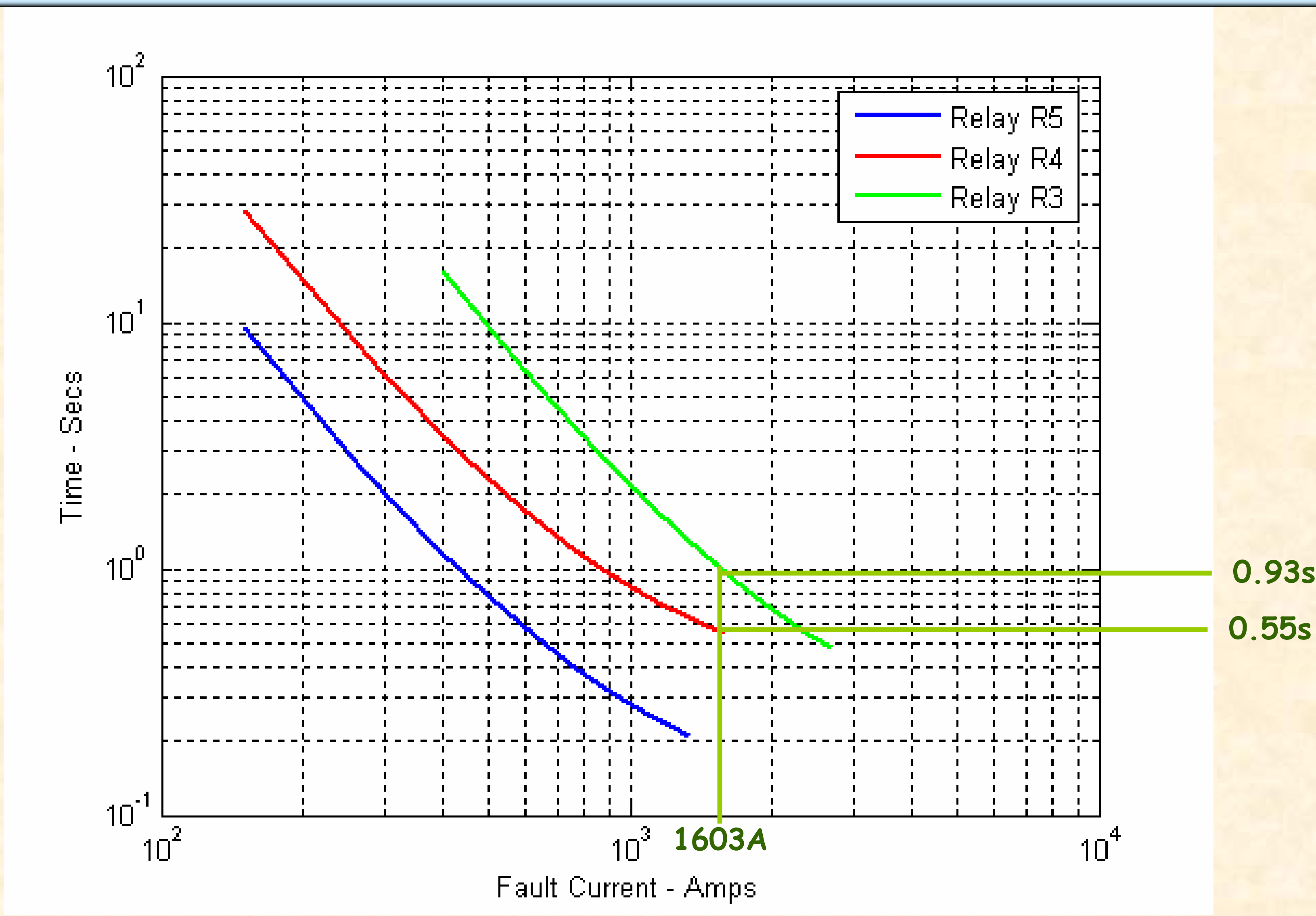


Example 8 - Solution

Choosing relay 3 parameters

Relay at Bus	Coordination parameters – Fault at Bus 4		
	Current in Multiples of Relay Setting	**TMS**	**Relay Operating Time**
4	(1603/75) **21.373**	**3**	**0.55**
3	(1603/200)**8.015**	**1.7**	**0.93**

Example 8 - Solution



Example 8 - Solution

Checking relay 3 parameters

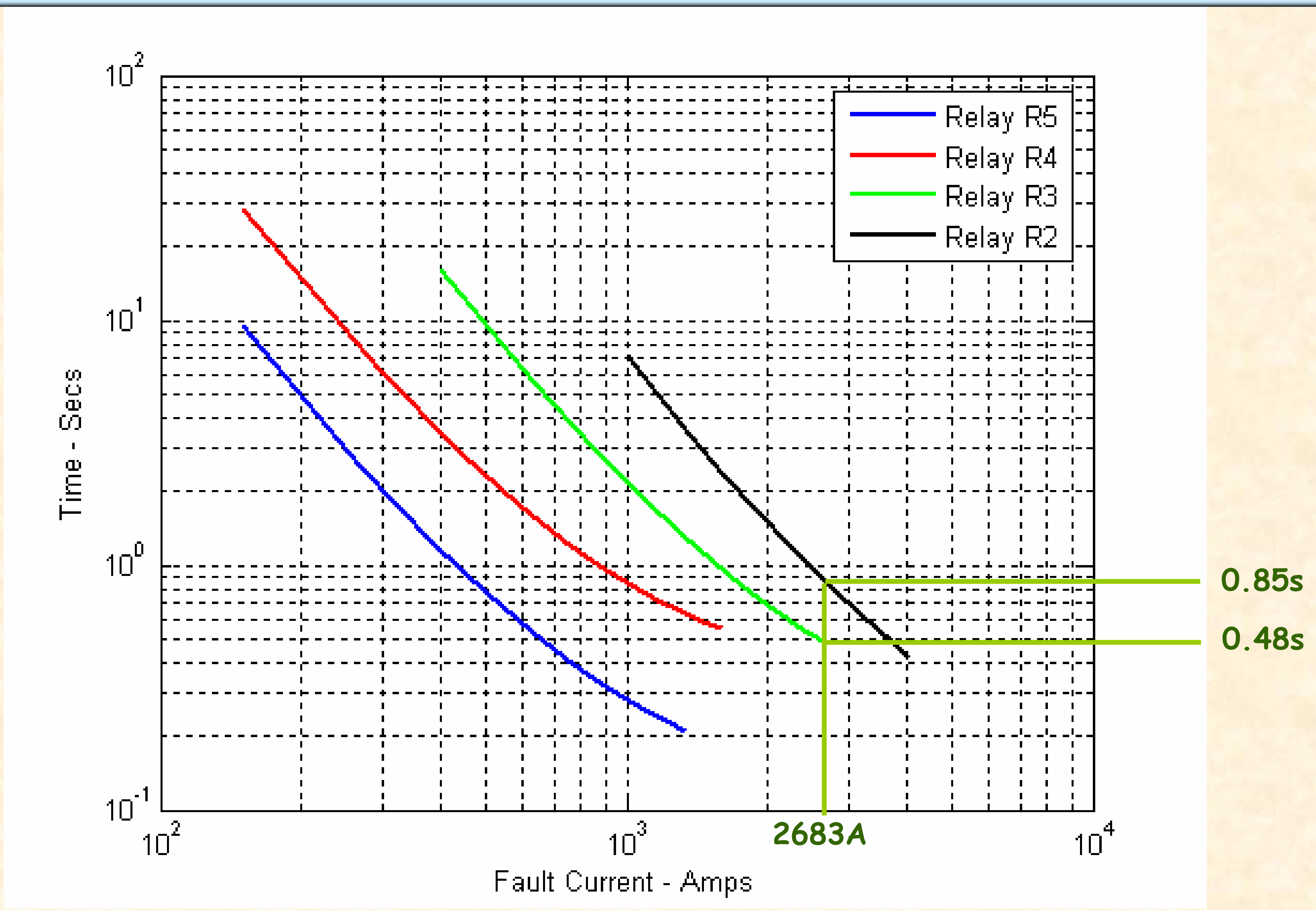
Current	Coordination parameters – Fault at Bus 3		
	Current in Multiples of Relay Setting	TMS	Relay Operating Time
2683	13.415	1.7	0.48
2172	10.86	1.7	0.62

Example 8 - Solution

Choosing relay 2 parameters

Relay at Bus	Coordination parameters – Fault at Bus 3		
	Current in Multiples of Relay Setting	TMS	Relay Operating Time
3	(2683/200) **13.415**	**1.7**	**0.48**
2	(2683/500)**5.366**	**0.75**	**0.85**

Example 8 - Solution



Example 8 - Solution

Checking relay 2 parameters

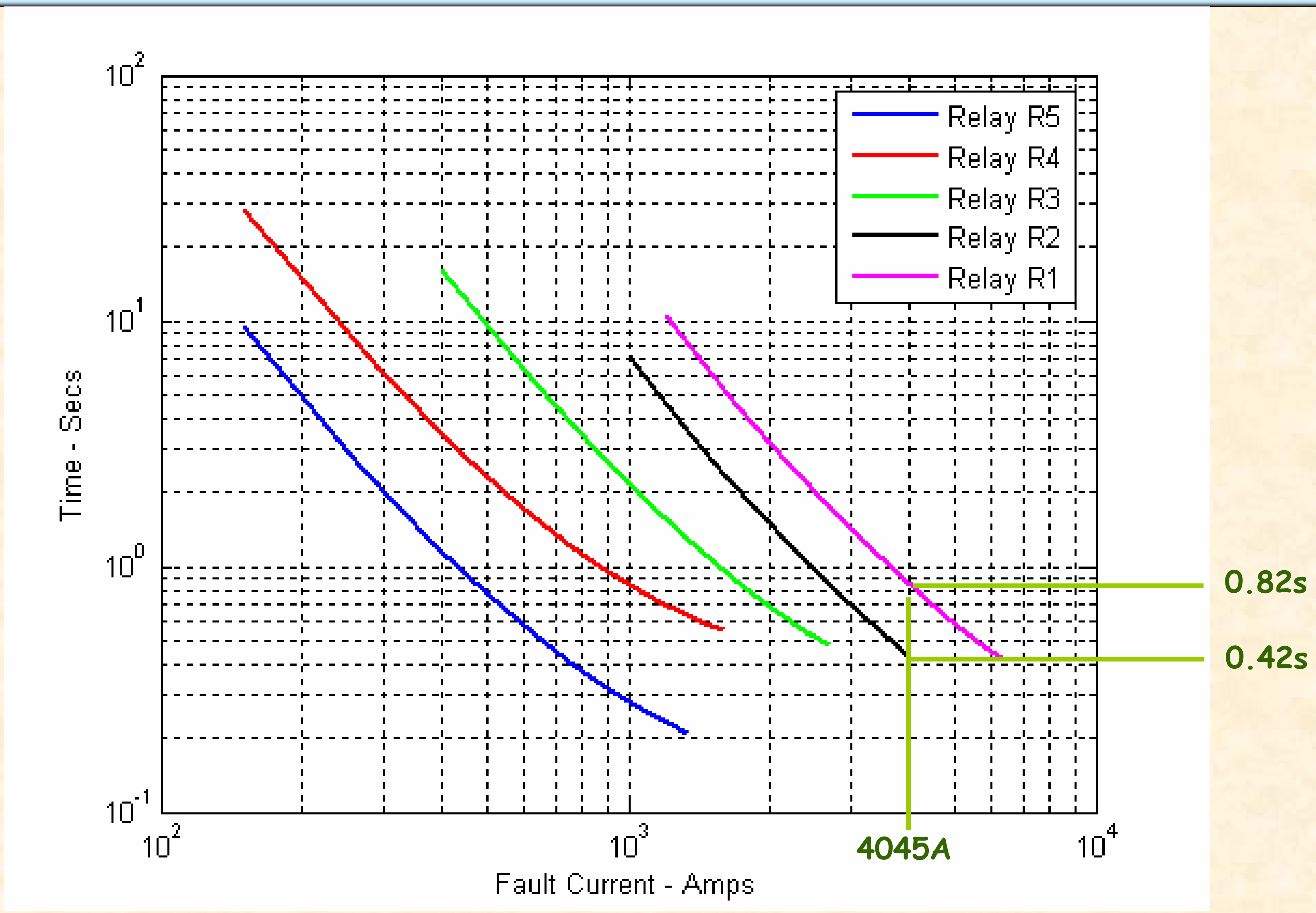
Current	Coordination parameters – Fault at Bus 2		
	Current in Multiples of Relay Setting	TMS	Relay Operating Time
4045	8.09	0.75	0.42
2986	5.97	0.75	0.69

Example 8 - Solution

Choosing relay 1 parameters

Relay at Bus	Coordination parameters – Fault at Bus 2		
	Current in Multiples of Relay Setting	TMS	Relay Operating Time
2	(4045/500) **8.09**	**0.75**	**0.42**
1	(4045/600)**6.74**	**1.1**	**0.82**

Example 8 - Solution



Example 8 - Solution

Checking relay 1 parameters

Current	Coordination parameters – Fault at Bus 1		
	Current in Multiples of Relay Setting	TMS	Relay Operating Time
6274	10.46	1.1	0.41
4049	6.75	1.1	0.82

Example 8 - Solution