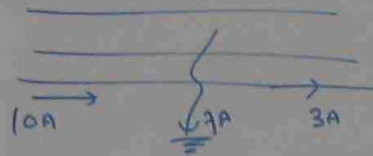


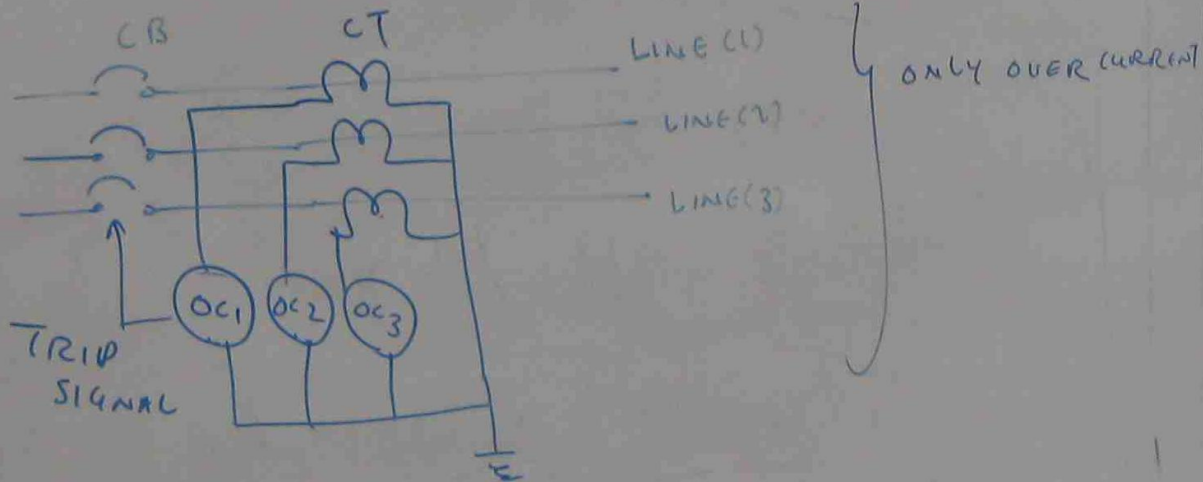
## OVER CURRENT AND EARTH FAULT PROTECTION

OVER CURRENT PROTECTION CAN BE PROVIDED BY OVER CURRENT RELAY.

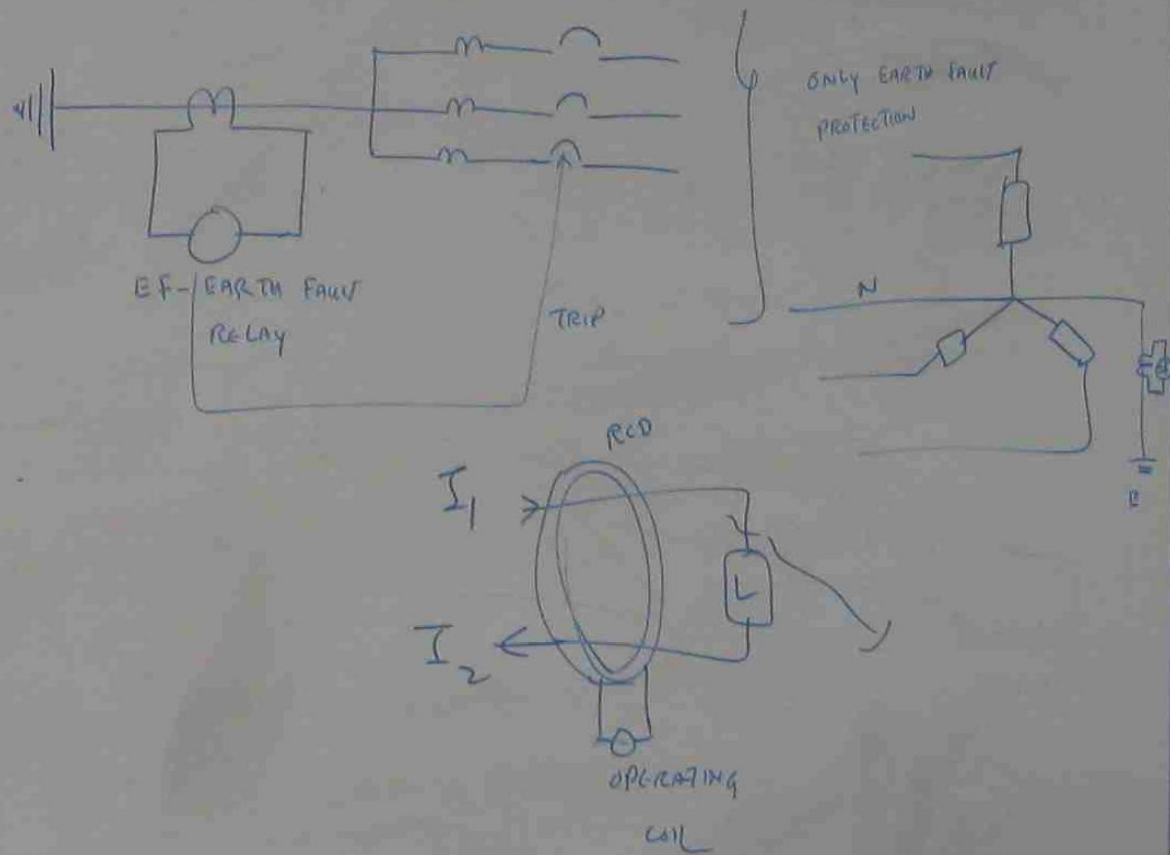
### EARTH FAULT



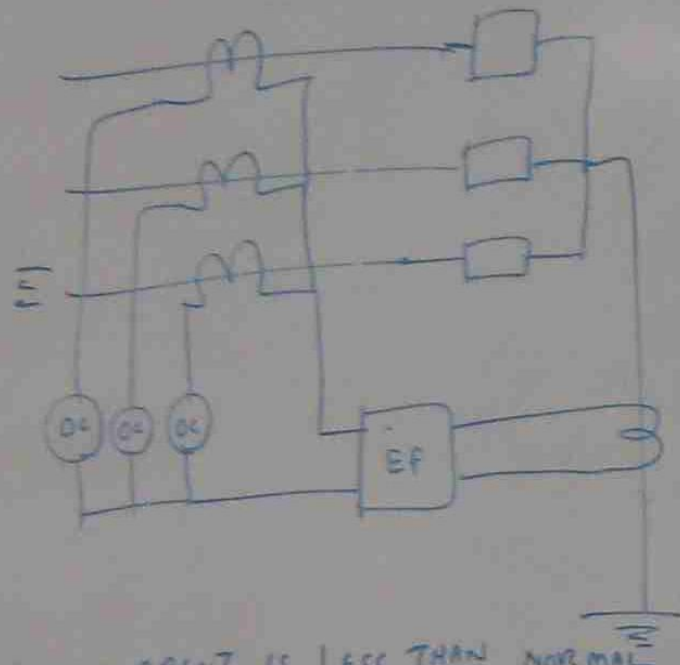
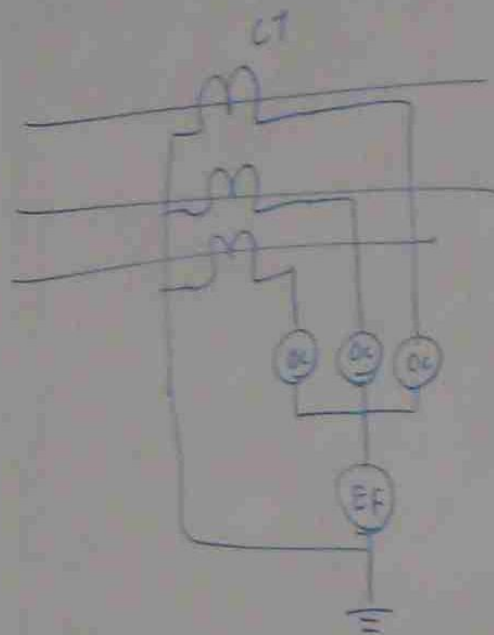
WHEN EARTH FAULT OCCURS, THE CURRENT WILL BE LESS THAN NORMAL CURRENT. OVER CURRENT RELAY WILL NOT OPERATE. EARTH FAULT RELAY WILL BE REQUIRED TO CUT OFF THE CIRCUIT.



# EARTH FAULT RELAY CONNECTION



## CONSEQUENT ZERO CURRENT AND EARTH FAULT PROTECTION

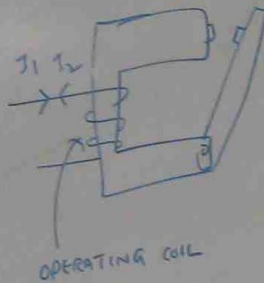


WHEN THE EARTH FAULT OCCURS, THE LINE CURRENT IS LESS THAN NORMAL CURRENT. IT IS NOT ENOUGH FOR EARTH FAULT RELAY TO OPERATE.

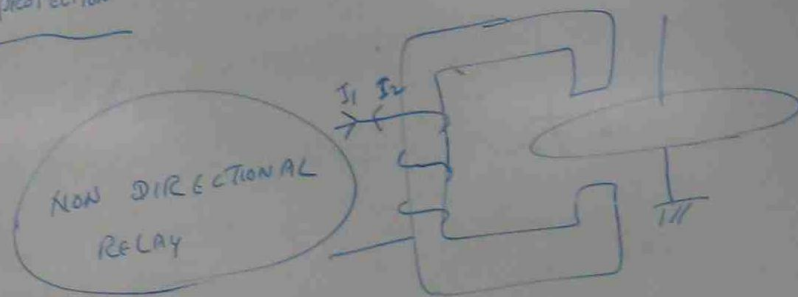
EARTH FAULT RELAY DETECTS THE ZERO SEQUENCE CURRENT AND OPERATE

IT IGNORES POSITIVE AND NEGATIVE SEQUENCE CURRENTS.

## DIRECTIONAL OVER CURRENT PROTECTION

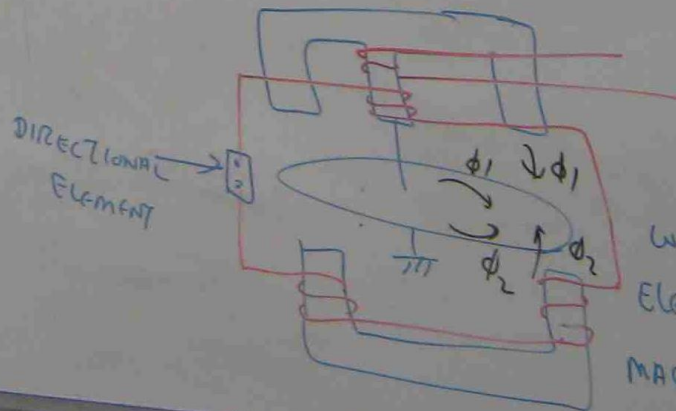


ANY DIRECTION CURRENT CAN OPERATE THE RELAY



## DIRECTIONAL RELAY

WHEN FAULT HAPPENS, THE REVERSE POWER CURRENT FLOWS BACK FROM FAULT POINT TO GENERATOR. DIRECTIONAL RELAY IS REQUIRED TO DETECT & OPERATE WHEN REVERSE POWER FLOWS.



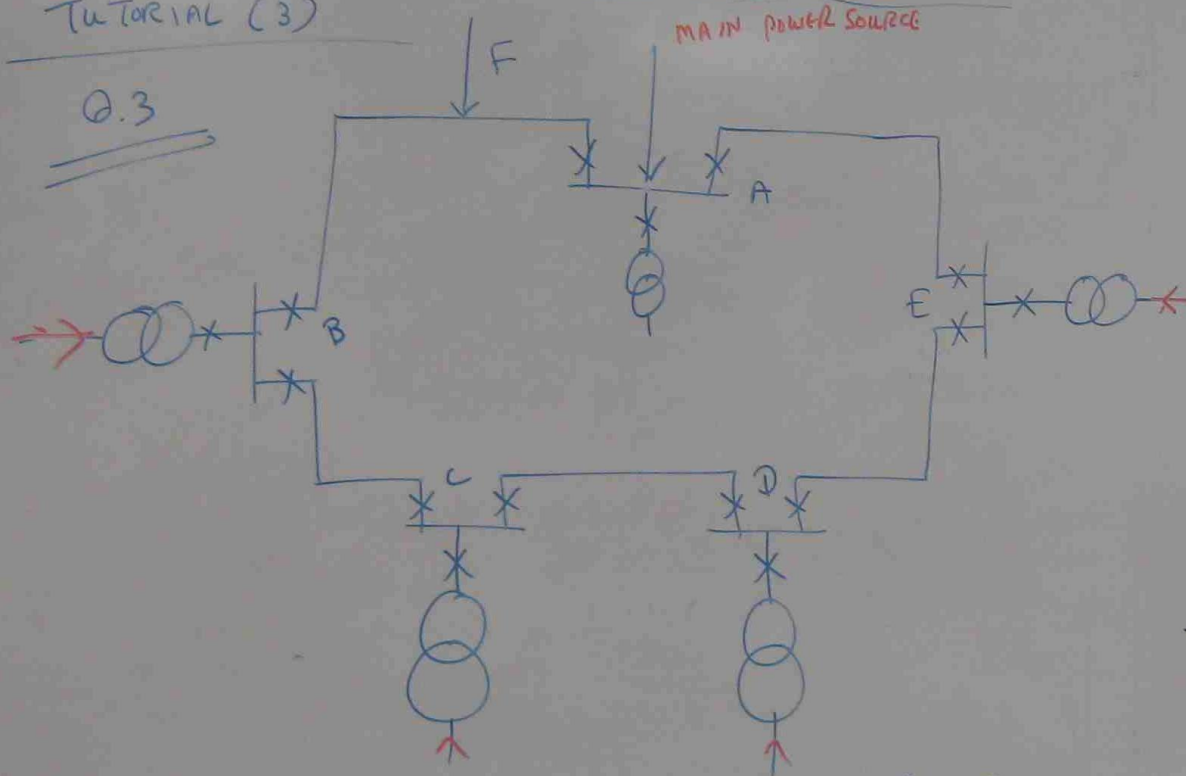
WHEN NORMAL CURRENT FLOWS, UPPER MAGNET PRODUCES  $\phi_1$  AND LOWER MAGNET PRODUCES  $\phi_2$  WHICH ARE OPPOSING EACH OTHER. NO RELAY OPERATION.

WHEN REVERSE CURRENT FLOWS, DIRECTIONAL ELEMENT BLOCKS IT. ONLY LOWER PART MAGNET PRODUCES  $\phi_2$  AND RELAY OPERATES.

# LOCATION OF DIRECTIONAL AND NON DIRECTIONAL ELEMENTS IN RING SYSTEM

## TUTORIAL (3)

Q.3



LOCATE THE RELAY PROTECTION SCHEME FOR GIVEN SYSTEM WHEN FAULT OCCURS AT POINT (F)



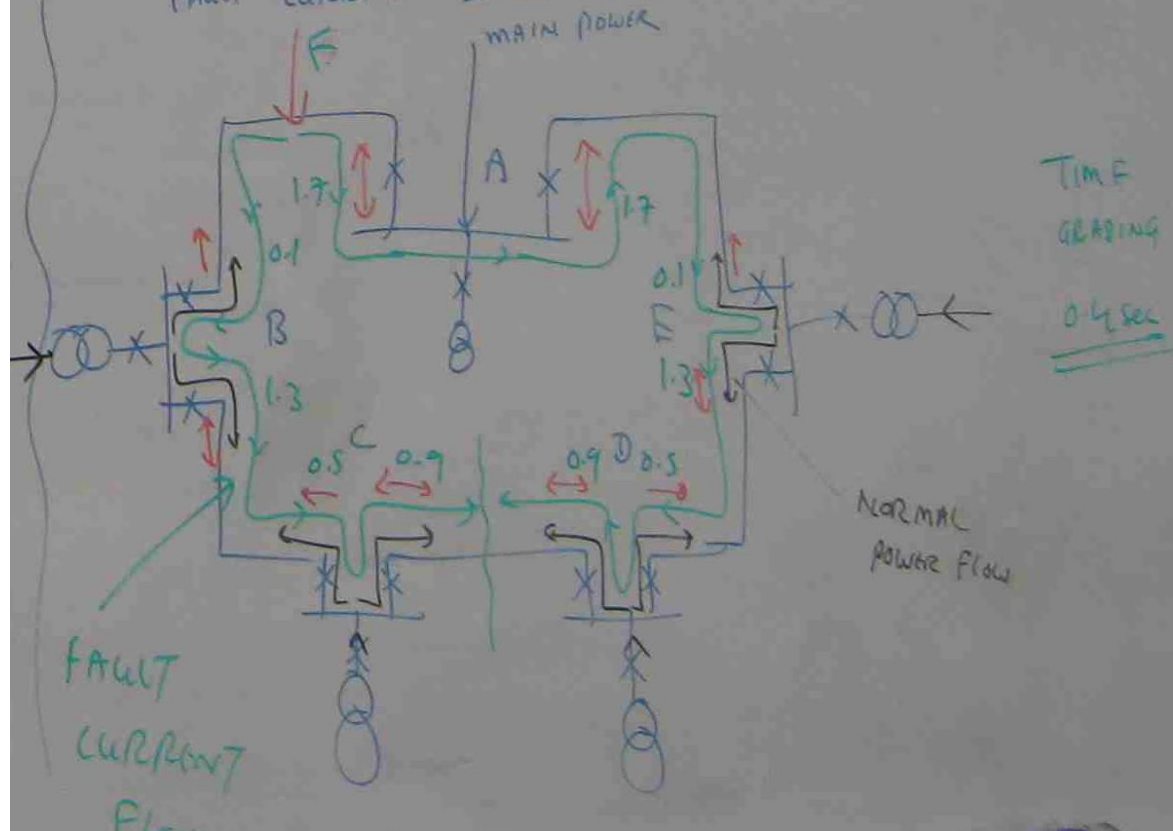
→ DIRECTIONAL  
ELEMENT

↔ NON DIRECTIONAL  
ELEMENT

(1) NEAR MAIN POWER SOURCE → NON DIRECTIONAL ELEMENT

(2) DETERMINE THE NORMAL & FAULT CURRENT DIRECTIONS

(3) FAULT CURRENT OPPOSES NORMAL CURRENT → DIRECTIONAL ELEMENT  
 FAULT CURRENT & NORMAL CURRENT THE SAME → NON DIRECTIONAL ELEMENT



### TIME GRADING

0.4 sec is provided for relays

CURRENT  
→

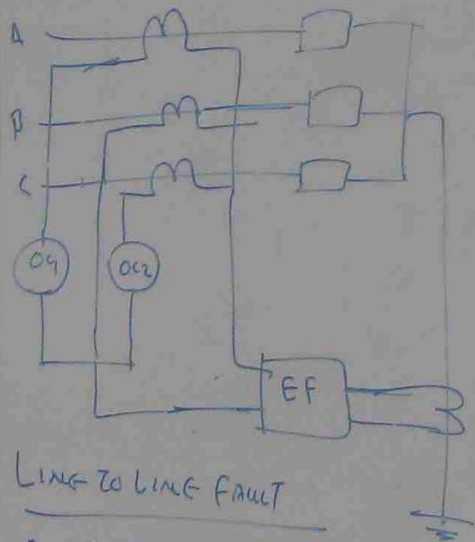
RELAY POINT	TIME
B	0.1 sec
C	0.5 sec
D	0.9 sec
E	1.3 sec
A	1.7 sec

CURRENT  
→

RELAY POINT	TIME
E	0.1 sec
D	0.5 sec
C	0.9 sec
B	1.3 sec
A	1.7 sec

### TUTORIAL (3)

Q1 SKETCH THE CONNECTION DIAGRAM OF COMBINATION PROTECTION SCHEME THAT CONTAINS TWO OVER CURRENT RELAYS AND ONE EARTH FAULT RELAY TO PROVIDE PHASE TO PHASE AND PHASE TO EARTH PROTECTION.



LINE TO LINE FAULT

A-C  $\rightarrow$  OC1, OC2 OPERATES

A-B  $\rightarrow$  OC1 OPERATES

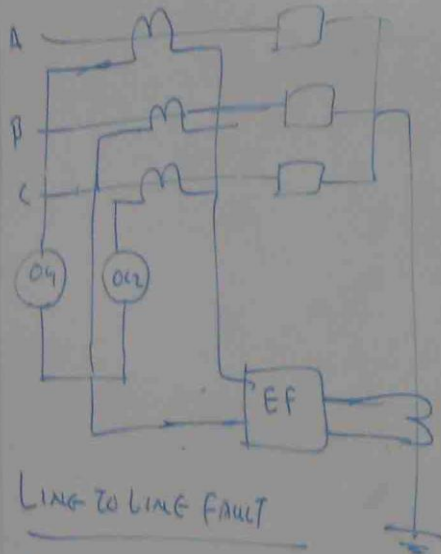
B-C  $\rightarrow$  OC2 OPERATES.

ANY LINE  $\rightarrow$  G FAULT  $\rightarrow$  E/F OPERATES.



## TUTORIAL 2

Q1 SKETCH THE CONNECTION DIAGRAM OF COMBINATION PROTECTION SCHEME THAT CONTAINS TWO OVER CURRENT RELAYS AND ONE EARTH FAULT RELAY TO PROVIDE PHASE TO PHASE AND PHASE TO EARTH PROTECTION.



LINE TO LINE FAULT

A-C  $\rightarrow$  OC1, OC2 OPERATES

A-B  $\rightarrow$  OC1 OPERATES

B-C  $\rightarrow$  OC2 OPERATES.

ANY LINE  $\rightarrow$  G FAULT  $\rightarrow$  E/F OPERATES.

Q2

HOW DOES DIRECTIONAL ELEMENT OF A RELAY PERFORM?

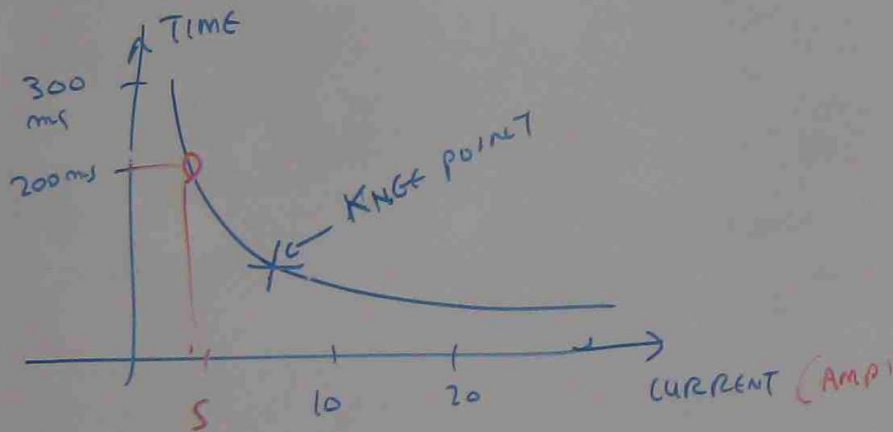
DIRECTIONAL ELEMENT IS CONNECTED IN LOWER MAGNET CIRCUIT OF DIRECTIONAL RELAY. IT BLOCKS THE REVERSE DIRECTION CURRENT CAUSED BY REVERSE POWER FLOWS.

ONLY ONE MAGNET RECEIVES THE CURRENT AND THE OPPOSING MAGNETIC FLUX CEASED.

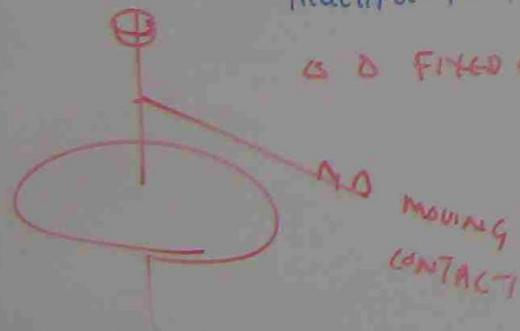
IT CAUSES THE RELAY OPERATION.

## TUTORIAL (4)

Q1 How will you ADJUST DEFINITE MINIMUM TIME POINT ON RELAY CURVE?



MULTIPLE PLUG SETTING



IS A FIXED CONTACT

AND MOVING CONTACT

THE DEFINITE MINIMUM TIME POINT IS A POINT ON RELAY CHARACTERISTICS CURVE AT WHICH SPECIFIC RELAY CURRENT CAUSES THE RELAY OPERATION IN A SPECIFIC TIME.

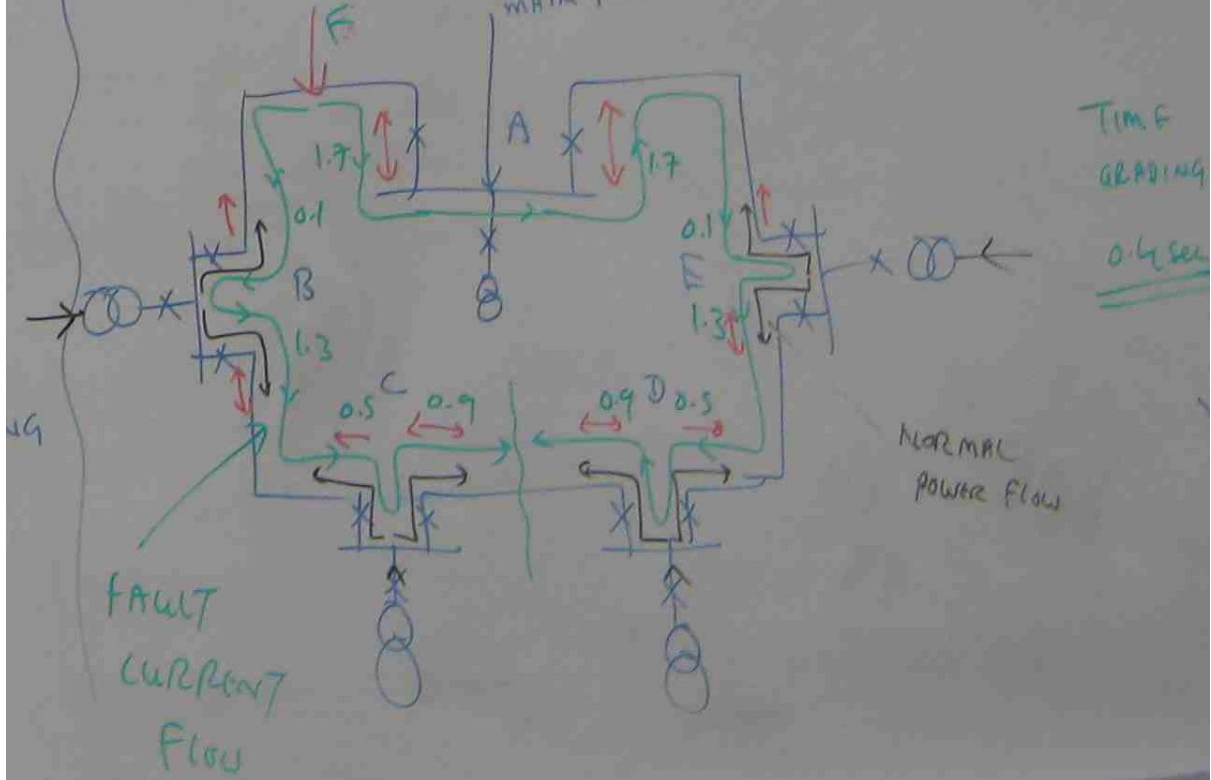
IT CAN BE ADJUSTED BY ADJUSTING THE FIXED AND MOVING POINT CONTACTS.

$\longrightarrow$  DIRECTIONAL ELEMENT       $\longleftrightarrow$  NON DIRECTIONAL ELEMENT

(1) NEAR MAIN POWER SOURCE  $\longrightarrow$  NON DIRECTIONAL ELEMENTS

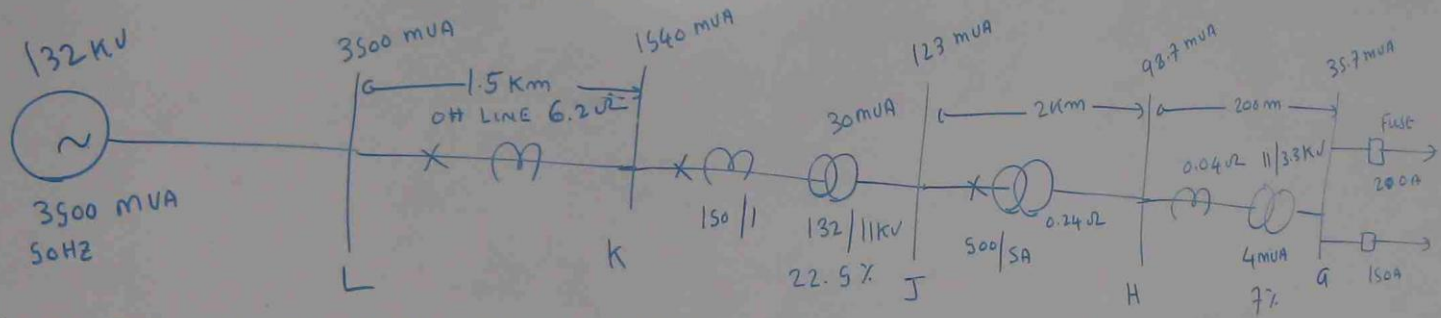
(2) DETERMINE THE NORMAL & FAULT CURRENT DIRECTIONS

(3) FAULT CURRENT OPPOSES NORMAL CURRENT  $\longrightarrow$  DIRECTIONAL ELEMENT  
 FAULT CURRENT & NORMAL CURRENT THE SAME  $\longrightarrow$  NON DIRECTIONAL ELEMENT



# TUTORIAL (4)

Q3 SKETCH CURVE FOR DISCRIMINATION BY BOTH TIME AND CURRENT OF THE FOLLOWING POWER SYSTEM.



SELECT BASE MVA AND BASE VOLTAGE

BASE MVA = 35.7 MVA, BASE VOLTAGE = 3.3 kV

$$132 \text{ kV} \rightarrow \frac{132}{3.3} = 40 \text{ pu}$$

$$3500 \text{ MVA} \rightarrow \frac{3500}{35.7} = 98 \text{ pu}$$

$$1540 \text{ MVA} \rightarrow \frac{1540}{35.7} = 43 \text{ pu}$$

$$123 \text{ MVA} \rightarrow \frac{123}{35.7} = 3.445 \text{ pu}$$

$$98.7 \text{ MVA} \rightarrow \frac{98.7}{35.7} = 2.76 \text{ pu}$$

$$35.7 \text{ MVA} \rightarrow 1 \text{ pu}$$

$$\text{Full load current } I_{FL} = \frac{\text{BASE MVA}}{\sqrt{3} \times \text{BASE VOLTAGE}} = \frac{35.7 \times 10^6}{\sqrt{3} \times 3.3 \times 10^3} = 6245 \text{ A}$$

$\Omega \rightarrow \text{p.u}$

$$\% X = \frac{I_{FL}^2 \times X}{\text{BASE MVA}}$$

$$\begin{aligned} \frac{L \rightarrow K}{\% X} &= \frac{I_{FL}^2 \times X}{\text{BASE MVA}} = \frac{6245^2 \times 6.2}{35.7 \times 10^6} \\ &= 6.73 \text{ pu} \end{aligned}$$



K → J

$$X_2 = \frac{\text{BASE MVA}}{\text{MVA}_1} \times X_1$$

30 MVA T.R ,  $X_1 = 22.5\%$  ,  $\text{MVA}_1 = 30$

$$X_2 = \frac{35.7}{30} \times 22.5 = 26.4 \text{ pu} \quad (\%)$$

J → I

$$\% X \text{ (or) } X \text{ (pu)} = \frac{6245^2 \times 0.24}{35.7 \times 10^6}$$
$$= 0.26 \text{ pu}$$

H → G

TRANSFORMER 4 MVA ←  $\text{MVA}_1$   
7% ←  $X_1$

LINE 0.04 Ω

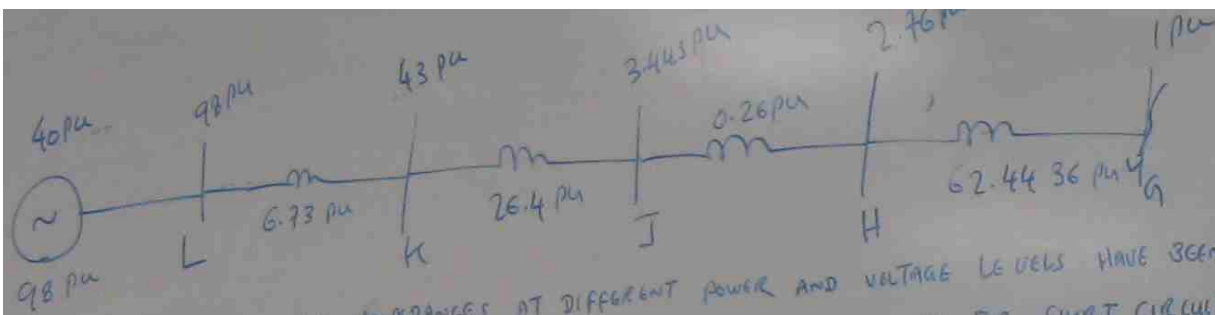
TRANSFORMER

$$X_2 = \frac{\text{BASE MVA}}{\text{MVA}_1} \times X_1 = \frac{35.7}{4} \times 7 = 62.4 \text{ pu}$$

LINE

$$X = \frac{6245^2 \times 0.04}{35.7 \times 10^6} = 0.0436 \text{ pu}$$

$$X_T = 62.4 + 0.0436 = 62.4436 \text{ pu}$$



ORIGINAL VOLTAGE, POWER, IMPEDANCES AT DIFFERENT POWER AND VOLTAGE LEVELS HAVE BEEN CONVERTED TO P.U. THIS SIMPLIFIED DIAGRAM WILL BE UTILIZED FOR SHORT CIRCUIT CURRENT.

$$\text{SHORT CIRCUIT CURRENT } (I_{sh}) = \frac{I_{fl}}{\% X \text{ BETWEEN GENERATOR AND FAULT POINT}} \times 100$$

FAULT AT (G) 
$$I_{sh} = \frac{6245}{6.73 + 26.4 + 0.26 + 62.44} \times 100 = 6499 \text{ Amp}$$

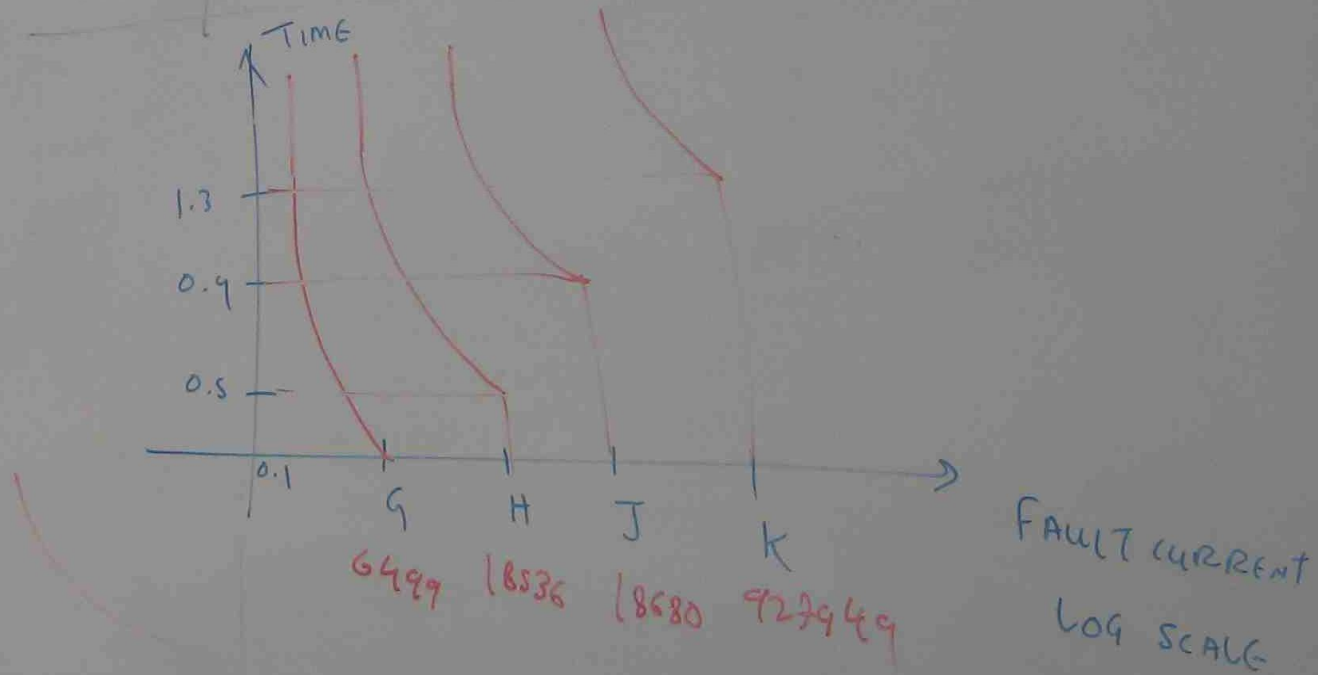
FAULT AT (H) 
$$I_{sh} = \frac{6245}{6.73 + 26.4 + 0.26} \times 100 = 18536 \text{ Amp}$$

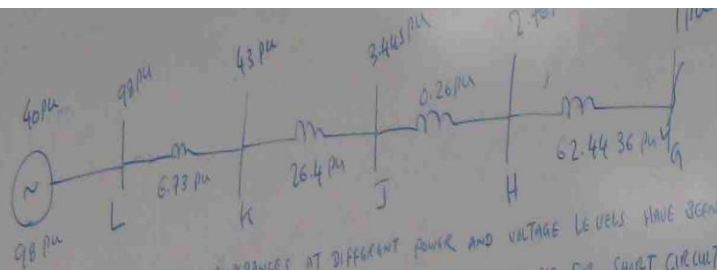
FAULT AT (J) 
$$I_{sh} = \frac{6245}{6.73 + 26.4} \times 100 = 18680 \text{ Amp}$$

FAULT AT (K) 
$$I_{sh} = \frac{6245}{6.73} \times 100 = 927949 \text{ A}$$



POINT	FAULT CURRENT	TIME SETTING FOR RELAY
G	6499	0.1
H	18536	0.5
J	18680	0.9
K	927949	1.3
L	INFINITY	





ORIGINAL VOLTAGE, POWER, IMPEDANCES AT DIFFERENT POWER AND VOLTAGE LEVELS HAVE BEEN CONVERTED TO P.U. THIS SIMPLIFIED DIAGRAM WILL BE UTILIZED FOR SHORT CIRCUIT CURRENT.

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FAULT AT (G)  $I_{sh} = \frac{6245}{6.73 + 26.4 + 0.26 + 62.44} \times 100 = 6499 \text{ Amp}$

FAULT AT (H)  $I_{sh} = \frac{6245}{6.73 + 26.4 + 0.26} \times 100 = 18536 \text{ Amp}$

FAULT AT (J)  $I_{sh} = \frac{6245}{6.73 + 26.4} \times 100 = 18680 \text{ Amp}$

FAULT AT (K)  $I_{sh} = \frac{6245}{6.73} \times 100 = 927949 \text{ A}$

POINT	FAULT CURRENT	TIME
G	6499	0.1
H	18536	0.5
J	18680	0.9
K	927949	1.3
L	INFINITY	

