UNIT III

TRANSMISSION LINE & FEEDER PROTECTION

SYLLABUS

- a)Feeder protection - protection of ring main feeder, protection of parallel feeders.

- b) Transmission line protection - Over current protection of lines, Three step distance protection, effect of power swings on distance relay, Directional comparison carrier current protection, phase comparison carrier current protection, carrier aided distance protection.

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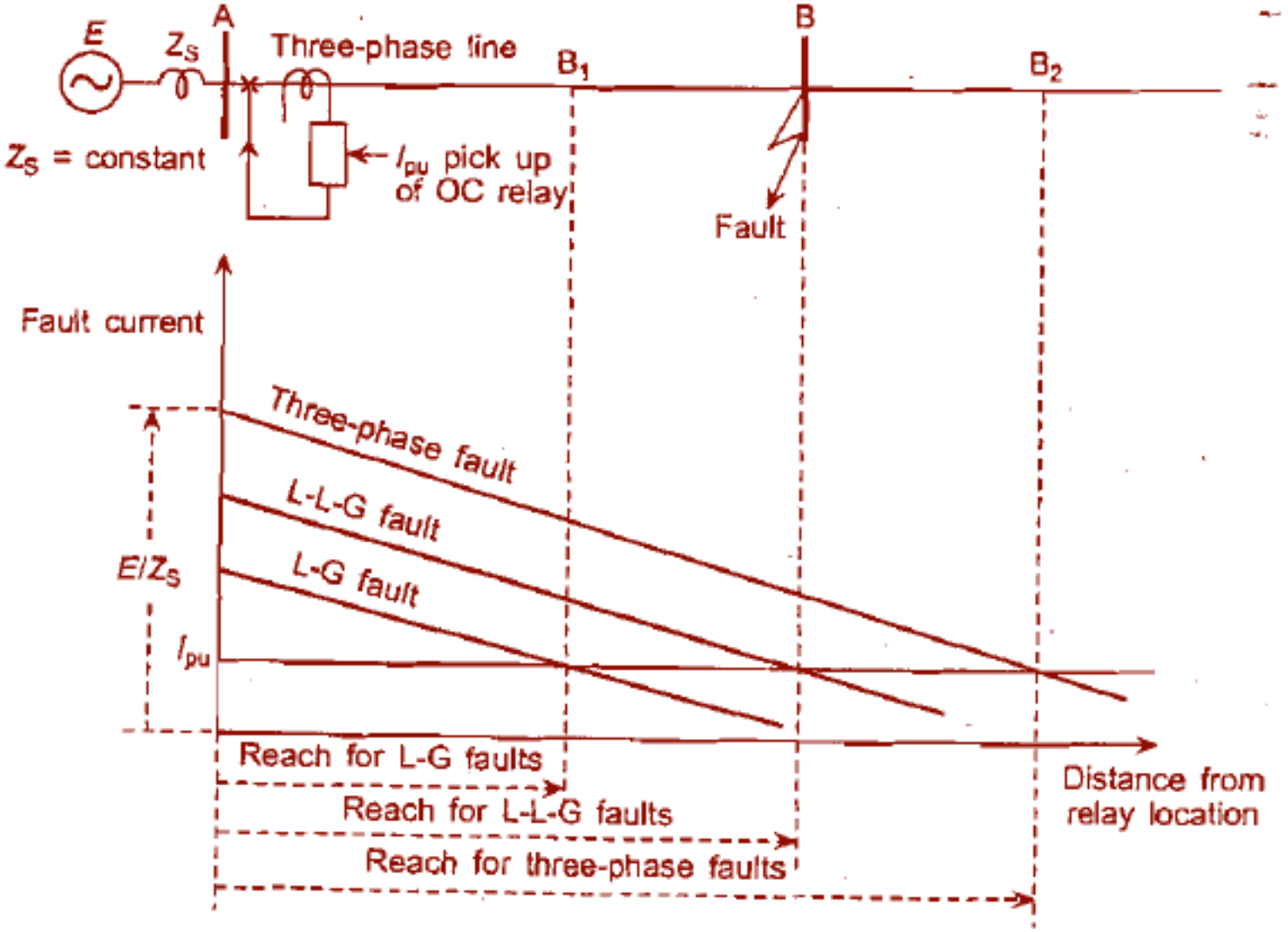
OVER CURRENT PROTECTION OF TRANSMISSION LINE

- Over-current protection is very appealing and attractive because of its inherent simplicity. It is used as a primary protection for low voltage (LV) distribution lines. However, it has some major drawbacks which causes it to mal operate. In LV systems, however, mal operation of relays **can be tolerated. The only consideration in LV systems is the** continuity of supply to the consumers. However, in EHV systems mal operations cannot be tolerated. This is because EHV lines are part of an interconnected grid.

- The reach of over-current relay depends on the type of fault as well as on the source impedance **as shown in Figures.**

- It can be seen from Figure that if the OC relay pick-up setting equal to **Ipu gives** a reach up to bus B for L-L-G faults, then the reach for L-G faults is only up to point B1, *whereas the reach for three-phase faults is up to point B2. Thus, the relay may under reach* or over-reach depending upon the type of fault. This is clearly not a desirable trait.

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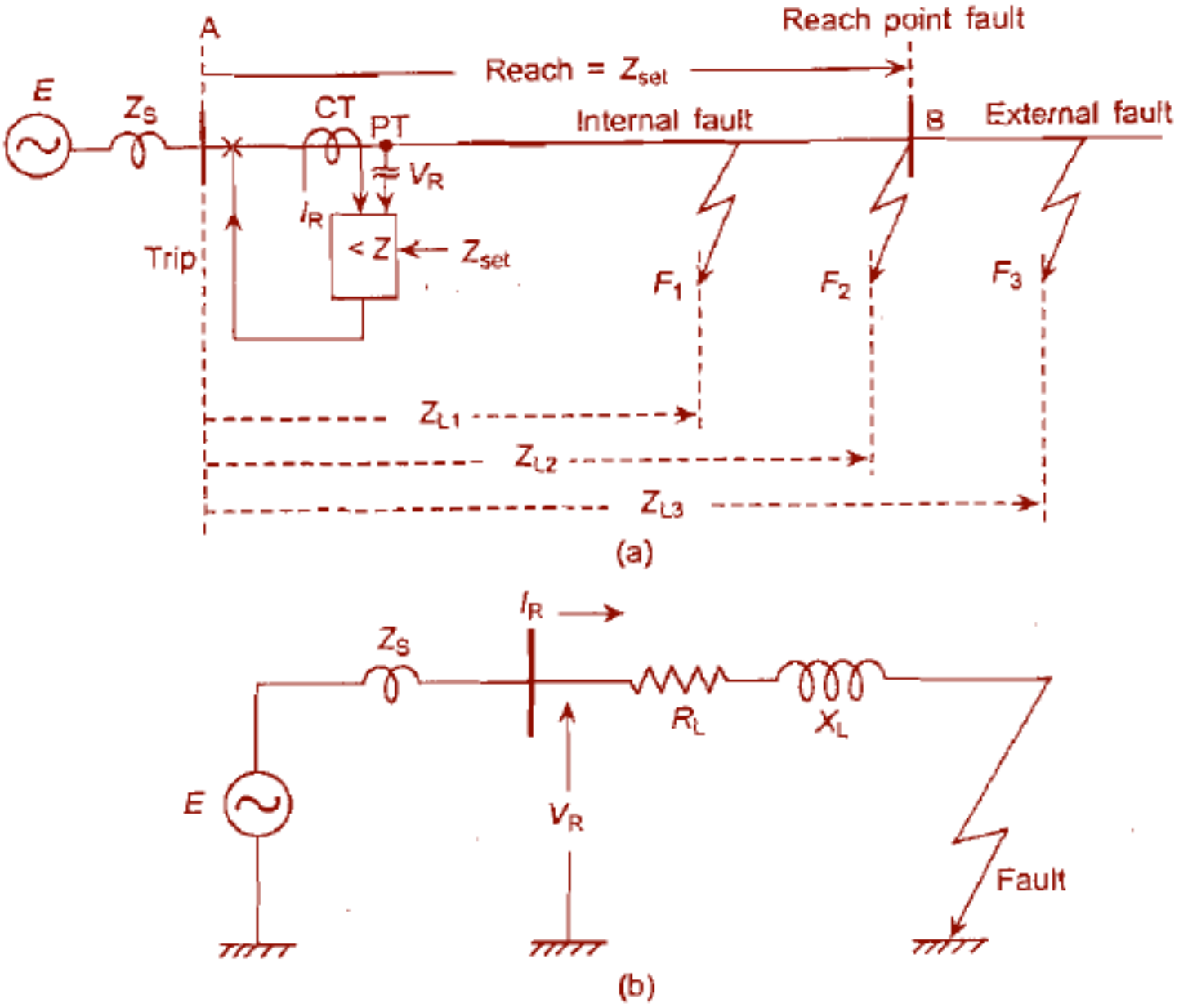
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Introduction to distance protection

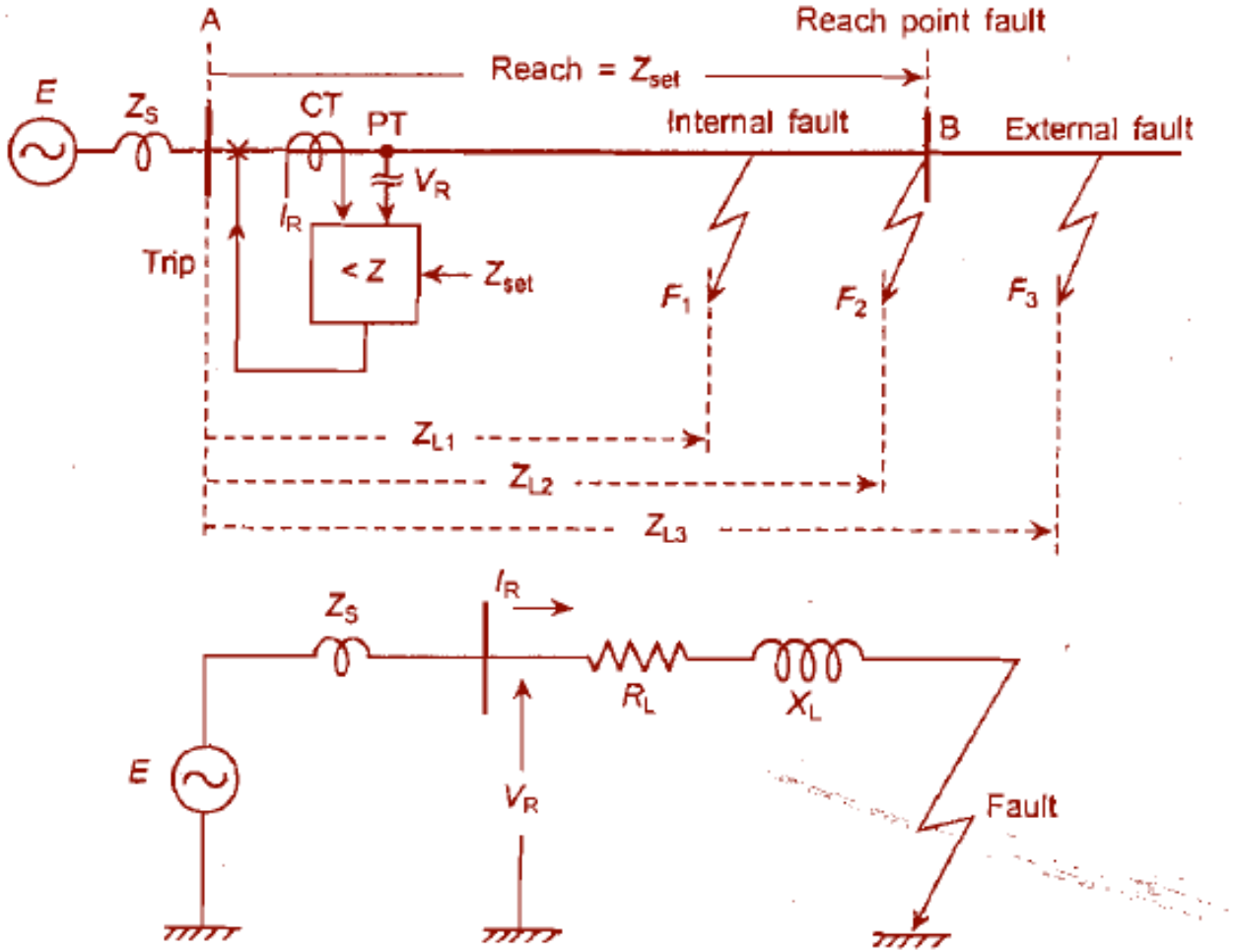
- Consider a transmission line AB as shown in Figure. Let us assume that there is source only at end A. We wish to generate a zone of protection which extends from A to B.
- Assume that the proposed relay is located at end A, where the local current and voltage are available through a CT and a PT, whose ratios have been assumed as 1 : 1 for the sake of simplicity. The reach of the distance relay is thus made equal to *Zset The line is* modeled as a series R-L circuit for the purpose of relaying without much loss of accuracy, as shown in Figure

- Consider three faults: an internal fault Fl, an external fault *F3, and a fault at reach* point fault *F2. Now, let us compare the relay voltage VR with the product of relay current* IR and Z, as shown in Table for all the three faults.

Fault	*Current at relay location,* I_R	*Voltage at relay location,* V_R	*Compare* $\lvert V_R\rvert : \lvert I_R\rvert\lvert Z_{set}\rvert$	*Desired response of relay*
F_3, External	I_{R3}	V_{R3}	$\lvert V_{R3}\rvert > \lvert I_{R3}\rvert\lvert Z_{set}\rvert$	Restrain
F_2, Reach point	I_{R2}	V_{R2}	$\lvert V_{R2}\rvert = \lvert I_{R2}\rvert\lvert Z_{set}\rvert$	Verge of operation
F_1, Internal	I_{R1}	V_{R1}	$\lvert V_{R1}\rvert < \lvert I_{R1}\rvert\lvert Z_{set}\rvert$	Trip

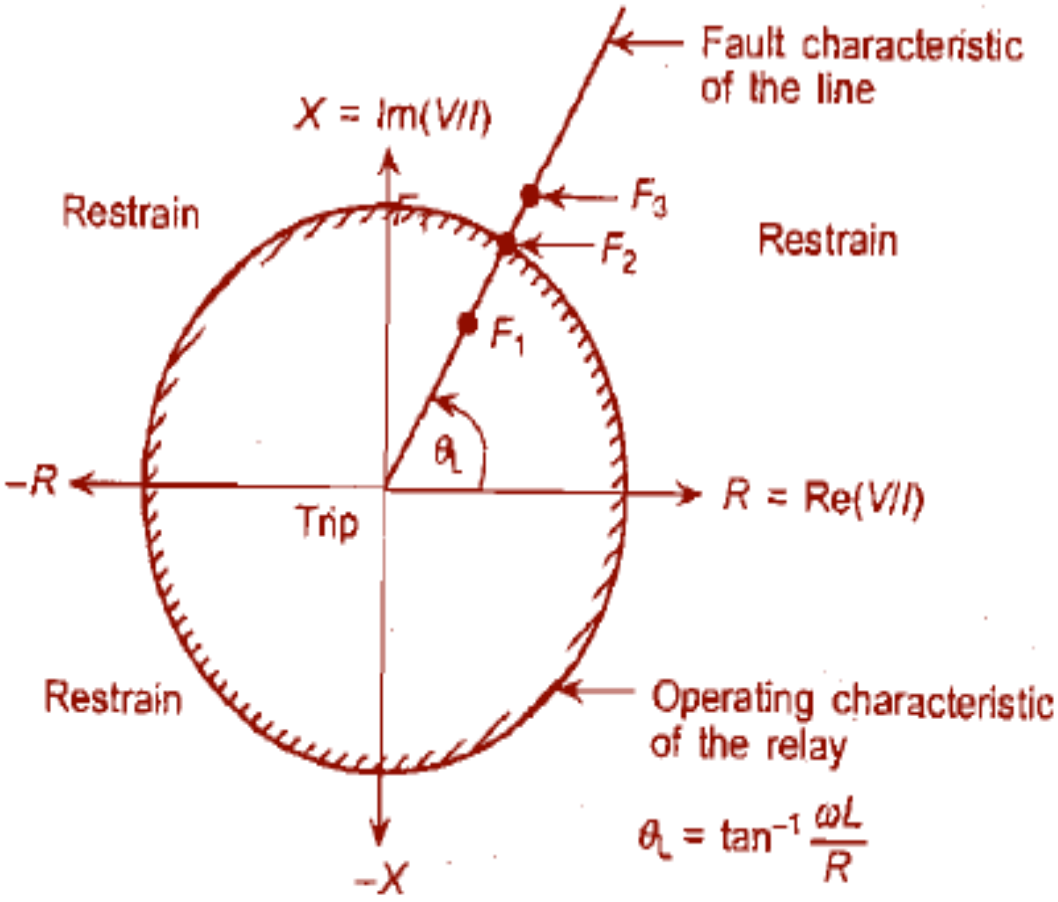

A
Reach point fault
Reach = Z_{set}
E
Z_S
CT
PT
Internal fault
B
External fault
V_R
I_R
Trip
< Z
Z_{set}
F_1
F_2
F_3
Z_{L1}
Z_{L2}
Z_{L3}
(a)
I_R
Z_S
R_L
X_L
E
V_R
Fault
(b)

Characteristics of simple impedance relay on *R-X plane with fault characteristic* of the line superimposed.



Model of the faulted transmission line

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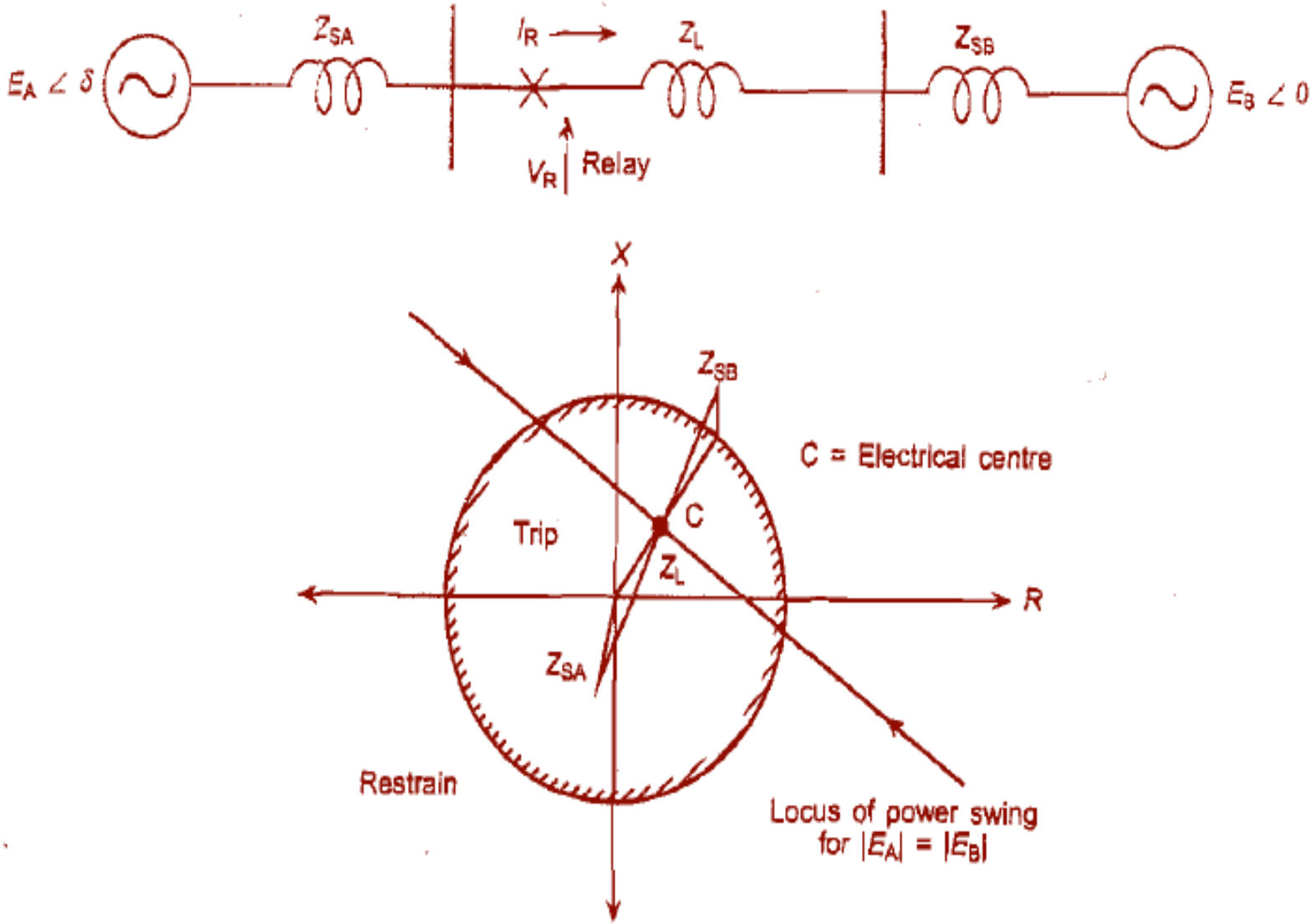
Characteristics of simple impedance relay on R-X plane with fault characteristic of the line superimposed.

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Performance of Simple Impedance Relay During Power Swing

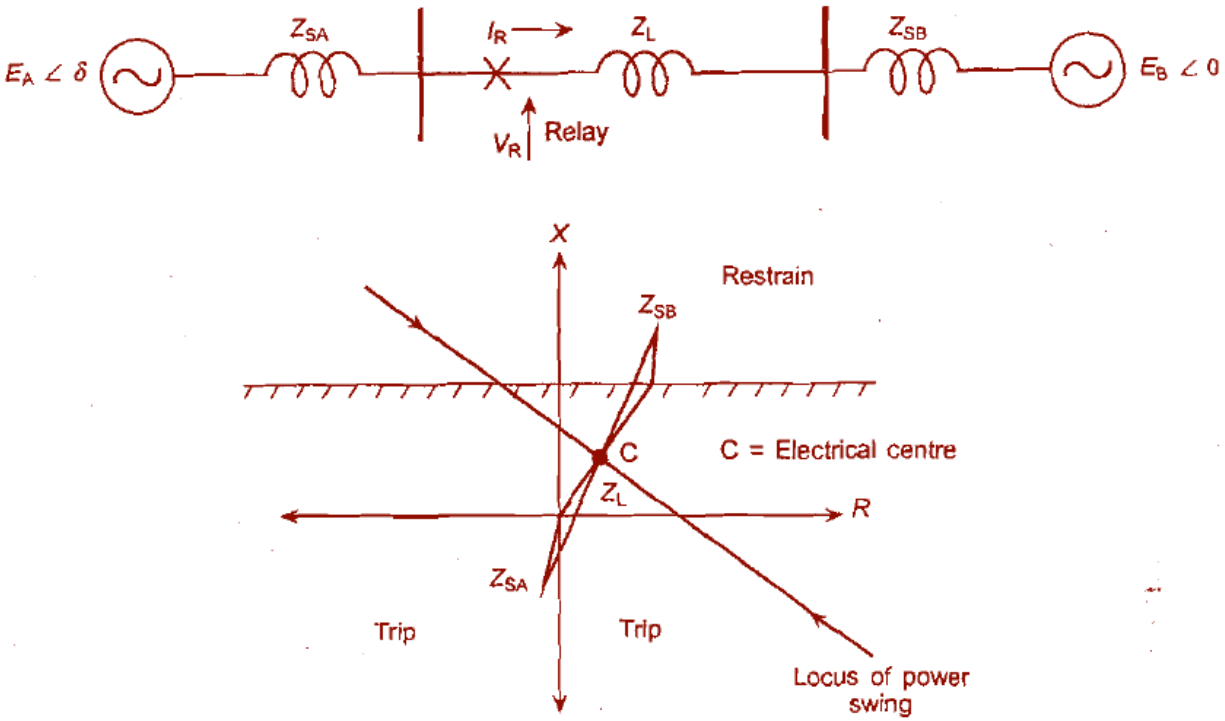
- When a power system is operating in steady state, all the rotor or machine angles are constant. Whenever there are sudden and large changes of power in the system, (say due to outage of a major tie-line), the rotor angles undergo oscillations till the system reaches a new stable state. This phenomenon is known as ***power swing. The frequency of*** oscillations of the rotor angle during power swing is quite low, of the order of a few hertz, ' due to large inertias of the rotating masses involved.

- The impedance seen by the distance relay during power swing is of special interest to the relaying engineer. It can be shown that, during power swing, the locus of the tip of impedance seen by the relay passes, rather slowly, through the electrical centre of the transmission system consisting of the series combination of the source impedance behind the relay location, the transmission line impedance and the impedance of the source at the remote end. This is shown in Figure Thus, at some point during the power swing, the apparent impedance enters the trip region of the relay operating characteristic. Further, when it passes through the electrical centre, it looks as if there is a metallic fault at the electrical centre of the transmission system. This causes the relay to trip, putting the line out of service, adding to the disturbance already present in the system. Therefore, tripping because of power swing has to be more often blocked than unblocked.


$E_A \angle \delta$
Z_{SA}
I_R
Z_L
Z_{SB}
$E_B \angle 0$
V_R
Relay
X
Z_{SB}
C = Electrical centre
C
Trip
Z_L
R
Z_{SA}
Restrain
Locus of power swing
for $|E_A| = |E_B|$

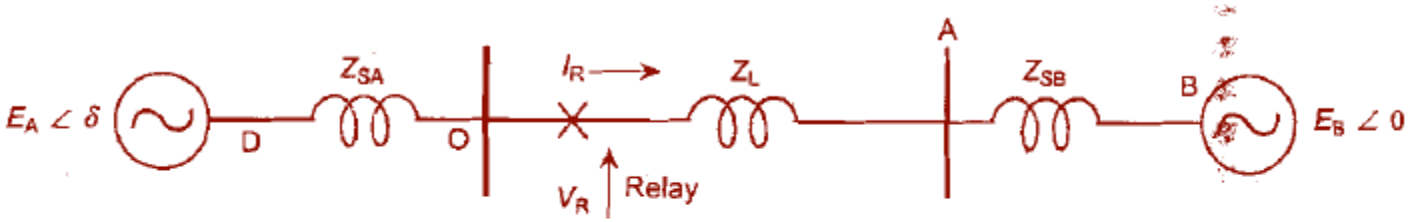
Performance of Reactance Relay During Power Swing

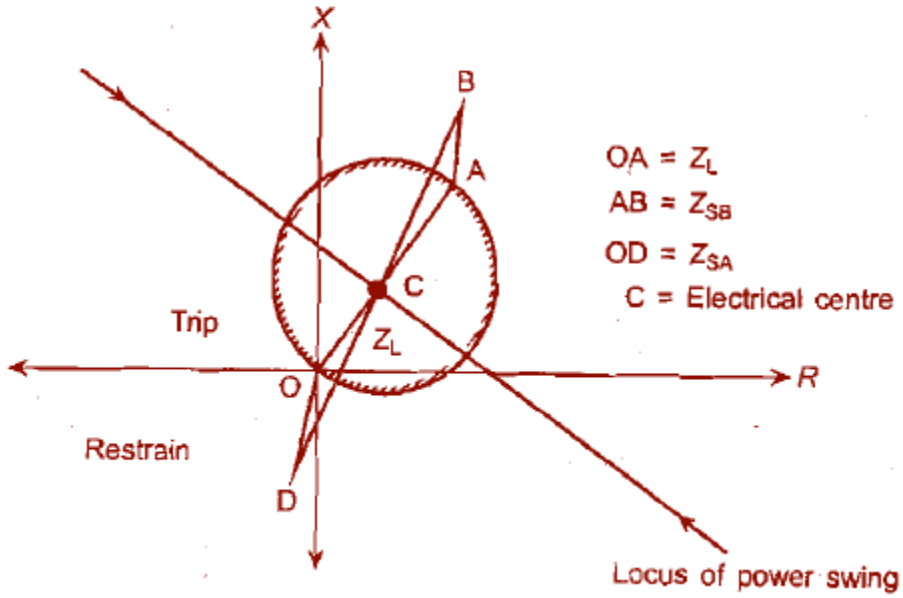
- The reactance relay occupies such a large area on the R-X plane that it operates even during normal load flow. As shown in Figure during power swing, the tip of the impedance-seen phasor approaches the electrical centre of the system. Even before this happens, it is already in the trip region of the reactance relay characteristic. Therefore, the reactance relay operates on power swing as well. Again, this is not a desirable trait.



Performance of Mho Relay During Power Swing

- The mho relay occupies a much smaller area on the R-X plane. To that extent, it is less immune to power swing. However, when the swing is very large, the impedance seen 4 enters the mho circle and the relay trips, as shown in Figure Special relays known as *blinders can be used to prevent operation on power swing.*





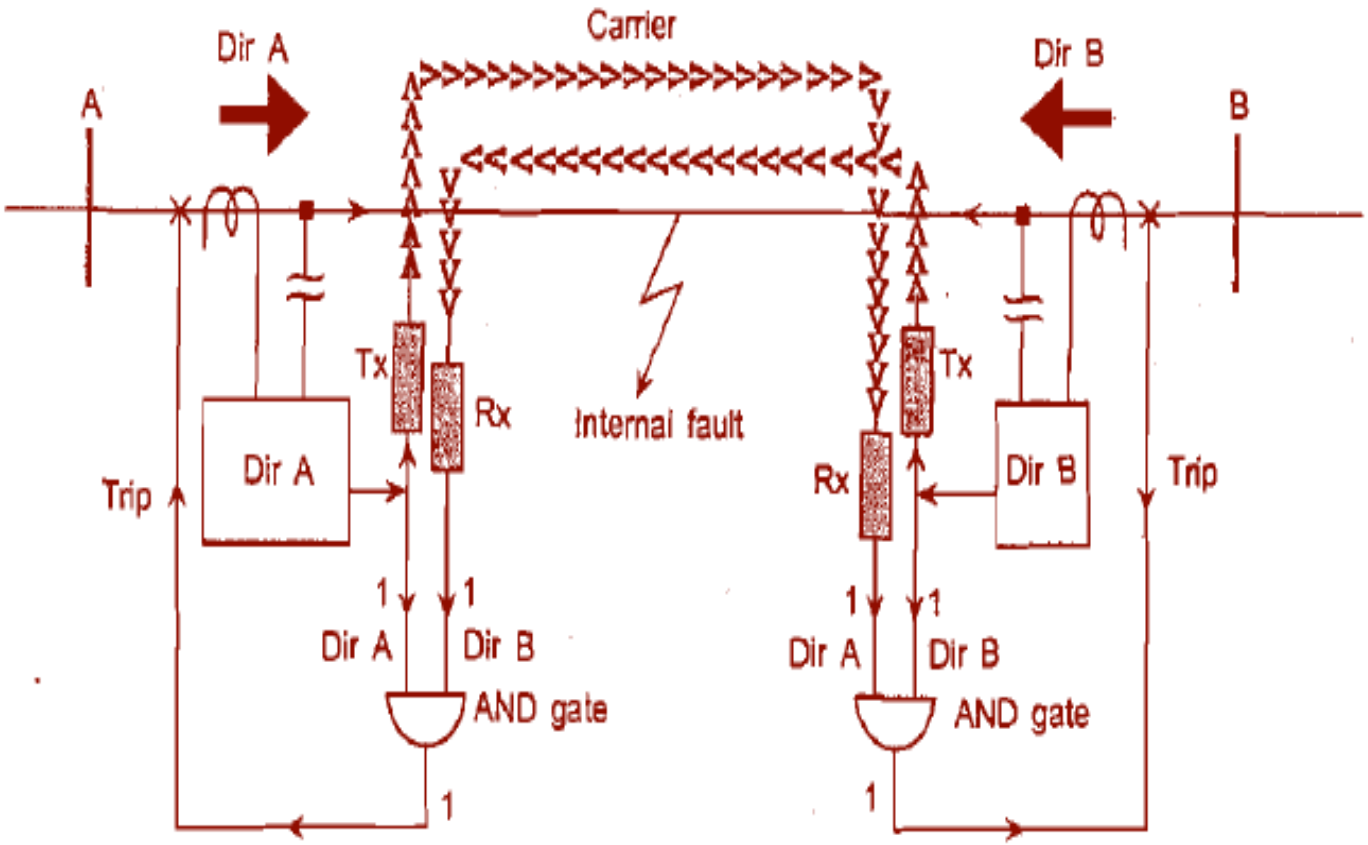
Need for Carrier-aided Protection

- The main aim of the electrical power system is to maintain uninterrupted supply of electricity to consumers. Electrical faults, however, cause interruption to the supply When a fault takes place it is detected by protective relays and the fault current is interrupted by the circuit breaker. The maintenance personnel must then rush to the fault location, rectify the fault, and restore the supply This applies to permanent faults. However, there is statistical evidence, as shown in Table that about 80% of faults are not permanent but are transient. These faults are caused by breakdown of air surrounding the insulator. These faults **can disappear by themselves, if the supply is** briefly interrupted and the arc-path is allowed to de-ionize.

Type of fault	*Probability*
Transient	80%
Semi-permanent	10%
Permanent	10%

System voltage	*Typical de-ionization time*
66 kV	0.10 s
132 kV	0.17 s
220 kV	0.28 s
400 kV	0.50 s

Relaying Unit Type Carrier-aided Directional Comparison (for internal fault)



Relaying Unit Type Carrier-aided Directional Comparison (for external fault)

