Expt: 3b

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Case-I

1. Fault Type : Phase-A-ground fault

2. Voltage of Phase A during fault
$$V_a = 235.8 \text{ V (rms)}$$
Current during fault $= I_a = 18.85$ A

3. $Z_{app} = \dfrac{V_a}{I_a + k_0 I_0} = \dfrac{V_a}{I_a} \, (k_0 = 0) = \dfrac{235.8}{18.85} \, \Omega = 12.51 \, \Omega$

4. Line Impedance $(Z) = (1.7 + j28.59)\Omega = 28.64 \angle 86.6° \, \Omega$

Zone 1 setting $= 80\% \, Z = 22.91 \angle 86.6° \, \Omega$

$Z_{app} = 12.51 \, \Omega$

$Z_{app} <$ Zone 1 setting $\Rightarrow$ fault is in Zone 1

5. Here relay has tripped for fault
Relay decision time $= 23$ ms
Circuit breaker operation time $= 28$ ms.

6. Here the relay trips as the fault in zone-1.
Apparent Impedance is close to line impedance in normal condition but here it is not the case as the relay has tripped.
$$\frac{Z_{app}}{Z_{line}} = \frac{12.51}{28.64} = 0.437 \%$$

Hence the fault according occurred at 44% of the line in zone-1. Also $k_0 = 0$ here as no mutual inductance was taken as zero between lines which is not generally the case in real.

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Case-2

1) Fault type : phase-C-ground fault

2) $V_c = 237.8V$, $I_c = 14.35A$

3) $Z_{app} = \dfrac{V_c}{I_c + k_0 I_0} = \dfrac{V_c}{I_c} = \dfrac{237.8}{14.35} \Omega = 16.57 \Omega$

   $(k_0 = 0)$

4) $Z_{line} = 28.64 \angle 86.6° \Omega$

   Zone-1 setting $= 80\% Z_{line} = 22.91 \angle 87° \Omega$

   $Z_{app} = 16.57 \Omega$

   $Z_{app} <$ Zone 1 setting

   ∴ Fault in Zone-1.

5) Relay has tripped for fault
   Relay decision time = 35ms
   Circuit breaker operation time = 31 ms
   Total time from fault start to fault clearance =
   66 ms

6) Discussion:
   In this case, the relay trips since the fault in zone-1.
   $\dfrac{Z_{app}}{Z} = \dfrac{16.57}{28.64} = 0.579 \approx 58\%$
   fault occured at 58% of line i-e, In zone-1. Here
   $k_0 = 0$ as the lines are not mutually coupled here.
   The relay takes 35 ms to decide and circuit breaker
   breaks in 31 ms, so total time taken in trip = 66ms.

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8.)

PT ratio $= 132kV/110V.$

Zapp referred to secondary side $= 4.25\Omega$

Zapp referred to primary $=$
$$= 4.25 \times \frac{132 \times 10^3}{110} \times \frac{5}{500} \; \Omega = 51\;\Omega$$

Total line impedance is Z_L.
$$= (0.03 + 0.3j) \times 210$$
$$= 75.37 \; \underline{/84.3°} \; \Omega$$

Zone-1 setting $= 80\%$ of $Z_L = 60.3 \; \underline{/84.3°}\; \Omega$

Zapp $<$ Zone-1-setting

$\therefore$ fault is in Zone-1.