

EE 460
Solution of Home Work # 4

10.3 From Figure 10.8, the secondary resistance $Z' = 0.125 \Omega$ for the 200:5 CT.

(a) Step (1) – $I' = 10$ A

$$\text{Step (2) – } E = (Z' + Z_B)I' = (0.125 + 1)(10) = 11.25 \text{ V}$$

Step (3) – From Figure 10.8, $I_e = 0.18$ A

$$\text{Step (4) – } I = \left(\frac{200}{5}\right)(10 + 0.18) = \underline{\underline{407.2 \text{ A}}}$$

(b) Step (1) – $I' = 10$ A

$$\text{Step (2) – } E = (Z' + Z_B)I' = (0.125 + 4)(10) = 41.25 \text{ V}$$

Step (3) – From Figure 10.8, $I_e = 1.5$ A

$$\text{Step (4) – } I = \left(\frac{200}{5}\right)(10 + 1.5) = \underline{\underline{460 \text{ A}}}$$

(c) Step (1) – $I' = 10$ A

$$\text{Step (2) – } E = (Z' + Z_B)I' = (0.125 + 5)(10) = 51.25 \text{ V}$$

Step (3) – From Figure 10.8, $I_e = 30$ A

$$\text{Step (4) – } I = \left(\frac{200}{5}\right)(10 + 30) = \underline{\underline{1600 \text{ A}}}$$

10.7 (a) The current tap setting (pickup current) is $I_p = 1.0$ A.

$$\frac{I'}{I_p} = \frac{10}{1} = 10. \text{ From curve } \frac{1}{2} \text{ in Figure 10.12}$$

$$t_{\text{operating}} = \underline{\underline{0.08 \text{ s}}}$$

(b) $\frac{I'}{I_p} = \frac{10}{2} = 5$. Interpolating between curve 1 and curve 2 in Figure 10.12, $t_{\text{operating}} = \underline{\underline{0.55 \text{ s}}}$

(c) $\frac{I'}{I_p} = \frac{10}{2} = 5$. From curve 7, $t_{\text{operating}} = \underline{\underline{3 \text{ s}}}$

(d) $\frac{I'}{I_p} = \frac{10}{3} = 3.33$ From curve 7, $t_{\text{operating}} = \underline{\underline{5.2 \text{ s}}}$

(e) $\frac{I'}{I_p} = \frac{10}{12} < 1$. The relay does not operate. It remains in the blocking position.

10.12 First select current Tap settings (*TS*s). Starting at B3, the primary and secondary CT currents for maximum load *L3* are:

$$I_{L3} = \frac{S_{L3}}{V_3 \sqrt{3}} = \frac{9 \times 10^6}{34.5 \times 10^3 \sqrt{3}} = 150.6 \text{ A}$$

$$I'_{L3} = \frac{150.6}{(200/5)} = 3.77 \text{ A}$$

From Figure 10.12, select 4-A *TS3*, which is the lowest *TS* above 3.77 A.

$$I_{L2} = \frac{(S_{L2} + S_{L3})}{V_2 \sqrt{3}} = \frac{(9.0 + 9.0) \times 10^6}{34.5 \times 10^3 \sqrt{3}} = 301.2 \text{ A}$$

$$I'_{L2} = \frac{301.2}{(400/5)} = 3.77 \text{ A}$$

Again, select 4-A *TS2* for B2.

$$I_{L1} = \frac{S_{L1} + S_{L2} + S_{L3}}{V_1 \sqrt{3}} = \frac{(9 + 9 + 9) \times 10^6}{34.5 \times 10^3 \sqrt{3}} = 451.8 \text{ A}$$

$$I'_{L1} = \frac{451.8}{(600/5)} = 3.77$$

Again select a 4 A *TS1* for B1. Next select Time Dial Settings (*TDS*s). Starting at B3, the largest fault current through B3 is 3000 A, for the maximum fault at bus 2 (just to the right of B3). The fault to pickup ratio at B3 for this fault is

$$\frac{I'_{3 \text{ fault}}}{TS3} = \frac{3000 / (200/5)}{4} = 18.75$$

Select *TDS* = $\frac{1}{2}$ at B3, in order to clear this fault as rapidly as possible. Then from curve $\frac{1}{2}$ in Fig. 10.12, $t_{\text{operating}3} = 0.05$ s. Adding the breaker operating time (5 cycles = 0.083 s), primary protection clears this fault in $0.05 + 0.083 = 0.133$ s.

For this same fault, the fault-to-pickup ratio at B2 is

$$\frac{I'_{2 \text{ fault}}}{TS2} = \frac{3000 / (400/5)}{4} = \frac{37.5}{4} = 9.4$$

Adding B3 relay operating time, breaker operating time, and 0.3 s coordination interval, $(0.05 + 0.083 + 0.3) = 0.433$ s, which is the desired B2 relay operating time. From Figure 10.12, select *TDS2* = 2.

Next select the *TDS* at B1. The largest fault current through B2 is 5000 A, for the maximum fault at bus 1 (just to the right of B2). The fault-to-pickup ratio at B2 for this fault is

$$\frac{I'_{2 \text{ fault}}}{TS2} = \frac{5000 / (400/5)}{4} = \frac{62.5}{4} = 15.6$$

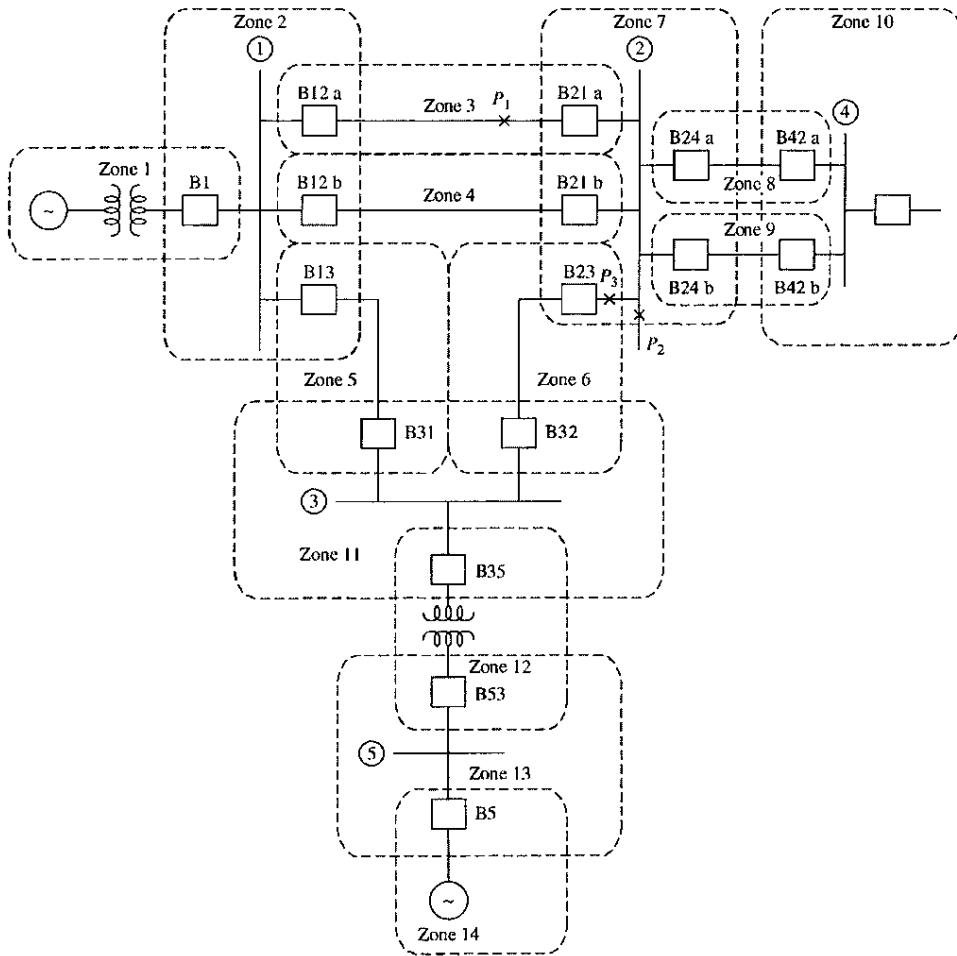
From curve 2 in Fig. 10.12, the relay operating time is 0.38 s. Adding the 0.083 s breaker operating time and 0.3 s coordination time interval, we want a B1 relay operating time of $(0.38 + 0.083 + 0.3) = 0.763$ s. Also, for this same fault,

$$\frac{I'_{1 \text{ fault}}}{TS1} = \frac{5000 / (600/5)}{4} = \frac{41.66}{4} = 10.4$$

From Fig. 10.12, select *TDS1* = 3.5.

Breaker	Relay	<i>TS</i>	<i>TDS</i>
B1	CO-8	4	3.5
B2	CO-8	4	2
B3	CO-8	4	$\frac{1}{2}$

10.18



- (a) For a fault at P_1 , breakers in zone 3 operate (B12a and B21a).
- (b) For a fault at P_2 , breakers in zone 7 operate (B21a, B21b, B23, B24a, B24b).
- (c) For a fault at P_3 , breakers in zone 6 and zone 7 operate (B23, B32, B21a, B21b, B24a, and B24b).