ECE471 INDUSTRIAL POWER SYSTEMS
Homework Set 6 – Solutions

7.2. Using Figure 7.11, determine the minimum melting and total clearing times for (a) 200 A fuse with a current of 1000 A, and (b) 30 A fuse with a current of 100 A.

7.2. From the curves in Figure 7.11, the minimum melting and maximum clearing times respectively are:
(a) for 1000 A, 1.5 and 3.5 seconds,
(b) for 100 A, 4 and 7 seconds.

7.4. Using Figure 7.5, determine the effective let-through symmetrical rms current with a 200 A, 250 V current-limiting fuse if the prospective short-circuit current is 70,000 symmetrical rms amperes.

7.4. In Figure 7.5(a), the 70,000 A vertical line intersects the 200 A, 250 V fuse curve at 30,000 A. The 30,000 A horizontal line intersects line AB at 13,000 A which is the effective let-through symmetrical rms current.

7.5. Refer to Figure 7.13. Both fuses are class RK-5, time delay. Fuse B is rated for 60 A. Determine the smallest standard rating for fuse A that will coordinate with fuse B.

7.5. From Table 7.3, the selectivity ratio is 2:1.
Smallest rating for fuse A is 2 X 60 = 120 A.
From Table 7.1, the next highest standard fuse rating is 125 A.

7.6. Repeat Problem 5, except fuse A is class T.

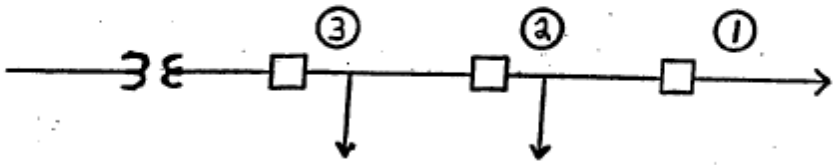
7.6. From Table 7.3, the selectivity ratio is 8:1.
Smallest rating for fuse A is 8 X 60 = 480 A.
From Table 7.1, the next highest standard fuse rating is 500 A.
Note that using class T fuses ahead of class RK-5 fuses is generally not a good selection.

The 13.8 kV feeders shown below are to be protected using CO-7 inverse-time overcurrent relays. The relays are to pick-up for currents in excess of the continuous rating of the line section. Each relay is to allow 0.3 sec co-ordination margin 0.1 sec breaker operating time.

Section 1, continuous rating = 120 A, fault level = 1 kA
Section 2, continuous rating = 360 A, fault level = 2 kA
Section 3, continuous rating = 660 A, fault level = 5 kA

a) select appropriate CT ratios.
b) Determine the necessary pick-up taps.
c) Determine the appropriate time-dial settings.
d) How long will it take to clear a fault on section 3?

Standard CT ratios:
50 : 5
100 : 5
150 : 5
200 : 5
250 : 5
300 : 5
400 : 5
450 : 5
500 : 5
600 : 5
800 : 5
900 : 5
1000 : 5
1200 : 5
1600 : 5
2400 : 5
3200 : 5
4000 : 5



R1: Since the continuous rating of this section is 120 A, choose a C.T.R. of **100:5**. With this ratio, the normal relay current would be

$$i = \frac{120\ A}{\frac{100}{5}} = 6\ A \quad \therefore \boxed{C.T.S._1 = 6A}$$

Since the fastest action is required for this relay, we choose the lowest T.D.S. for this relay. $\therefore \boxed{T.D.S._1 = \frac{1}{2}}$

For a fault at (1) $i_f = \frac{1000\ A}{\frac{100}{5}} = 50\ A \Longrightarrow \frac{i_f}{C.T.S.} = \frac{50A}{6\ A} = 8\frac{1}{3}$ multiples

Referring to the relay characteristic, for $T.D.S._1 = \frac{1}{2}$ and $8\frac{1}{3}$ multiples, we find that $T_1 = 0.1$ sec. Allowing for a 0.3 sec co-ordination margin and 0.1 sec operating time, we see that $T_2 = 0.1 + 0.3 + 0.1 = 0.5$ sec { R2 must take 0.5 sec to respond to a fault at (1) }

NOTE if 150:5 is chosen then $i = \frac{120}{150} = 4A$ & $CTS_1 = 4A$ is OK

R2: Continuous rating is 360 A, choose a C.T.R. of **400:5**.

Normal relay current $= \frac{360\text{ A}}{\frac{400}{5}} = 4.5\text{ A}$ $\therefore$ **C.T.S.$_2$ = 5 A**

For a fault at ① $i_f = \frac{1000}{\frac{400}{5}} = 12.5\text{ A} \Rightarrow \frac{i_f}{\text{C.T.S}} = \frac{12.5\text{A}}{5\text{ A}} = 2\frac{1}{2}$ multiples

Referring again to the relay characteristics, for $2\frac{1}{2}$ multiples and $T_2 = 0.5$ sec, we find that **T.D.S.$_2 \approx 1$**

For a fault at ② $i_f = \frac{2000\text{ A}}{\frac{400}{5}} = 25\text{ A} \Rightarrow \frac{i_f}{\text{C.T.S.}} = \frac{25\text{A}}{5\text{ A}} = 5$ multiples

Referring to the relay characteristics, for T.D.S.$_2$ = 1 and 5 multiples, we find that $T_2 = 0.35$ sec.

$\therefore T_3 = 0.35 + 0.1 + 0.3 = 0.75$ sec { R3 must take 0.75 sec to respond to a fault at ② }

R3: Continuous rating is 660 A, choose a C.T.R. of **600:5**.

Normal relay current $= \frac{660\text{ A}}{\frac{600}{5}} = 5.5\text{ A}$ $\therefore$ **C.T.S.$_3$ = 6 A** (5A if CTR$_2$ = 800:5)

For a fault at ② $i_f = \frac{2000\text{A}}{\frac{600}{5}} = 16.67\text{ A} \Rightarrow \frac{i_f}{\text{C.T.S.}} = \frac{16.67\text{ A}}{6\text{ A}} = 2.78$ multiples

Referring to relay characteristics, for 2.78 multiples and $T_3 = 0.75$ sec, we find **T.D.S.$_3 = 1\frac{1}{2}$**

For a fault at ③ $i_f = \frac{5000\text{ A}}{\frac{600}{5}} = 41.67\text{ A} \Rightarrow \frac{i_f}{\text{C.T.S.}} = \frac{41.67\text{A}}{6\text{ A}} = 6.94$ multiples

Referring to relay characteristics, for 6.94 multiples and T.D.S.$_3 = 1\frac{1}{2}$, we find $T_3 \approx 0.4$ sec.

$\therefore$ for a fault at ③, the clearing time $= 0.4 + 0.1$ **$= 0.5$ sec.**