كلية المأمون الجامعة

قسم هندسة تقنيات القدرة الكهربائية

المرحلة الرابعة

Calculation of Relay Operating Time

أنظمة النقل والتوزيع

محاضرة رقم (17)

Calculation of Relay Operating Time

In order to calculate the actual relay operating time, the following things must be known :

(*a*) Time/P.S.M. curve

(*b*) Current setting

(*c*) Time setting

(*d*) Fault current

(*e*) Current transformer ratio

Time/P.S.M. Curve

the curve between time of operation and plug setting multiplier of a typical relay.

- The horizontal scale is marked in terms of plug-setting multiplier and represents the number of times the relay current is in excess of the current setting.
- The vertical scale is marked in terms of the time required for relay operation.
- The actual time of operation is obtained by multiplying this time by the time-setting multiplier.

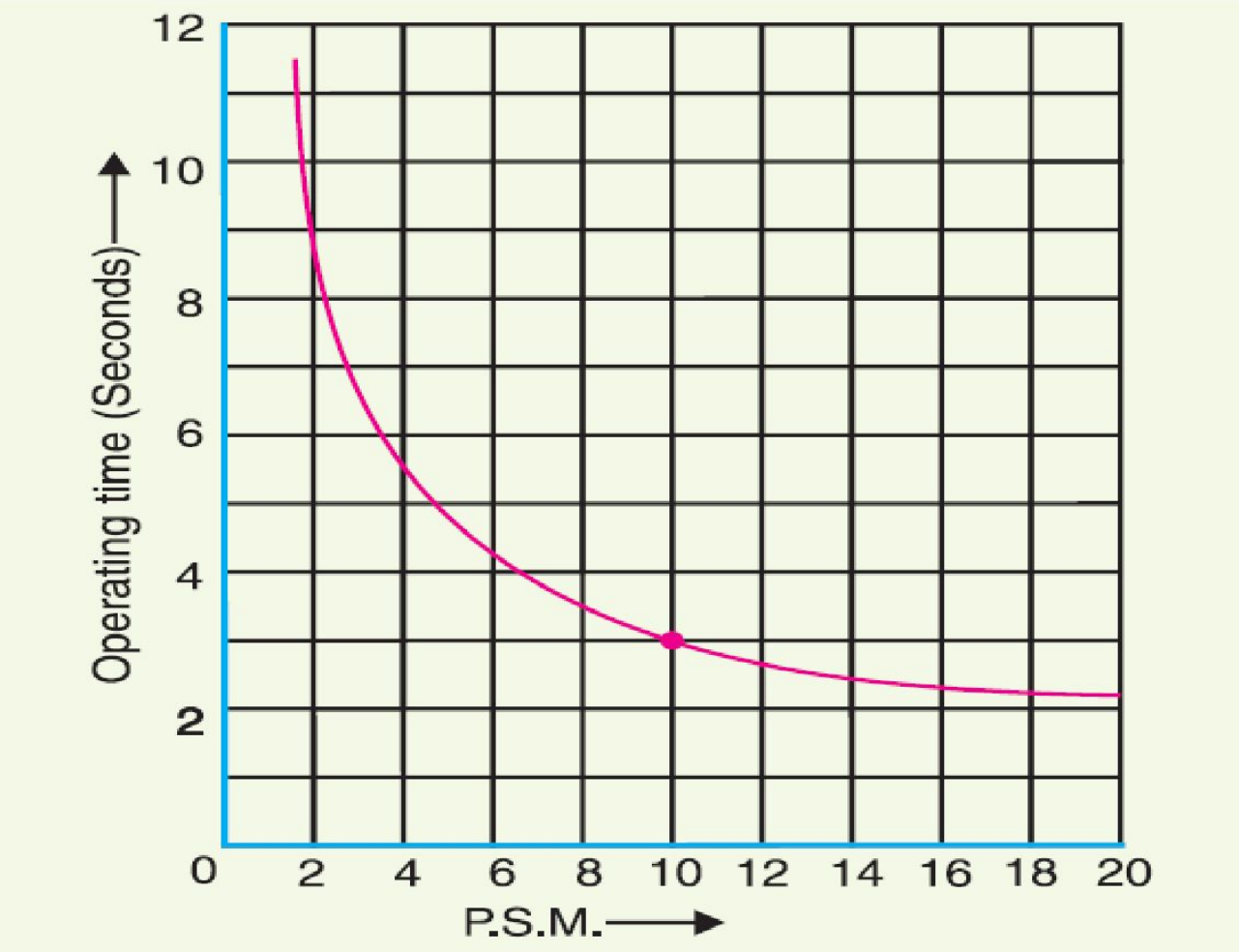
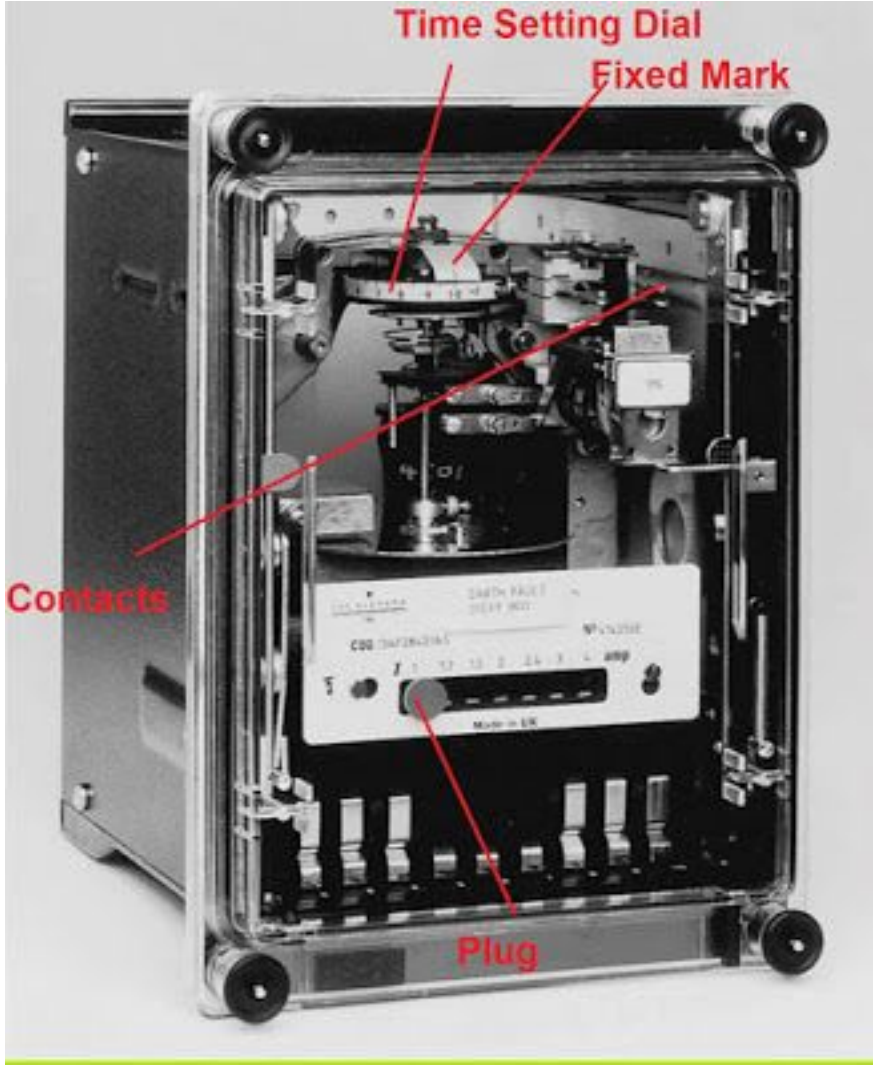


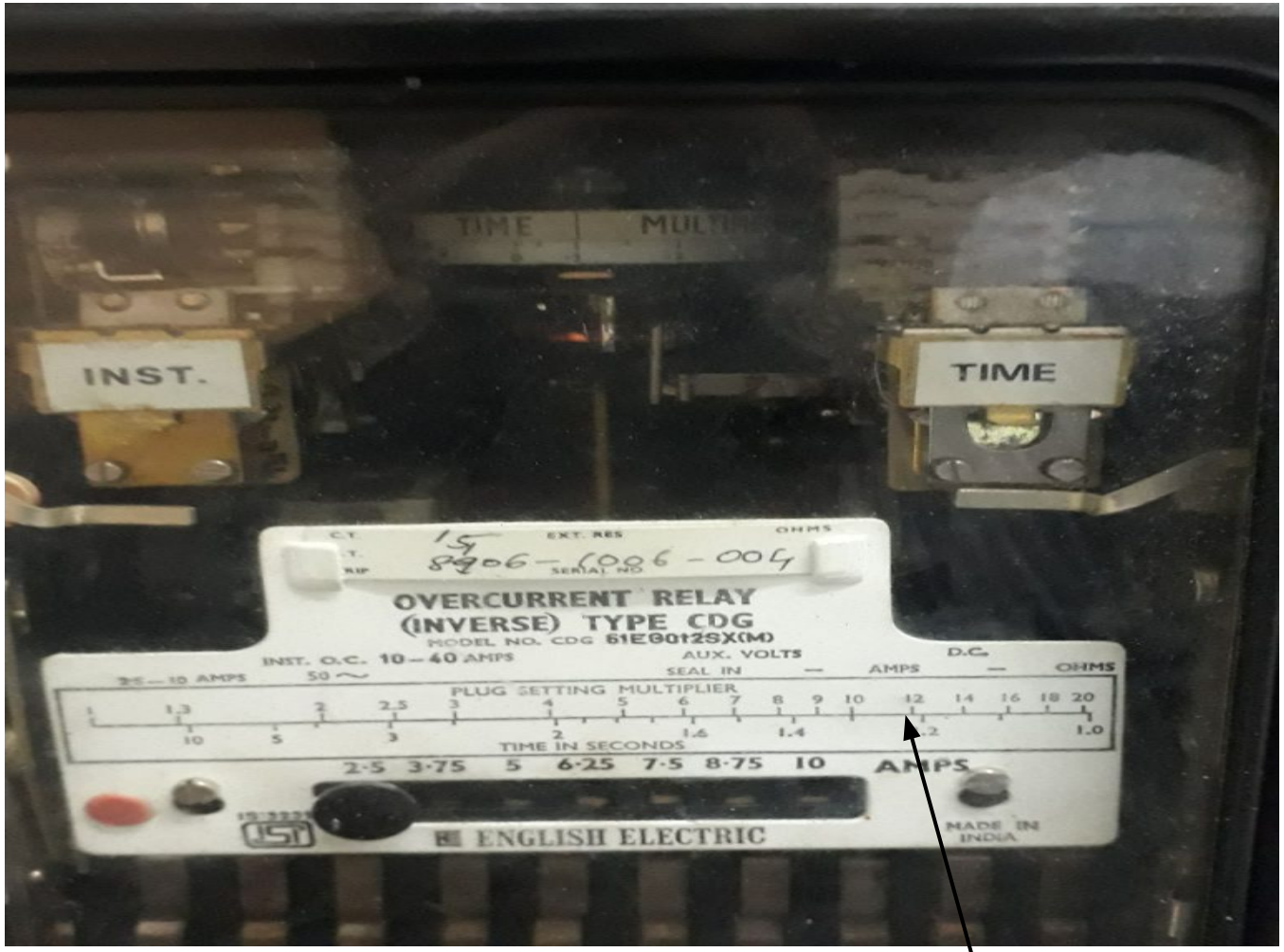
Fig 21.16 Time/P.S.M curve

If the P.S.M. is 10, then the time of operation (from the curve) is 3 seconds.

As shown in figure above, the plug is kept at 5. This means that pick-up current of relay will be 5 times of rated CT Secondary current. Likewise, if we put the plug at 8.75 then pick-up current of relay will be 8.75 times of the rated CT Secondary current.



As can be seen from the figure, there is a Time Setting Dial which is rotated to set the time of operation of the relay. Lets say we want to set the time on Time Setting Dial to 0.5 s, then we need to rotate the dial till 0.5 s on the dial matches with the fixed mark provided. So in this case, our TSM is 0.5.



The P.S.M. and time of operation

The procedure for calculating the actual relay operating time is as follows :

(*i*) Convert the fault current into the relay coil current by using the current transformer ratio.

(*ii*) Express the relay current as a multiple of current setting *i.e.* calculate the P.S.M.

(*iii*) From the Time/P.S.M. curve of the relay, read off the time of operation for the calculated P.S.M.

(*iv*) Determine the actual time of operation by multiplying the above time of the relay by time setting multiplier in use.

Example The current rating of a relay is 5 A. PSM = 1.5, TMS = 0.4, C.T. ratio = 400/5, fault current = 6000 A. Determine the operating time of the relay. At TMS = 1, operating time at various PSM are:

PSM	2	4	5	8	10	20
Operating time in seconds	10	5	4	3	2.8	2.4

Solution C.T. ratio = 400/5 = 80

Relay current setting = 5 × 1.5 = 7.5 A

$$\text{PSM} = \frac{\text{Secondary current}}{\text{Relay current setting}}$$

$$= \frac{\text{Primary current (fault current)}}{\text{Relay current setting} \times \text{C.T. ratio}}$$

$$= \frac{6000}{7.5 \times 80} = 10$$

Operating time from the given table at PSM = 10 is 2.8s. This time is for TMS = 1. The operating time for TMS = 0.4 will be equal to $2.8 \times 0.4 = 1.12$ s.

Example 21.1. *Determine the time of operation of a 5-ampere, 3-second overcurrent relay having a current setting of 125% and a time setting multiplier of 0·6 connected to supply circuit through a 400/5 current transformer when the circuit carries a fault current of 4000 A. Use the curve shown in Fig. 21.16.*

Solution.

$$\text{Rated secondary current of C.T.} = 5 \text{ A}$$

$$\text{Pickup current} = 5 \times 1{\cdot}25 = 6{\cdot}25 \text{ A}$$

$$\text{Fault current in relay coil} = 4000 \times \frac{5}{400} = 50 \text{ A}$$

$$\therefore \quad \text{Plug-setting multiplier (P.S.M.)} = \frac{50}{6{\cdot}25} = 8$$

Corresponding to the plug-setting multiplier of 8 (See Fig. 21.16), the time of operation is 3.5 seconds.

$$\therefore \quad \text{Actual relay operating time} = 3{\cdot}5 \times \text{Time-setting} = 3{\cdot}5 \times 0{\cdot}6 = \mathbf{2{\cdot}1 \text{ seconds}}$$

Example 2.2 : *The Fig. 2.18 shows the part of a typical power system. If for the discrimination, the time grading margin between the relays is 0.6 sec, calculate the time of operation of relay 1 and time setting multiplier for relay 2. Refer to characteristics given in the Fig. 2.17. The time setting multiplier of relay 1 is 0.3.*

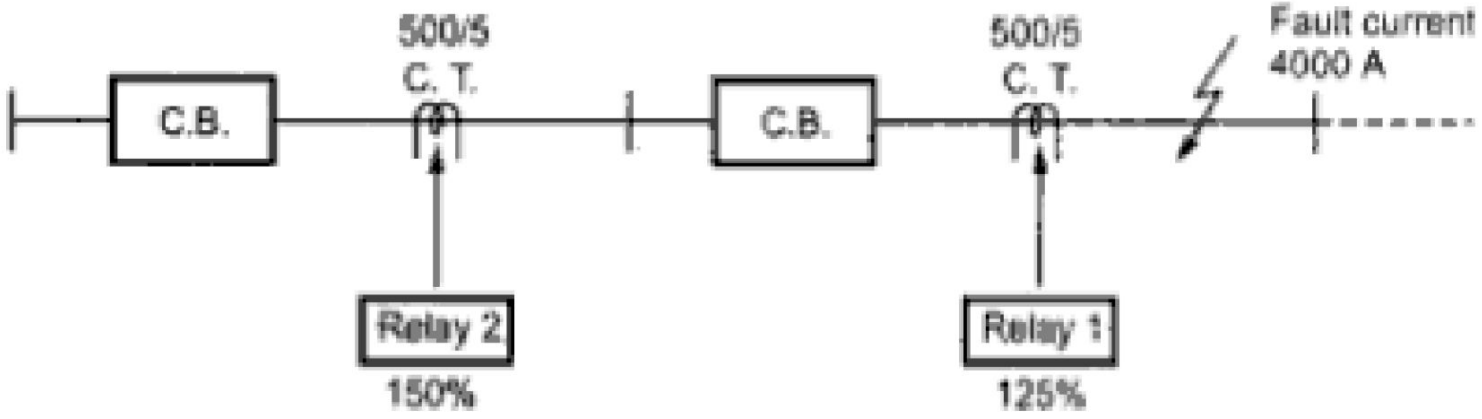


Fig. 2.18

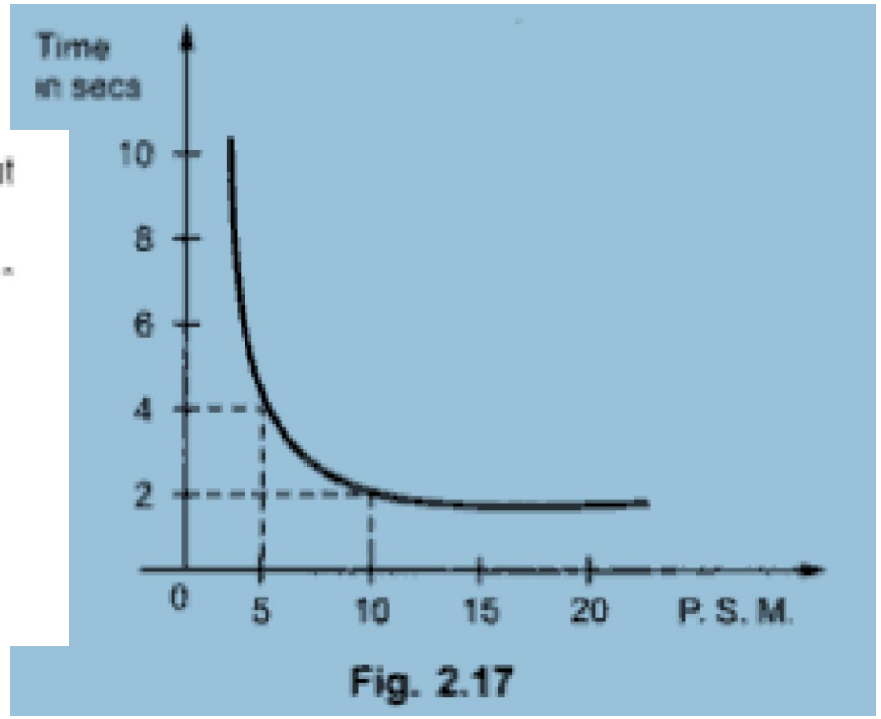


Fig. 2.17

Solution : **For relay 1 :** Current setting = 125 % = 1.25

Fault current = 4000 A

C.T. ratio = 500/5

$\therefore$ Fault current in relay coil = $4000 \times \frac{5}{500}$

= 40 A

$\therefore$ P.S.M. = $\frac{40}{5 \times 1.25} = 6.4$

From the Fig. 2.17, the corresponding time for 6.4 P.S.M. is approximately 3 sec.

$\therefore$ Actual time of operation = 3 × time setting multiplier = 3 × 0.3

= 0.9 sec

For relay 2 : Current setting = 150% = 1.5

Actual time of operation = time of operation of relay 1 + time margin

$$= 0.9 + 0.6 = 1.5 \text{ sec}$$

$$\text{Fault current} = 4000 \times \frac{5}{500} = 40 \text{ A}$$

$$\therefore \quad \text{P.S.M.} = \frac{\text{Fault current}}{\text{C.T. secondary rating} \times \text{current setting}}$$

$$= \frac{40}{5 \times 1.5} = 5.33$$

From the Fig. 2.17, the corresponding time for 5.33 P.S.M. is approximately 3.8 sec.

$$\therefore \quad \text{Time setting multiplier} = \frac{\text{Actual time of operation}}{\text{Time for P.S.M. obtained}}$$

$$= \frac{1.5}{3.8} = 0.395 \approx 0.4$$