produced by both the windings is proportional to product of voltage and the current. Mathematically we can write,

Torque produced by current coil, = $K_1 I^2$

Torque produced by voltage coil = K_2V^2

Torque produced by both the coils = $K_3VI \cos(\theta - \tau)$

where K_1, K_2 and K_3 = constant θ = angle between V and I

τ = maximum torque angle

Torque produced by control spring = K_4

The control springs are used as restraining elements

If all the elements are present in a relay then total torque produced by all the causes can be expressed by a general equation as,

$$T = K_1I^2 + K_2V^2 + K_3VI \cos(\theta - \tau) + K_4$$

This equation is called universal relay torque equation the term K_4 can be a restraining torque due to springs or gravity.

By assigning positive and negative signs to certain constants and lets other constants to be zero and sometimes by adding similar other terms, the operating characteristics equation of all the types of protective relays can be obtained from universal equation.

For example, for overcurrent relay $K_2 = K_3 = 0$ and the spring torque is negative so we get,

$$T = K_1I^2 - K_4$$

For the directional relay $K_1 = K_2 = 0$ and the spring torque is negative .

So we get,

$$T = K_3 VI \cos(\theta - \tau) - K_4$$

Review Questions

1. *Explain the operation of basic trip circuit*
2. *Explain the following schemes used in circuit breakers,*
   - *i) Relay with make type contact*
   - *ii) Relay with break type contact*
3. *Describe any one type of electromagnetic attracted armature relay*
4. *Describe with neat sketch the operation of solenoid and plunger type relay*

5. *Derive the torque equating for electromagnetic attraction relays when used for,*
   - *i) a.c. operation*
   - *ii) d.c. operation*
6. *State the advantages, disadvantages and applications of electromagnetic relays*
7. *Derive the torque equation for the induction type relays*
8. *Describe the operation of following relays with neat sketches.*
   - *i) Shaded pole type induction relay*
   - *ii) Watthour meter type induction relay*
   - *iii) Induction cup type relay*
9. *Explain with the help of a neat diagram, the construction and working of a nondirectional induction type overcurrent relay. Draw and explain its time-current characteristics.*
10. *What is I.D.M.T characteristics of a relay?*
11. *Explain the working principle of directional power relay.*
12. *What is the procedure of setting I.D.M.T. relay ? What initial data is required ? How is the directional relay different than simple I.D.M.T relay ?*
13. *Explain with the help of neat sketch, the construction and working of directional induction type overcurrent relay.*
14. *State the conditions to be satisfied by a directional relay before its operation*
15. *Draw the directional characteristics and explain what is maximum torque angle*
16. *What is universal relay torque equation ? What is its use ?*
17. *An I.D.M.T. overcurrent relay has a current setting of 150% and has a time multiplier setting of 0.5 . The relay is connected in the circuit with the help of C.T. having ratio 500 : 5 A. Calculate the time of operation of the relay if circuit carries a fault current of 6000 A. The relay characteristics are given in the Fig. 2.24.*

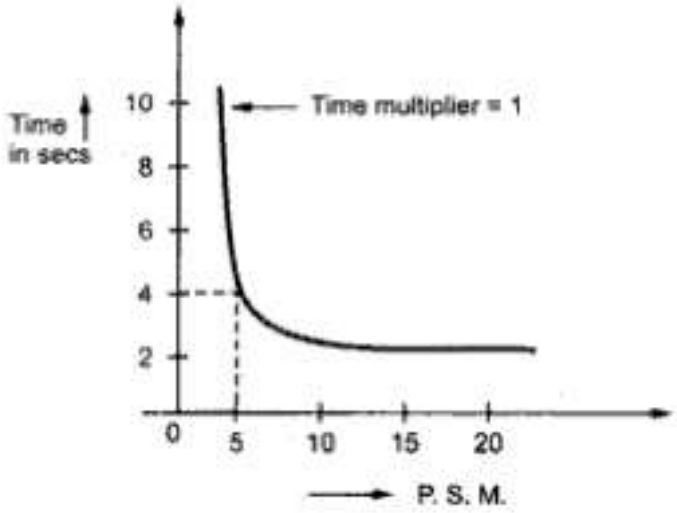

Fig. 2.24 Relay characteristics

18. *For a particular transmission line, relays are used as shown in the Fig. 2.25.*

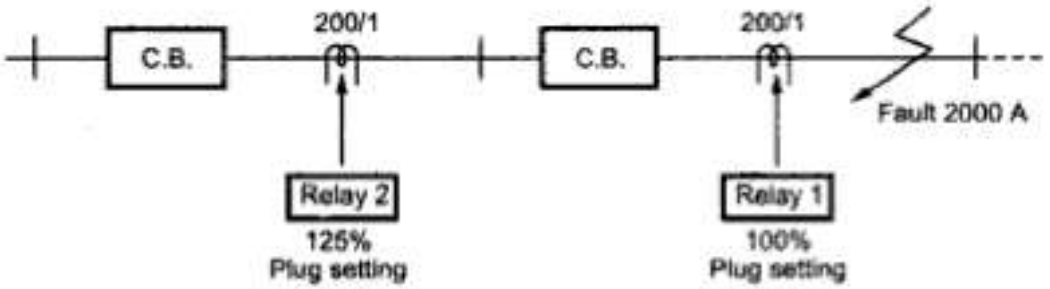

Fig. 2.25

For discrimination, the time grading margin is 0.5 sec.

Determine the time of operation of the two relays assuming that both the relays have characteristics as shown in the Fig. 2.25. The relay 1 has time setting multiplier of 0.2. Find the time setting multiplier of relay 2. **(Ans. : 0.56 sec, 1.06 sec, 0.3364)**

19. *Write a note on thermal relays.*

❑❑❑