13.5 Distributor Fed at Both Ends — Concentrated Loading

Whenever possible, it is desirable that a long distributor should be fed at both ends instead of at one end only, since total voltage drop can be considerably reduced without increasing the cross-section of the conductor. The two ends of the distributor may be supplied with (*i*) equal voltages (*ii*) unequal voltages.

(*i*) **Two ends fed with equal voltages.** Consider a distributor *AB* fed at both ends with equal voltages *V* volts and having concentrated loads I_1, I_2, I_3, I_4 and I_5 at points *C*, *D*, *E*, *F* and *G* respectively as shown in Fig. 13.14. As we move away from one of the feeding points, *say A*, p.d. goes on decreasing till it reaches the minimum value at some load point, *say E*, and then again starts rising and becomes *V* volts as we reach the other feeding point *B*.

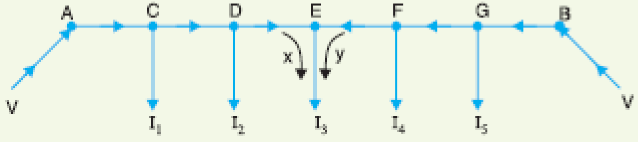

Fig. 13.14

All the currents tapped off between points *A* and *E* (minimum p.d. point) will be supplied from the feeding point *A* while those tapped off between *B* and *E* will be supplied from the feeding point *B*. The current tapped off at point *E* itself will be partly supplied from *A* and partly from *B*. If these currents are *x* and *y* respectively, then,

$$I_3 = x + y$$

Therefore, we arrive at a very important conclusion that at the point of minimum potential, current comes from both ends of the distributor.

Point of minimum potential. It is generally desired to locate the point of minimum potential. There is a simple method for it. Consider a distributor AB having three concentrated loads I_1, I_2 and I_3 at points C, D and E respectively. Suppose that current supplied by feeding end A is I_A. Then current distribution in the various sections of the distributor can be worked out as shown in Fig. 13.15 (*i*). Thus

$$I_{AC} = I_A \, ; \qquad I_{CD} = I_A - I_1$$

$$I_{DE} = I_A - I_1 - I_2 \, ; \qquad I_{EB} = I_A - I_1 - I_2 - I_3$$

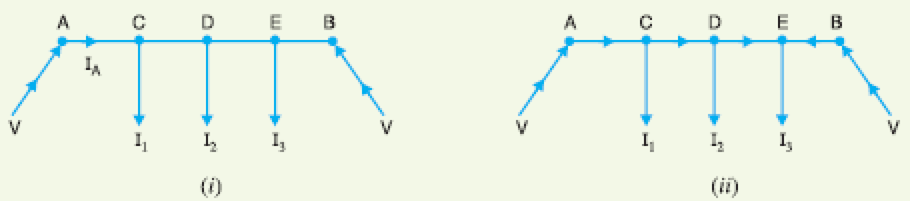

Fig. 13.15

Voltage drop between A and B = Voltage drop over AB

or $\quad V - V = I_A R_{AC} + (I_A - I_1) R_{CD} + (I_A - I_1 - I_2) R_{DE} + (I_A - I_1 - I_2 - I_3) R_{EB}$

From this equation, the unknown I_A can be calculated as the values of other quantities are generally given. Suppose *actual* directions of currents in the various sections of the distributor are indicated as shown in Fig. 13.15 (*ii*). The load point where the currents are coming from both sides of the distributor is the point of minimum potential *i.e.* point E in this case

(*ii*) **Two ends fed with unequal voltages.** Fig. 13.16 shows the distributor AB fed with unequal voltages ; end A being fed at V_1 volts and end B at V_2 volts. The point of minimum potential can be found by following the same procedure as discussed above. Thus in this case,

Voltage drop between A and B = Voltage drop over AB

or $\quad V_1 - V_2$ = Voltage drop over AB

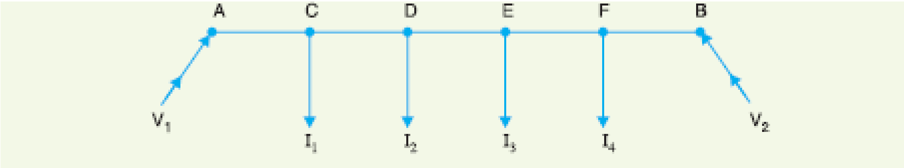

Fig. 13.16

Example 13.10. *A 2-wire d.c. street mains AB, 600 m long is fed from both ends at 220 V. Loads of 20 A, 40 A, 50 A and 30 A are tapped at distances of 100m, 250m, 400m and 500 m from the end A respectively. If the area of X-section of distributor conductor is 1cm², find the minimum consumer voltage. Take* $\rho = 1{\cdot}7 \times 10^{-6}\ \Omega$ *cm.*

Solution. Fig. 13.17 shows the distributor with its tapped currents. Let I_A amperes be the current supplied from the feeding end A. Then currents in the various sections of the distributor are as shown in Fig. 13.17.

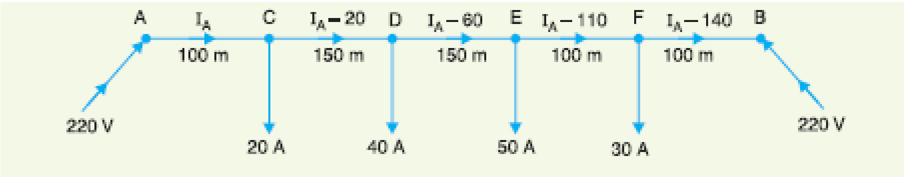

Fig. 13.17

Resistance of 1 m length of distributor

$$= 2 \times \frac{1{\cdot}7 \times 10^{-6} \times 100}{1} = 3{\cdot}4 \times 10^{-4}\ \Omega$$

Resistance of section AC, R_{AC} $= (3{\cdot}4 \times 10^{-4}) \times 100 = 0{\cdot}034\ \Omega$

Resistance of section CD, R_{CD} $= (3{\cdot}4 \times 10^{-4}) \times 150 = 0{\cdot}051\ \Omega$

Resistance of section DE, R_{DE} $= (3{\cdot}4 \times 10^{-4}) \times 150 = 0{\cdot}051\ \Omega$

Resistance of section EF, R_{EF} $= (3{\cdot}4 \times 10^{-4}) \times 100 = 0{\cdot}034\ \Omega$

Resistance of section FB, R_{FB} $= (3{\cdot}4 \times 10^{-4}) \times 100 = 0{\cdot}034\ \Omega$

Voltage at B = Voltage at A − Drop over length AB

or $$V_B = V_A - [I_A R_{AC} + (I_A - 20) R_{CD} + (I_A - 60) R_{DE} + (I_A - 110) R_{EF} + (I_A - 140) R_{FB}]$$

or $$220 = 220 - [0{\cdot}034\, I_A + 0{\cdot}051\,(I_A - 20) + 0{\cdot}051\,(I_A - 60) + 0{\cdot}034\,(I_A - 110) + 0{\cdot}034\,(I_A - 140)]$$

$$= 220 - [0{\cdot}204\, I_A - 12{\cdot}58]$$

or $$0{\cdot}204\, I_A = 12{\cdot}58$$

∴ $$I_A = 12{\cdot}58/0{\cdot}204 = 61{\cdot}7 \text{ A}$$

The *actual distribution of currents in the various sections of the distributor is shown in Fig. 13.18. It is clear that currents are coming to load point E from both sides *i.e.* from point D and point F. Hence, E is the point of minimum potential.

∴ Minimum consumer voltage,

$$V_E = V_A - [I_{AC} R_{AC} + I_{CD} R_{CD} + I_{DE} R_{DE}]$$

Example 13.11. *A 2-wire d.c. distributor AB is fed from both ends. At feeding point A, the voltage is maintained as at 230 V and at B 235 V. The total length of the distributor is 200 metres and loads are tapped off as under :*

25 A at 50 metres from A ; 50 A at 75 metres from A

30 A at 100 metres from A ; 40 A at 150 metres from A

The resistance per kilometre of one conductor is 0·3 Ω. Calculate :

(i) currents in various sections of the distributor

(ii) minimum voltage and the point at which it occurs

Solution. Fig. 13.19 shows the distributor with its tapped currents. Let I_A amperes be the current supplied from the feeding point A. Then currents in the various sections of the distributor are as shown in Fig 13.19.

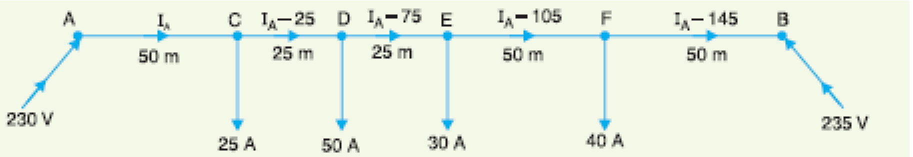

Fig. 13.19

Resistance of 1000 m length of distributor (both wires)

$$= 2 \times 0{\cdot}3 = 0{\cdot}6\ \Omega$$

Resistance of section AC, $R_{AC} = 0{\cdot}6 \times 50/1000 = 0{\cdot}03\ \Omega$

Resistance of section CD, $R_{CD} = 0{\cdot}6 \times 25/1000 = 0{\cdot}015\ \Omega$

Resistance of section DE, $R_{DE} = 0{\cdot}6 \times 25/1000 = 0{\cdot}015\ \Omega$

Resistance of section EF, $R_{EF} = 0{\cdot}6 \times 50/1000 = 0{\cdot}03\ \Omega$

Resistance of section FB, $R_{FB} = 0{\cdot}6 \times 50/1000 = 0{\cdot}03\ \Omega$

Voltage at B = Voltage at A – Drop over AB

or
$$V_B = V_A - [I_A R_{AC} + (I_A - 25) R_{CD} + (I_A - 75) R_{DE} + (I_A - 105) R_{EF} + (I_A - 145) R_{FB}]$$

or
$$235 = 230 - [0{\cdot}03\, I_A + 0{\cdot}015\,(I_A - 25) + 0{\cdot}015\,(I_A - 75) + 0{\cdot}03\,(I_A - 105) + 0{\cdot}03\,(I_A - 145)]$$

or
$$235 = 230 - [0{\cdot}12\, I_A - 9]$$

$\therefore$
$$I_A = \frac{239 - 235}{0{\cdot}12} = 33{\cdot}34\ \text{A}$$

(*i*) $\therefore$ Current in section AC, $I_{AC} = I_A =$ **33·34 A**

Current in section CD, $I_{CD} = I_A - 25 = 33{\cdot}34 - 25 =$ **8·34 A**