Example 13.5. *A 2-wire d.c. distributor 200 metres long is uniformly loaded with 2A/metre. Resistance of single wire is 0·3 Ω/km. If the distributor is fed at one end, calculate :*

(*i*) *the voltage drop upto a distance of 150 m from the feeding point*

(*ii*) *the maximum voltage drop*

Solution.

Current loading, $i = 2$ A/m

Resistance of distributor per metre run,

$$r = 2 \times 0{\cdot}3/1000 = 0{\cdot}0006\ \Omega$$

Length of distributor, $l = 200$ m

(*i*) Voltage drop upto a distance x metres from feeding point

$$= i\,r\left(l\,x - \frac{x^2}{2}\right) \qquad \text{[See Art. 13·4]}$$

Here, $x = 150$ m

$\therefore$ Desired voltage drop $= 2 \times 0{\cdot}0006\left(200 \times 150 - \dfrac{150 \times 150}{2}\right) =$ **22·5 V**

(*ii*) Total current entering the distributor,

$$I = i \times l = 2 \times 200 = 400 \text{ A}$$

Total resistance of the distributor,

$$R = r \times l = 0{\cdot}0006 \times 200 = 0{\cdot}12\ \Omega$$

$\therefore$ Total drop over the distributor

$$= \frac{1}{2}\,I\,R = \frac{1}{2} \times 400 \times 0{\cdot}12 = \textbf{24 V}$$

Example 13.6. *A uniform 2-wire d.c. distributor 500 metres long is loaded with 0.4 ampere/metre and is fed at one end. If the maximum permissible voltage drop is not to exceed 10 V, find the cross-sectional area of the distributor conductor. Take $\rho = 1{\cdot}7 \times 10^{-6}\ \Omega$ cm.*

Solution.

Current entering the distributor, $I = i \times l = 0{\cdot}4 \times 500 = 200$ A

Max. permissible voltage drop $= 10$ V

Let r ohm be the resistance per metre length of the distributor (both wires).

Max. voltage drop $= \frac{1}{2} I R$

or $10 = \frac{1}{2} I r l$ $\quad [\because R = r\,l]$

or $$r = \frac{2 \times 10}{I \times l} = \frac{2 \times 10}{200 \times 500} = 0{\cdot}2 \times 10^{-3}\ \Omega$$

$\therefore$ Area of cross-section of the distributor conductor is

$$a = \frac{\rho\, l}{r/2} = \frac{1{\cdot}7 \times 10^{-6} \times 100^{*} \times 2}{0{\cdot}2 \times 10^{-3}} = 1{\cdot}7\ \text{cm}^2$$

Example 13.7. *A 250 m, 2-wire d.c. distributor fed from one end is loaded uniformly at the rate of 1·6 A/metre. The resistance of each conductor is 0·0002 Ω per metre. Find the voltage necessary at feed point to maintain 250 V (i) at the far end (ii) at the mid-point of the distributor.*

Solution.

Current loading, $i = 1\cdot6 \text{ A/m}$

Current entering the distributor, $I = i \times l = 1\cdot6 \times 250 = 400 \text{ A}$

Resistance of the distributor per metre run

$$r = 2 \times 0\cdot0002 = 0\cdot0004 \ \Omega$$

Total resistance of distributor, $R = r \times l = 0\cdot0004 \times 250 = 0\cdot1 \ \Omega$

(*i*) Voltage drop over the entire distributor

$$= \frac{1}{2} I R = \frac{1}{2} \times 400 \times 0\cdot1 = 20 \text{ V}$$

∴ Voltage at feeding point $= 250 + 20 =$ **270 V**

(*ii*) Voltage drop upto a distance of x metres from feeding point

$$= i\, r \left(l\, x - \frac{x^2}{2} \right)$$

Here $x = l/2 = 250/2 = 125$ m

∴ Voltage drop $= 1\cdot6 \times 0\cdot0004 \left(250 \times 125 - \frac{(125)^2}{2} \right) = 15 \text{ V}$

∴ Voltage at feeding point $= 250 + 15 =$ **265 V**

Example 13.8. *Derive an expression for the power loss in a uniformly loaded distributor fed at one end.*

Solution. Fig. 13.13 shows the single line diagram of a 2-wire d.c. distributor *AB* fed at end *A* and loaded uniformly with *i* amperes per metre length.

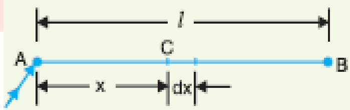

Fig. 13.13

Let l = length of the distributor in metres

r = resistance of distributor (both conductors) per metre run

Consider a small length *dx* of the distributor at point *C* at a distance x from the feeding end *A*. The small length *dx* will carry current which is tapped in the length *CB*.

∴ Current in $dx = i\,l - i\,x = i\,(l - x)$

$$\text{Power loss in length } dx = (\text{current in length } dx)^2 \times \text{Resistance of length } dx$$
$$= [i\,(l - x)]^2 \times r\,dx$$

Total power loss P in the whole distributor is

$$P = \int_0^l [i\,(l - x)]^2\, r\,dx = \int_0^l i^2 \left(l^2 + x^2 - 2\,lx\right) r\,dx$$

$$= i^2 r \int_0^l \left(l^2 + x^2 - 2\,lx\right) dx = i^2 r \left[l^2 x + \frac{x^3}{3} - \frac{2lx^2}{2}\right]_0^l$$

$$= i^2 r \left[l^3 + \frac{l^3}{3} - l^3\right] = i^2 \times \frac{r\,l^3}{3}$$

$$\therefore \quad P = \frac{i^2\, r\, l^3}{3}$$

Example 13.9. *Calculate the voltage at a distance of 200 m of a 300 m long distributor uniformly loaded at the rate of 0.75 A per metre. The distributor is fed at one end at 250 V. The resistance of the distributor (go and return) per metre is 0·00018 Ω. Also find the power loss in the distributor.*

Solution.

Voltage drop at a distance x from supply end

$$= i\,r\left(l\,x - \frac{x^2}{2}\right)$$

Here $i = 0{\cdot}75$ A/m; $l = 300$ m ; $x = 200$ m ; $r = 0{\cdot}00018$ Ω/m

$$\therefore \quad \text{Voltage drop} = 0{\cdot}75 \times 0{\cdot}00018 \left[300 \times 200 - \frac{(200)^2}{2}\right] = 5.4 \text{ V}$$

Voltage at a distance of 200 m from supply end

$$= 250 - 5{\cdot}4 = \mathbf{244{\cdot}6\ V}$$

Power loss in the distributor is

$$P = \frac{i^2\, r\, l^3}{3} = \frac{(0{\cdot}75)^2 \times 0{\cdot}00018 \times (300)^3}{3} = \mathbf{911{\cdot}25\ W}$$