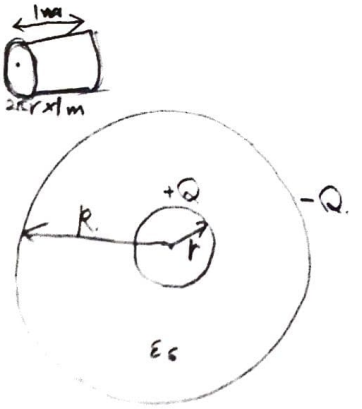
[S61. 送3]

(1) ケーブルを同心円筒と考え、単位長当たり導体に $+Q_{(C)}$、シースに $-Q_{(C)}$ 電荷が分布しているとすると $\int E\,dS = \frac{Q}{\varepsilon_0\varepsilon_s}$



$$2\pi r \times 1\,m \cdot E = \frac{Q}{\varepsilon_0\varepsilon_s} \qquad E = \frac{Q}{2\pi r \varepsilon_0\varepsilon_s}$$

電位差は

$$V = -\int_R^r \frac{Q}{2\pi r\varepsilon_0\varepsilon_s}\,dr = -\frac{Q}{2\pi\varepsilon_0\varepsilon_s}\left[\log r\right]_R^r = \frac{Q}{2\pi\varepsilon_0\varepsilon_s}\log\frac{R}{r}$$

ケーブル1相当たりの対地静電容量 C は

$$C = \frac{Q}{V} = \frac{2\pi\varepsilon_0\varepsilon_s}{\log\frac{R}{r}}\ [F/m] = 2\pi \times \frac{1}{4\pi\times 9\times 10^9} \times 3.7 \cdot \frac{1}{\log\frac{40\times10^{-3}}{25\times10^{-3}}} = \frac{37}{12\times10^9}\cdot\frac{1}{\log 1.6}$$

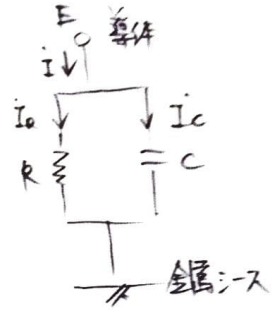
$$= 0.44\times10^{-9}\ F/m = 0.44\ [\mu F/km] \quad //$$

(2) 右図のような等価回路で考えれば、

E: 導体の対地電位 (V)

C: ケーブル単位長の対地静電容量 (F/m)

R: 〃 絶縁抵抗 (Ω)



$C = \varepsilon_0\varepsilon_s \frac{S}{d}$

$R = \rho \frac{d}{S} \leftarrow l$

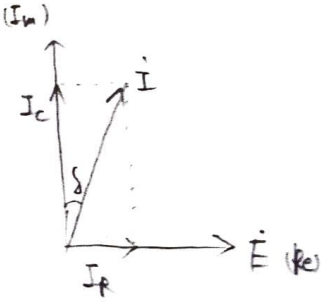
$CR = \varepsilon_0\varepsilon_s\rho$

$CR = \varepsilon\varepsilon_0\rho$ より $\quad \rho = \frac{\varepsilon\varepsilon_0\rho}{C} = \frac{\varepsilon\varepsilon_0\rho}{2\pi\varepsilon_0\varepsilon_s}\log\frac{R}{r} = \frac{\rho}{2\pi}\log\frac{R}{r}$

$I_c = j\omega C E \qquad I_R = \frac{E}{R}$ より $\tan\delta = \frac{I_R}{I_c}$

誘電損 [W/cm] はジュール熱より

$$W = I_R E = I_c \tan\delta \times E = \omega C \tan\delta E^2$$



ここで $\tan\delta = \frac{E/R}{\omega C E} = \frac{1}{\omega C R} = \frac{1}{2\pi\times50\times\frac{2\pi\varepsilon_0\varepsilon_s}{\log\frac{R}{r}}\times\frac{\rho}{2\pi}\log\frac{R}{r}} = \frac{1}{2\pi\times50\times\varepsilon_0\varepsilon_s\times\rho}$

$$= \frac{1}{100\pi\times\frac{1}{4\pi\times9\times10^9}\times37\times10^{14}\times\frac{1}{10^2}\ [\Omega\cdot m]} = 9.7\times10^{-5} \quad //$$

$10^{14}\ (\Omega\cdot cm) \Rightarrow \times\frac{1}{10^2}$ (考え方: $\Omega/cm \rightarrow \Omega/m \times 10^2$)

$$\therefore W = 2\pi\times50\times0.44\times10^{-9}\times9.7\times10^{-5}\times\left(\frac{275\times10^3}{\sqrt{3}}\right)^2 = 0.938\ [W/m] = 3.4\times10^{-3}\ [W/cm] \quad //$$

(3) 充相電力 P_0 有効電力 P 無効電力 Q とすれば

$P_0^2 = P^2 + Q^2 \qquad Q = \sqrt{P_0^2 - P^2}$ (W) が最大となる

$$Q = 3\times I_c \times V/\sqrt{3} = 3\times\omega C l (V/\sqrt{3})^2 = \sqrt{P_0^2 - P^2}$$

$$\therefore l = \frac{\sqrt{P_0^2 - P^2}}{3\omega C (V/\sqrt{3})^2} = \frac{\sqrt{(300\times10^6)^2 - (200\times10^6)^2}}{3\times2\pi\times50\times0.44\times10^{-9}\ F/m\times\left(\frac{275\times10^3}{\sqrt{3}}\right)^2} = \frac{223.607\times10^6}{10453.649}$$

$$\fallingdotseq 21390.33\ m \fallingdotseq 21\ [km]\ \text{まで可能} \quad //$$