电压降及功率损耗的习题

1、一回 220kV 输电线路，长为 150km，单位长度的电阻、电抗分别为：0.131Ω/km，0.394Ω/km。已知线路始端电压为 225kV，始端流入线路的复功率为 $S_1 = 100 + \mathrm{j}20\ \mathrm{MVA}$ 。采用有名值进行以下计算。一、计算电压降的纵向分量、横向分量和末端电压的幅值和相角（相位角用度）并画出相量图（示意即可）；二、忽略电压降的横向分量，计算末端电压的幅值并画出相量图；三、计算末端负荷 S_2；四、送端有功率不变，若无功从 20Mvar 增加到 40Mvar，计算输电线电压降的纵向分量、横向分量和末端电压的幅值和相角以及末端负荷。

解：

$R = 150 \times 0.131 = 19.65\ \Omega$

$X = 150 \times 0.394 = 59.1\ \Omega$

$$\mathrm{d}\dot{U} = \frac{PR + QX}{U} + \mathrm{j}\frac{PX - QR}{U} = \frac{19.65P + 59.1Q}{225} + \mathrm{j}\frac{59.1P - 19.65Q}{225}$$

$$= \frac{19.65 \times 100 + 59.1 \times 20}{225} + \mathrm{j}\frac{59.1 \times 100 - 19.65 \times 20}{225}$$

=13.987+24.52j kV

所以 $\mathrm{d}\dot{U} = \Delta U + \mathrm{j}\delta U = 13.987 + \mathrm{j}24.52$ kV

$\dot{U}_2 = \dot{U}_1 - \mathrm{d}\dot{U} = 225 - 13.987 - \mathrm{j}24.52 = 211.013 - \mathrm{j}24.52 = 212.433\angle(-6.628^{\circ})$ kV

忽略横向分量时为 $U_2 = 225 - 13.987 = 211.013$ kV

串联损耗

$$\Delta S_z = \frac{P^2 + Q^2}{U^2}(R + \mathrm{j}X) = \frac{100^2 + 20^2}{225^2}(19.65 + \mathrm{j}59.1) = 0.205 \times (19.65 + \mathrm{j}59.1) = 4.037 + \mathrm{j}12.116\ \mathrm{MVA}$$

$$S_2 = S_1 - \Delta S_z = 100 + \mathrm{j}20 - (4.037 + \mathrm{j}12.116) = 95.963 + \mathrm{j}7.885\ \mathrm{MVA}$$

无功为 40Mvar 时，

$$\mathrm{d}\dot{U} = \frac{19.65 \times 100 + 59.1 \times 40}{225} + \mathrm{j}\frac{59.1 \times 100 - 19.65 \times 40}{225} = 19.24 + \mathrm{j}22.773$$

$\dot{U}_2 = \dot{U}_1 - \mathrm{d}\dot{U} = 225 - (19.24 + \mathrm{j}22.773) = 205.76 - \mathrm{j}22.773 = 207.016\angle(-6.316^{\circ})$ kV

$$\Delta S_z = \frac{P^2 + Q^2}{U^2}(R + \mathrm{j}X) = \frac{100^2 + 40^2}{225^2}(19.65 + \mathrm{j}59.1) = 0.229 \times (19.65 + \mathrm{j}59.1) = 4.503 + \mathrm{j}13.534\ \mathrm{MVA}$$

$$S_2 = S_1 - \Delta S_z = 100 + \mathrm{j}40 - (4.503 + \mathrm{j}13.534) = 95.497 + \mathrm{j}26.466\ \mathrm{MVA}$$

2、输电线路如上题，但现在考虑对地电纳，设线路的单位长度电纳为 2.89μs/km。求始、末端电压分别为 225kV 和 $215\angle(-6^{\circ})$ 时该输电线路的总功率损耗（采用有名值计算）。

解：

并联损耗为 $\Delta S_y = \Delta S_y + \Delta S_y = -\mathrm{j}\frac{1}{2} \times 150 \times 2.89 \times 10^{-6} \times (225^2 + 215^2) = -\mathrm{j}20.9922$ Mvar

串联损耗为

$$\Delta S_z = \sqrt{3}\dot{U}_z \dot{I}^* = \sqrt{3}(\dot{U}_1 - \dot{U}_2)\left(\frac{\dot{U}_1 - \dot{U}_2}{\sqrt{3}Z}\right)^* = \frac{\left|\dot{U}_1 - \dot{U}_2\right|^2}{Z^*} =$$

$$= \frac{\left|225 - 215\angle(-6^o)\right|^2}{19.65 - \text{j}59.1} = \frac{\left|225 - (213.822 + \text{j}22.474)\right|^2}{62.281\angle(-71.61^o)} =$$

$$= \frac{\left|11.178 - \text{j}22.474\right|^2}{62.281\angle(-71.61^o)} = \frac{25.1^2}{62.281\angle(-71.61^o)} =$$

$$= 10.116\angle 71.61^o = 3.191 + \text{j}9.599 \text{ MVA}$$

$$\Delta S = \Delta S_y + \Delta S_z = -\text{j}20.9922 + 3.191 + \text{j}9.599 = 3.191 - \text{j}11.3932 \text{ MVA}$$