Hanoi University of Science and Technology	Final Examination		
	Course: **Power Distribution System**	Duration: 90min	No. 1

Item 1 (2 points). Analyse advantages and disadvantages of distribution network configurations and bus schemes at substations and their applications.

Item 2 (4 points). Allocate kVAr compensation in the 10kV industrial distribution system as shown in Fig. 1. Followings are concerned parameters:

r_1 = 0.03Ω ; Q_1 = 600kVAr
r_2 = 0.06Ω ; Q_2 = 500kVAr
r_3 = 0.04Ω ; Q_4 = 400kVAr
r_4 = 0.04Ω ; Q_5 = 250kVAr
r_5 = 0.08Ω ; Q_6 = 50kVAr
r_6 = 0.08Ω ;

Total allocated compensation: Q_c = 1000kVAr.

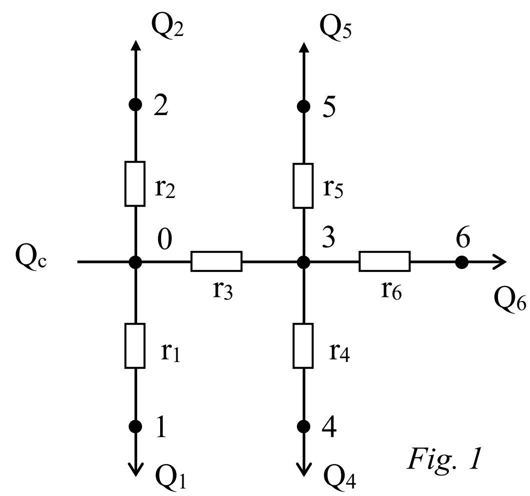


Fig. 1

Item 3 (4 points). Consider a distribution network feeding two factories as Fig. 2. Followings are related parameters

- Factory demands

  S_1 = 1500kVA, $\cos\varphi_1$ = 0.8

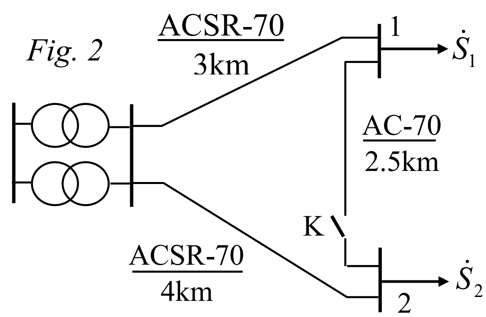
  S_2 = 3000kVA, $\cos\varphi_2$ = 0.6

- OHL, ACSR-70 conductor, r_o = 0.46Ω/km, x_o = 0.38Ω/km
- Distribution substation, two transformers 35/10kV with following ratings

  S_r = 4000kVA

  ΔP_o = 12.5kW, ΔP_I = 42kW

Fig. 2



Maximum loss hours of 4000 hour is applicable for both two loads.

Question 1. Determine annual energy loss of the whole distribution network in the case of opening switch K.

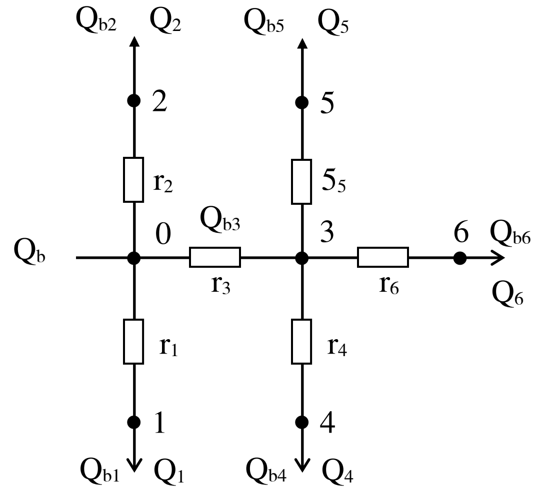
Question 2. In the case of closing switch K, how does the voltage of bus 2 change, given the operating voltage at the 10kV bus of distribution substation is 10.5kV?

Notes : Open-book exam.

Solution :

<u>Item 2 (4 points):</u>

$r_1 = 0{,}03\Omega$; $Q_1 = 600$ kVAr
$r_2 = 0{,}06\Omega$; $Q_2 = 500$ kVAr
$r_3 = 0{,}04\Omega$; $Q_4 = 400$ kVAr
$r_4 = 0{,}04\Omega$; $Q_5 = 250$ kVAr
$r_5 = 0{,}08\Omega$; $Q_6 = 50$ kVAr
$r_6 = 0{,}08\Omega$;
compensation amount of : $Q_b = 1000$kVAr



Solve

$Q_{03} = Q_4 + Q_5 + Q_6 = 700$kVAr
$Q = Q_{03} + Q_1 + Q_2 = 1800$kVAr
$R_{tđ1} = r_4//r_5//r_6 = 0{,}02\Omega$
$r_{03} = R_{tđ1} + r_3 = 0{,}06\Omega$
$R_{tđ} = r_{03}//r_1//r_2 = 0{,}015\Omega$

$$Q_{b1} = Q_1 - \frac{(Q - Q_b).R_{tđ}}{r_1} = 600 - \frac{(1800 - 1000).0{,}015}{0{,}03} = \underline{200\text{kVAr}}$$

$$Q_{b2} = Q_2 - \frac{(Q - Q_b).R_{tđ}}{R_2} = 500 - \frac{(1800 - 1000).0{,}015}{0{,}06} = \underline{300\text{kVAr}}$$

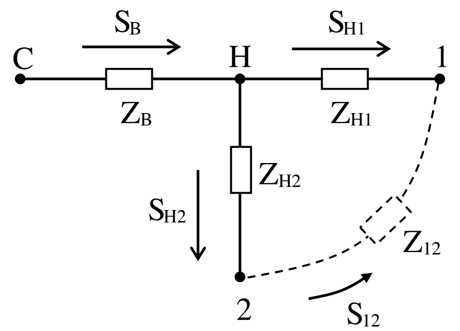
$$Q_{b3} = Q_b - Q_{b1} - Q_{b2} = 1000 - 200 - 300 = 500\text{kVAr}$$

$$Q_{b4} = Q_4 - \frac{(Q_{03} - Q_{b3}).R_{tđ1}}{r_4} = 400 - \frac{(700 - 500).0{,}02}{0{,}04} = \underline{300\text{kVAr}}$$

$$Q_{b5} = Q_5 - \frac{(Q_{03} - Q_{b3}).R_{tđ1}}{r_5} = 250 - \frac{(700 - 500).0{,}02}{0{,}08} = \underline{200\text{kVAr}}$$

$$Q_{b6} = Q_6 - \frac{(Q_{03} - Q_{b3}).R_{tđ1}}{r_6} = 50 - \frac{(700 - 500).0{,}02}{0{,}08} = \underline{0\text{kVAr}}$$

<u>Item 3 (4 points) :</u>



$Z_{H1} = r_o.l_{H1} + j\ x_o.l_{H1} = 0{,}46.3 + j\ 0{,}38.3 = 1{,}38 + j.1{,}14\Omega$

$Z_{H2} = r_o.l_{H2} + j\ x_o.l_{H2} = 0{,}46.4 + j\ 0{,}38.4 = 1{,}84 + j.1{,}52\Omega$

$Z_{12} = r_o.l_{12} + j\ x_o.l_{12} = 0{,}46.2{,}5 + j0{,}38.2{,}5 = 1{,}15 + j0{,}95\Omega$

$S_1 = P_1+jQ_1 = 2000.0{,}8+j2000.0{,}6=1600+j1200$ kVA

$S_2 = P_2+jQ_2 = 3000.0{,}6+j3000.0{,}8=1800+j2400$ kVA

$\tau = (0{,}124+T_{max}.10^{-4})^2.8760 = (0{,}124+5000.10^{-4})^2.8760 = 3410$(hour)

*1. **K open***

$\dot{S}_{H1} = \dot{S}_1 = \underline{1200 + j900(kVA)}$

$\dot{S}_{H2} = \dot{S}_2 = \underline{1800 + j2400(kVA)}$

$\dot{S}_B = \dot{S}_1 + \dot{S}_2 = \underline{3000 + j3300(kVA)}$

$$\Delta P_{H1} = \frac{\left(P_1^2 + Q_1^2\right)}{U_{dm}^2}.R_1 = \frac{\left(1200^2 + 900^2\right)}{10^2}.1{,}38.10^{-3} = 31{,}05kW$$

$\Delta A_{H1} = \Delta P_{H1}.\tau = 31{,}05.\ 2405 =$ **<u>74675 kWh/year</u>**

$$\Delta P_{H2} = \frac{\left(P_2^2 + Q_2^2\right)}{U_{dm}^2}.R_2 = \frac{\left(1800^2 + 2400^2\right)}{10^2}.1{,}84.10^{-3} = 165{,}6kW$$

$\Delta A_{H2} = \Delta P_{H2}.\tau = 165{,}6.2405 =$ **<u>389268kWh/year</u>**

$$S_B = \sqrt{P_B^2 + Q_B^2} = \sqrt{3000^2 + 3300^2} = 4460kVA$$

$$\Delta P_B = N_B.\Delta P_{oB} + \frac{1}{N_B}.\left(\frac{S_B}{S_{dmB}}\right)^2.\Delta P_{nB} = 2.12{,}5 + \frac{1}{2}.\left(\frac{4460}{4000}\right)^2.42 = 51{,}11kW$$

$$\Delta A_B = N_B.\Delta P_{oB}.T_{nam} + \frac{1}{N_B}.\left(\frac{S_B}{S_{dmB}}\right)^2.\Delta P_{nB}.\tau = 2.12{,}5.8760 + \frac{1}{2}.\left(\frac{4460}{4000}\right)^2.42.2405 = 281789kWh$$

$\Delta A = \Delta A_{H1} + \Delta A_{H2} + \Delta A_B = 74675+389268+281789=$ **<u>745732kWh/year</u>**

$$\Delta U_{H2} = \frac{P_2.R_{H2} + Q_2.X_{H2}}{U_{dm}} = \frac{1800.1{,}84 + 2400.1{,}52}{10}.10^{-3} = 0{,}696kV$$

$U_2 = U_H - \Delta U_{H2} = 10{,}5 - 0{,}696 = \underline{9{,}804kV}$

2. ***K close***

$$\dot{S}'_{H2} = \frac{\dot{S}_2.(Z_{12}+Z_{H1})+\dot{S}_1.Z_{H1}}{Z_{H1}+Z_{12}+Z_{H2}} = \frac{\dot{S}_2.(l_{12}+l_{H1})+\dot{S}_1.l_{H1}}{l_{H1}+l_{12}+l_{H2}}$$

$$\dot{S}'_{H2} = \frac{(1800+j2400).5,5+(1200+j900).3}{9,5} = \underline{1421,05+j1673,68kVA}$$

$$\Delta U'_{H2} = \frac{P'_{H2}.R_{H2}+Q'_{H2}.X_{H2}}{U_{dm}} = \frac{1421,05.1,84+1673,68.1,52}{10}.10^{-3} = 0,516kV$$

Vậy $U'_2 = U_H - \Delta U'_{H2} = 10,5-0,516 = 9,984kV$

Therefore, K close the voltage at node 2 increase from **9,804kV** to **9,984kV**.

Hanoi University of Science and Technology	**Final Examination**		
	Course: **Power Distribution System**	Duration: 90min	No. 1

Item 1. Analyze advantages and disadvantages of distribution network configurations and bus schemes at substations and their applications.

Item 2. Allocate kVAr compensation in the 10kV industrial distribution system as shown in Fig. 1. Followings are concerned parameters:

$r_1 = 0.03\Omega$; $Q_1 = 600$kVAr
$r_2 = 0.06\Omega$; $Q_2 = 500$kVAr
$r_3 = 0.04\Omega$; $Q_4 = 400$kVAr
$r_4 = 0.04\Omega$; $Q_5 = 250$kVAr
$r_5 = 0.08\Omega$;

Total allocated compensation: $Q_c = 1000$kVAr.

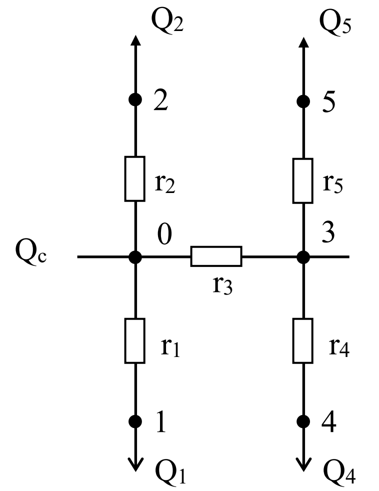


Fig. 1

Item 3. Consider a distribution network feeding two factories as Fig. 2. Followings are related parameters

- Factory demands

$S_1 = 2000$kVA, $\cos\varphi_1 = 0.8$

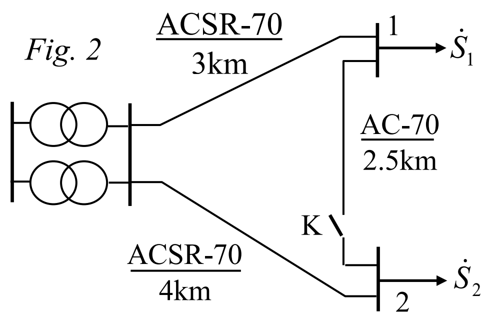
$S_2 = 3000$kVA, $\cos\varphi_2 = 0.6$

- OHL, ACSR-70 conductor, $r_o = 0.46\Omega$/km, $x_o = 0.38\Omega$/km
- Distribution substation, two transformers 35/10kV with following ratings

$S_r = 4000$kVA

$\Delta P_o = 12.5$kW, $\Delta P_I = 42$kW

Fig. 2



Maximum loss hours of 5000 hour is applicable for both two loads.

Question 1. Determine annual energy loss of the whole distribution network in the case of opening switch K.

Question 2. In the case of closing switch K, how does the voltage of bus 2 change, given the operating voltage at the 10kV bus of distribution substation is 10.5kV?

Notes : Open-book exam.

Hanoi University of Science and Technology	**Final Examination**		
	Course: **Power Distribution System**	Duration: 90min	No. 2

Item 1. Analyze advantages and disadvantages of distribution network configurations and bus schemes at substations and their applications.

Item 2. Allocate kVAr compensation in the 10kV industrial distribution system as shown in Fig. 1. Followings are concerned parameters:

$r_1 = 0.03\Omega$; $Q_1 = 600$kVAr

$r_2 = 0.06\Omega$; $Q_2 = 500$kVAr

$r_3 = 0.04\Omega$; $Q_4 = 400$kVAr

$r_4 = 0.04\Omega$; $Q_5 = 50$kVAr

$r_5 = 0.08\Omega$;

Total allocated compensation: $Q_c = 1000$kVAr.

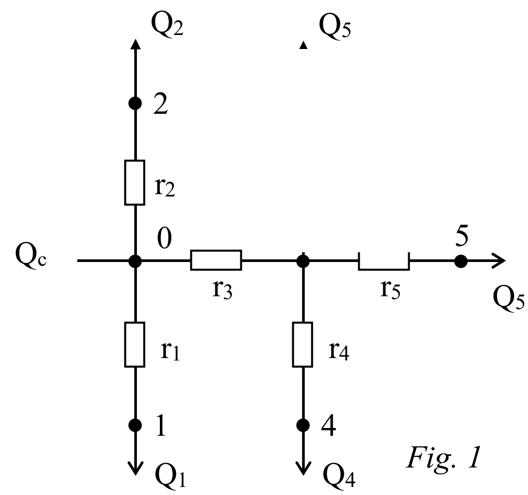


Fig. 1

Item 3. Consider a distribution network feeding two factories as Fig. 2. Followings are related parameters

- Factory demands

  $S_1 = 3000$kVA, $\cos\varphi_1 = 0.8$

  $S_2 = 4000$kVA, $\cos\varphi_2 = 0.6$

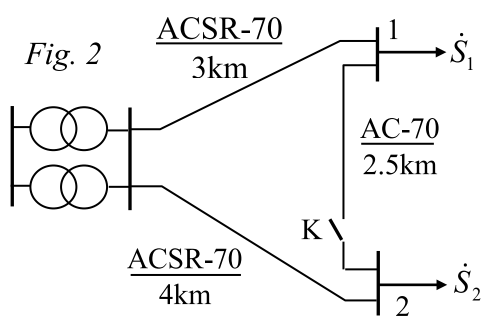
- OHL, ACSR-70 conductor, $r_o = 0.46\Omega$/km, $x_o = 0.38\Omega$/km
- Distribution substation, two transformers 35/10kV with following ratings

  $S_r = 5000$kVA

  $\Delta P_o = 12.5$kW, $\Delta P_I = 42$kW

Maximum loss hours of 4500 hour is applicable for both two loads.

Fig. 2



Question 1. Determine annual energy loss of the whole distribution network in the case of opening switch K.

Question 2. In the case of closing switch K, how does the voltage of bus 2 change, given the operating voltage at the 15kV bus of distribution substation is 16kV?

Notes : Open-book exam.