ELEKTRIJADA 2010 – Power System Analysis

ANNOTATION: You must chose only one of given answers for problems. Right answers worth given number of points. Wrong answers worth -25% of given points. For answer “I don’t know” there are no negative points.

1. (5 points) Official unit for reactive power is:
   a) VAr
   b) VAR
   c) var
   d) No one of given answers
   e) I don’t now

2. (5 points) Lossless transmission line \((r=0, g=0)\) with no load at one end is given. Voltages at ends of line are \(U_1 = U_1 e^{j \delta_1}\) and \(U_2 = U_2 e^{j \delta_2}\). One of following statement is true. The answer is:
   a) \(U_1 = U_2, \ \delta_1 = \delta_2\)
   b) \(U_1 \neq U_2, \ \delta_1 = \delta_2\)
   c) \(U_1 = U_2, \ \delta_1 \neq \delta_2\)
   d) No one of given answers
   e) I don’t now

3. (8 points) Transmission line \((U_n=220 \text{ kV}, f_n=50 \text{ Hz})\) with parameters:
   \(r_v=0.125 \Omega/\text{km}\); \(x_v=0.4 \Omega/\text{km}\);
   \(g_v=0.1 \cdot 10^{-6} \text{ S/km}\); \(c_v=9 \cdot 10^{-9} \text{ F/km}\);
   \(L_v=100 \text{ km}\).
   is given. Find characteristic impedance for transmission line. The answer is:
   a) \(Z_c = 384.87 e^{j 3.586} \Omega\)
   b) \(Z_c = 356.9 e^{j 1.586} \Omega\)
   c) \(Z_c = (381.43 - 51.33) \Omega\)
   d) No one of given answers
   e) I don’t now

4. (8 points) Voltage and current phasor diagram of one single phase consumer is shown on the figure. Find consumer power. \(I_p = 100 \text{ A}, \ \delta = 30^\circ\) \(U_p = 10 \text{ kV}\)
   The answer is:
   a) \(S_p = (500 \sqrt{3} + j 500) \text{ kVA}\)
   b) \(S_p = (1000 - j 500 \sqrt{3}) \text{ kVA}\)
   c) \(S_p = 1000 e^{j 30^\circ} \text{ kVA}\)
   d) No one of given answers
   e) I don’t now

5. (10 points) For transformer, given at the figure, find vector group.

The answer is:
   a) 2
   b) 8
   c) 10
   d) No one of given answers
   e) I don’t now

6. (10 points) Active network supply nonsymmetrical consumption (see figure). There are known: \(L_A = 2 e^{j 60^\circ} \text{ p.u.}\), \(L_C = 2 e^{-j 120^\circ} \text{ p.u.}\), \(U_B = \sqrt{3} \text{ p.u.}\), and \(Z = 1.5 e^{j 30^\circ} \text{ p.u.}\). Find consumer voltage zero sequence component.

The answer is:
   a) \(U_o = (3 \sqrt{3} + j 3) \text{ p.u.}\)
   b) \(U_o = 2 e^{j 30^\circ} \text{ p.u.}\)
   c) \(U_o = (\sqrt{3} / 3 + j 1) \text{ p.u.}\)
   d) No one of given answers
   e) I don’t now
7. (12 points) At the end of transmission line, with parameters \( R=0.02 \text{ p.u.}, \ X=0.08 \text{ p.u.}, \ B=0.16 \text{ p.u.}, \) is connected passive consumption area. Voltage magnitude at the beginning and the end of line are \( U_1=1.1 \text{ p.u.} \) and \( U_2=1 \text{ p.u.} \) respectively. Phase difference between voltage phasors is \( \delta=9^\circ \). Find active and reactive power of consumption area. The answer is:

a) \( S_p = (2.28 + j0.51) \text{ p.u.} \)

b) \( S_p = (2.28 + j0.43) \text{ p.u.} \)

c) \( S_p = (2.28 + j0.59) \text{ p.u.} \)

d) No one of given answers

e) I don’t now

8. (12 points) Radial network is given on the figure.

\[
\begin{array}{c}
1 \quad L_{12}=20 \text{ km} \\
2 \quad L_{24}=5 \text{ km} \\
3 \quad L_{34}=10 \text{ km} \\
4 \quad S_p=(6+j4) \text{ MVA} \\
\end{array}
\]

With shunt capacitor bank on the buses 3 and 4 with same reactive power, voltage magnitudes at buses 3 and 4 are \( U_3=U_4=10 \text{ kV} \). Find that reactive power of shunt capacitor bank. The answer is:

a) \( S_{BK} = jQ_{BK} = j1.95 \text{ MVA} \)

b) \( S_{BK} = jQ_{BK} = j2.63 \text{ MVA} \)

c) \( S_{BK} = jQ_{BK} = j2.32 \text{ MVA} \)

d) No one of given answers

e) I don’t now

9. (15 points) Simply power system with data is shown on the figure.

G: \( S_{nG}=50 \text{ MVA}, \ U_{nG}=10 \text{ kV} \), \( x_{dg}'=x_{ig}'=30 \%, x_{dg}=10 \% \)

T: \( S_n=S_{nG}, \ m_T=220/10 \text{ kV/kV), \ x_T=10 \%} \)

M: Strong network with \( \infty \) power.

Find value of resistance \( R \) which limits single phase to ground current at bus 1 at value 1000 A. Voltage at bus 1 before fault was equal to generator nominal voltage. The answer is:

a) \( R=5.77 \Omega \)

b) \( R=10 \Omega \)

c) \( R=17.31 \Omega \)

d) No one of given answers

e) I don’t now

10. (15 points) Simply power system is shown on the figure. System data are given in the table.

<table>
<thead>
<tr>
<th>( X_d \text{(p.u.)} )</th>
<th>( G_1 )</th>
<th>( G_2 )</th>
<th>( T_1 )</th>
<th>( T_2 )</th>
<th>( T_3 )</th>
<th>( \text{Lines} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( X_d \text{(p.u.)} )</td>
<td>0.14</td>
<td>0.14</td>
<td>0.06</td>
<td>0.06</td>
<td>0.05</td>
<td>0.1</td>
</tr>
<tr>
<td>( X_i \text{(p.u.)} )</td>
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<td>0.14</td>
<td>0.06</td>
<td>0.06</td>
<td>0.05</td>
<td>0.1</td>
</tr>
<tr>
<td>( X_x \text{(p.u.)} )</td>
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<td>0.05</td>
<td>0.06</td>
<td>0.06</td>
<td>0.05</td>
<td>0.3</td>
</tr>
</tbody>
</table>

In the case of single phase to ground fault of phase A at bus 3, find phase A current for transformer \( T_2 \). Voltage at bus 3 before fault was \( U_{3p}=1 \text{ p.u.} \) The answer is:

a) \( I_{AT2} = -j2.941 \text{ p.u.} \)

b) \( I_{AT2} = -j3.731 \text{ p.u.} \)

c) \( I_{AT2} = -j3.517 \text{ p.u.} \)

d) No one of given answers

e) I don’t now