NAME: ______________________ **NIF:** __________

The Power System – T3: Transmission and distribution of electricity

Exam 12/01/2018 Time: 17:00 – 17:50 h

Part I: TEST A (provide your answers to the questions at the table at the end of this page)

One correct answer for each question. Right answer: +1 pt. Wrong answer: -1/3 pt. Blank: = 0 pt. (10 points)

1. Power losses in HVDC in comparison to HVAC when transmitting the same power:

A. Are lower
B. Are higher
C. Are equal
D. Are irrelevant

2. Which sentence is true regarding AC power lines?

A. Undergrounded AC power lines length are limited to transmit power due to the their inductance
B. Overhead AC power lines length are limited to transmit power due to their capacitance
C. Undergrounded AC power lines length are limited to transmit power due to the their capacitance
D. Undergrounded AC power lines permit to transmit an amount of power longer distances than an overhead power line

3. Load flow studies permit to

A. Determine the electrical parameters of power lines
B. Determine the value and angle of bus voltages
C. Determine the power demanded
D. Determine the network topology

4. Which sentence can be applied to AC transmission networks?

A. They are radial and power lines are at HV level
B. They are meshed and power lines are at LV level
C. They are radial and power lines are at MV level
D. They are meshed and power lines are at HV level

5. The equivalent inductance of a power line is a parameter that is given by:

A. Electric field
B. Resistivity of the conductor
C. Magnetic field
D. Leaking currents

6. Which is false? Power flow through AC transmission power lines can be controlled in AC power system:

A. Modifying the voltage phase shifting between origin and end
B. Modifying the resistance of the power line
C. Modifying the reactance of the power line
D. Modifying the voltage amplitude at origin and end

7. Which sentence is true regarding AC power lines?

A. Two power lines with different voltage frequency can be connected directly
B. Lightning conductor is used in undergrounded power lines
C. Each phase can be formed of different conductors
D. A power line can only consist of one 3-phase circuit

8. Power losses in power lines depend on:

A. Resistance of power line conductor and current through power line
B. Square of voltage of power line and resistance of power line conductor
C. Square of current through power line and resistance of power line
D. Square of resistance of power line conductor and current through power line

9. Power system operator is not responsible for
A. International connections
B. Daily market
C. Technical restrictions
D. Grid codes

10. Which sentence is true?

A. In HVDC substations are cheaper than in HVAC
B. In HVDC power lines are more expensive than in HVAC
C. In HVAC power lines are narrower than in HVDC
D. In HVAC substations are cheaper than in HVDC

Question	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Answer										

Formulas for exercises:

- Single line: $R = R_{cond}$ $L = 0.2 \cdot \ln \frac{GMD}{GMR} [mH/km]$ $C = \frac{1000}{18 \ln \frac{GMD}{r_{cond}}} [nF/km]$ $GMD = \sqrt[3]{d_{AB} d_{BC} d_{CA}}$ $GMR = k_g r_{cond}$

- Double line: $R = R_{cond}/2$ $L = 0.2 \cdot \ln \frac{GMD}{GMR} [mH/km]$ $C = \frac{1000}{18 \ln \frac{GMD}{R_{eq}}} [nF/km]$ $GMD = \sqrt[3]{GMD_{AB} GMD_{BC} GMD_{CA}}$

$GMD_{ij} = \sqrt[4]{\prod d_{i-j}}$ $GMR = \sqrt[3]{GMR_A GMR_B GMR_C}$ $GMR_i = \sqrt[2]{k_g r_{cond} d_{i-i'}}$ $R_{eq} = \sqrt[3]{R_{eqA} R_{eqB} R_{eqC}}$ $R_{eqi} = \sqrt[2]{r_{cond} d_{i-i'}}$

- Bundle line: $R = R_{cond}/n$ $L = 0.2 \cdot \ln \frac{GMD}{GMR} [mH/km]$ $C = \frac{1000}{18 \ln \frac{GMD}{R_{eq}}} [nF/km]$

$GMD = \sqrt[3]{d_{AB} d_{BC} d_{CA}}$ $GMR = \sqrt[n]{n k_g r_{cond} r_{bundle}^{n-1}}$ $r_{bundle} = \frac{d_{bundle}}{2 \sin \frac{\pi}{n}}$ $R_{eq} = \sqrt[n]{n r_{cond} r_{bundle}^{n-1}}$

- Transmission equation: $\begin{pmatrix} \underline{V}_{in(s)} \\ \underline{I}_{in} \end{pmatrix} = \begin{pmatrix} \underline{A}_{11} & \underline{A}_{12} \\ \underline{A}_{21} & \underline{A}_{22} \end{pmatrix} \cdot \begin{pmatrix} \underline{V}_{out(s)} \\ \underline{I}_{out} \end{pmatrix}$

$\underline{S}_{out} = 3 \underline{V}_{out(s)} \underline{I}_{out}^{*} = \sqrt{3} \underline{V}_{out(l)} \underline{I}_{out}^{*} = P_{out} + jQ_{out}$ $\underline{S}_{in} = 3 \underline{V}_{in(s)} \underline{I}_{in}^{*} = \sqrt{3} \underline{V}_{in(l)} \underline{I}_{in}^{*} = P_{in} + jQ_{in}$

$\Delta v = \frac{V_o - V_f}{V_{ref}} 100$ $PF = \frac{P}{S}$ $\eta = \frac{P_{out}}{P_{in}} 100$ $\underline{V} = V \angle \alpha$ $\underline{V}_{(l)} = \sqrt{3} \underline{V}_{(s)}$

Long line	Medium line	Short line
$\underline{A}_{11} = \underline{A}_{22} = \cosh(\underline{\Theta})$ $\underline{A}_{12} = \underline{Z}_c \sinh(\underline{\Theta})$ $\underline{A}_{21} = \frac{\sinh(\underline{\Theta})}{\underline{Z}_c}$ $\underline{Z}_c = \sqrt{\frac{\underline{Z}}{\underline{Y}}} = \sqrt{\frac{R + j\omega L}{G + j\omega C}}$ $\underline{\Theta} = \underline{\beta} l = l \sqrt{(R + j\omega L)(G + j\omega C)}$ $\underline{\beta} = \sqrt{\underline{Z}\underline{Y}} = \sqrt{(R + j\omega L)(G + j\omega C)}$	$\underline{A}_{11} = \underline{A}_{22} = 1 + \frac{\underline{Z}_t \underline{Y}_t}{2}$ $\underline{A}_{12} = \underline{Z}_t$ $\underline{A}_{21} = \underline{Y}_t + \frac{\underline{Y}_t^{2} \underline{Z}_t}{4}$ $\underline{Z}_t = (R + j\omega L) l$ $\underline{Y}_t = (G + j\omega C) l$	$\underline{A}_{11} = \underline{A}_{22} = 1$ $\underline{A}_{12} = \underline{Z}_t$ $\underline{A}_{21} = 0$ $\underline{Z}_t = (R + j\omega L) l$

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Exam 10/01/2017 Time: 17:00 – 17:55 h

Part II: EXERCISES A (10 points)

The power line of the figure is 200 km long and its rated voltage is 400 kV. Its conductor has the following characteristics: 54 Al + 7 Steel wires (k_g=0,809), outer diameter 30,42 mm, R_{ca} = 0,062 Ω/km.

Calculate:

A. The resistance, inductance and capacitance per length
B. Its transmission matrix parameters
C. The phase-to-phase voltage at the origin if the phase-to-phase voltage at the end is 395 kV when it is supplying a load of 200 MW with PF=0,8 (i).