UNIVERSITY OF ESWATINI

SIT/RESIT EXAMINATION, SECOND SEMESTER

JUNE/JULY 2019

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

TITLE OF PAPER: Power Systems

COURSE CODE: EEE452/EE452

TIME ALLOWED: THREE HOURS

INSTRUCTIONS:

1. **There are five questions in this paper. Answer any FOUR questions. Each question carries 25 marks.**
2. **If you think not enough data has been given in any question you may assume any reasonable values.**

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THIS PAPER CONTAINS SIX (6) PAGES INCLUDING THIS PAGE

QUESTION ONE ***(25 marks)***

(a) A long transmission line is open circuited at the receiving end. Will there be any current in the line at the sending end? Explain your answer. [3]

(b) Explain why and how transposition of line is done. [3]

(c) Explain effect of poor power factor on efficiency and voltage regulation of transmission,[4]

(d)

i. Use the method of cascaded networks to show that the ABCD constants of a transmission line represented by its π model are given by:

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} 1+\frac{YZ}{2} & Z \\ Y\left(1+\frac{YZ}{4}\right) & 1+\frac{YZ}{2} \end{bmatrix}$$

Where Z is its series impedance and Y is its shunt admittance [5]

ii. If the ABCD Constants of a three phase transmission line are

$A = D = 0.936\angle 0.98°$

$B = 142\angle 76.4°$

$C = 0.000914015\angle -82.6°$

The load at the receiving end is 50 MW at 220kV with a power factor of 0.9 lagging. Find the magnitude of the sending end voltage and regulation. Assume the magnitude of the sending end voltage remains constant [10]

QUESTION TWO *(25 marks)*

(a) Discuss how you improve the efficiency and regulation of a transmission line. [5]

(b) Determine the *efficiency* and the *regulation* of a 3-phase, 100km, 50Hz transmission line delivering 20MW at a p.f. of 0.8 lagging and line-to-line voltage 66kV to a balanced load. The conductors are of copper, each having resistance 0.1 Ω per km, 1.5 cm outside diameter, spaced equilaterally 2 meters between centers, see Fig.Q.2. Neglect Shunt conductance and use nominal- π model. [20]

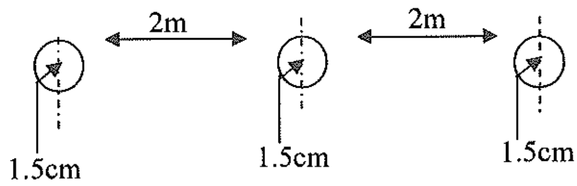


Fig Q.2

QUESTION THREE *(25 marks)*

(a) A hydroelectric power plant 9000 MW are to be transmitted to a load center located 600 km from the plant. Based on practical loadability criteria, determine the number of three phase 50 Hz transmission lines required to transmit this power with one line out of service for a 765 kV with $Z_c = 266\ \Omega$. Assume that $V_S = 1.0\ p.u$, $V_R = 0.95\ p.u$ and $\delta = 35°$, also assume that the lines are uncompensated and widely separated such that there is negligible mutual coupling between them. [10]

(b) Determine the *voltage at the generating station* and *the efficiency* of the following system Figure, The resistance on LV side of both transformers is 0.04 Ω and that on HV side is 1.3 Ω. Reactance on LV and HV side of both transformers is 0.125 Ω and 4.5 Ω respectively. [15]

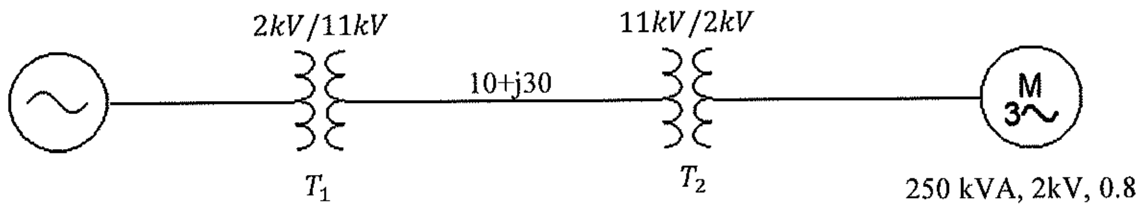


Fig. Q.3

QUESTION FOUR ***(25 marks)***

(a) Discuss any five (5) fundamental requirements of switchgear system [5]

(b) Describe the following terms as used in protection systems

(i) Pick-up Current [1]

(ii) Time Setting [1]

(c) Fig. Q.4 shows the curve between time of operation and plug setting multiplier.

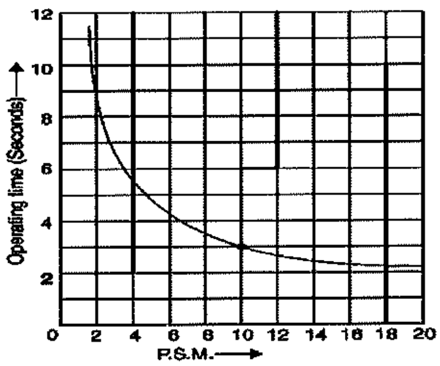


Fig. Q.4

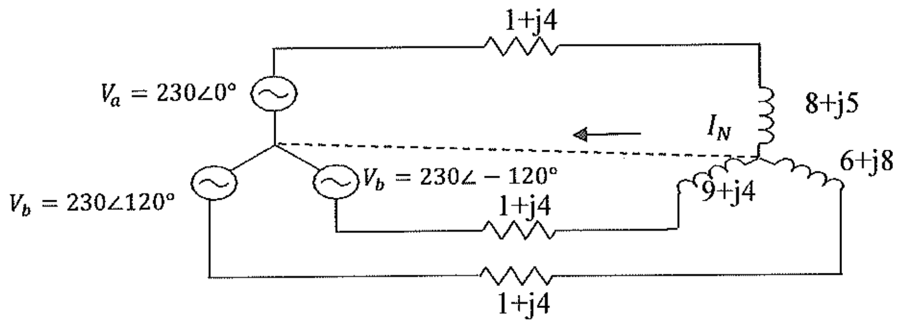
Determine the time of operation of a 5-ampere, 3-second overcurrent relay having a current setting of 125% and a time setting multiplier of 0.6 connected to supply circuit through a 400/5 current transformer when the circuit carries a fault current of 4000 A. [5]

(d) What is meant by the term phase rotation sequence, in a poly-phase electrical system? [3]

(e) What is the phase sequence of the following set of voltages? [3]

$$V_a = 240\cos(\omega t + 14^\circ) \quad V$$
$$V_b = 240\cos(\omega t - 106^\circ) \quad V$$
$$V_c = 240\cos(\omega t + 134^\circ) \quad V$$

(f) Calculate the Neutral current I_N in the three-wire Y-Y system as shown below [7]



QUESTION FIVE *(25 marks)*

(a) A factory takes a steady load of 200 kW at a lagging power factor of 0·8. The tariff is E100 per kVA of maximum demand per annum plus E0.05 per kWh. The phase advancing plant costs E500 per kVar and the annual interest and depreciation together amount to 10%.

Find:

(i) The Optimal power factor. [4]

(ii) The capacity of the phase advancing plant [3]

(iii) The new bill for energy, assuming that the factory works for 5000 hours per annum. [8]

(b) A generating station has a maximum demand of 200MW, a load factor of 60%, a plant capacity factor of 40% and a plant use factor of 80%.

Find

(i) The reserve capacity of the plant [6]

(ii) The daily energy produced [2]

(iii) Maximum energy that could be produced daily if the plant while running as per schedule, were fully loaded. [2]

Useful Formulae

Transmission line Constants

Parameter	A = D	B	C
Units	p.u.	Ω	S
Short Line G = C = 1	1	Z	0
Medium G = 0 (π *Model*)	$1+\frac{YZ}{2}$	Z	$Y\left(1+\frac{YZ}{2}\right)$
Long Line (*Length l Equivalent* π *Model*)	$\cosh(\gamma l) = 1+\frac{Y'Z'}{2}$	$Z_C\sinh(\gamma l) = Z'$	$\frac{1}{Z_C}\sinh(\gamma l) = Y\left(1+\frac{Y'Z'}{4}\right)$
	$\cos(\beta l)$	$jZ_C\sin(\beta l) = X'$	$\frac{j\sin(\beta l)}{Z_C}$

Equivalent π model of long line:

$$Z' = Z_C\sinh(\gamma l) = Z\frac{sinh(\gamma l)}{\gamma l}$$

$$\frac{Y'}{2} = \frac{1}{Z_C}\tanh\left(\frac{\gamma l}{2}\right) = \frac{Y}{2}\frac{tanh\left(\frac{\gamma l}{2}\right)}{\frac{\gamma l}{2}}$$

Equivalent π model of lossless line:

$$Z' = jX' = jZ_C sin(\beta l)$$

$$\frac{Y'}{2} = j\frac{sin(\beta l)}{Z_C}$$

Hyperbolic Identities

$$cosh(j\beta) = cos(\beta)\ , sinh(j\beta) = jsin(\beta)\ , tanh(j\beta) = jtan(\beta)$$

For lossless function

$$Z_C = \sqrt{\frac{L}{C}}\ \Omega,\quad \beta = \omega\sqrt{LC}\ \frac{rad}{m}\qquad v = \frac{1}{\sqrt{LC}}$$

NB. L is inductance per unit length.

For a lossy line

$$Z_C = \sqrt{\frac{z}{y}}\quad ,\quad \gamma^2 = yz$$

$L = \frac{\mu_0}{2\pi} ln\left(\frac{GMD}{GMR_L}\right)$ H/m per conductor $\mu_0 = 4\pi x 10^{-7}\ H/m$ or $1.2566x10^{-6}\ H/m$

$C_{an} = \frac{2\pi\varepsilon_0}{ln\left(\frac{GMD}{GMR_C}\right)}$ F/m to neutral $\varepsilon_0 = 8.854x10^{-12}$ F/m