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Electrical Engineering Department

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Power System Analysis (I), EE 0903481,

First Term 2016/2017

Date: 27/10/2016

Time: 1 hour

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16/30

Problem 1 (30 pts):

(a) **(15 pts)** In the circuit shown in Fig. 1, $|V_1|$ and $|V_2|$ are either 240 or 220 V, their phase angles are either 5^0 or 0^0. It was noted that source 1 supplies positive active power while it consumes positive reactive power. What are V_1 and V_2. Determine the amount of P, Q supplied/absorbed by each source.

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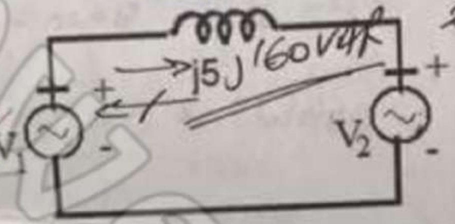


Fig.1

5 (b) **(5 pts)** Prove that the impedance base is the same for both the single phase and three phase systems.

5 (c) **(5pts)** Prove that

$$Z_{pu,new} = Z_{pu,old}\left(\frac{base\ kV_{old}}{base\ kV_{new}}\right)^2\left(\frac{Base\ MVA_{new}}{Base\ MVA_{old}}\right)$$

zero (d) **(5 pts)** Justify why the voltage magnitude along a lossless long transmission line is flat (not changing in magnitude) when surge impedance is connected to its end.

a) assume $V_1 = 240\angle 5$.

$I = \frac{240\angle 5 - 220}{5j} = 5.66\angle -42.3$.

$S = V \times I^* = (240\angle 5) \times (5.66\angle 42.3)$

$S = P - jQ$ → yes its the same sign

$S = 1080.5 - 823.1j$

∴ so $V_1 = 240\angle 5$ → supply P & consumes Q

$V_2 = 220\angle 0$ → consume P & supply Q

(b) $Z_{base\,1\phi} = \frac{V_{1\phi}^2}{S_{1\phi}}$

$Z_{Base\,3\phi} = \frac{V_{L-L}^2}{S_{3\phi}}$

where $V_{L-L} = \sqrt{3}V_{1\phi}$

& $S_{3\phi} = 3S_{1\phi}$

$Z_{B3\phi} = \frac{(\sqrt{3}V_{1\phi})^2}{3S_{1\phi}}$

Problem 2 (45 pts) ABET: The single line diagram of a power system is shown in Figure.2, the ratings and parameters of all components are as follows

G_1: 40MVA, 11kV, X=0.2 p.u.

G_2: 20MVA, 11.5kV, X=0.2 p.u.

M: 10MVA, 3.3kV, X=0.25 p.u.

T_1: Three single phase units each rated 15MVA, 11/19.63kV, X=0.15 p.u.

T.L.: The line impedance of the Transmission Line (T.L.) is $0 + j2\ \Omega$.

The static load at bus 4 is 30 MW at 0.8 PF lagging at 11kV.

T_2: Three winding transformers rated as follows:

Primary (p): 33kV, Δ-connected, 60 MVA

Secondary (s): 11kV, Y-connected, 40 MVA

Tertiary (t): 3.3kV, Δ-connected, 20 MVA

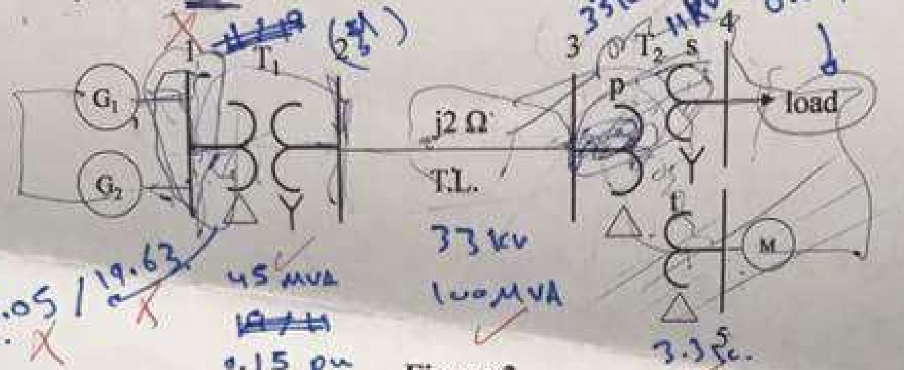


Figure 2

Short circuit tests on T_2 gave the following leakage reactance in p.u. as follows:

Primary (p)	Secondary (s)	Tertiary (t)	Base
0.1	Short circuit	Open circuit	60 MVA and 33 kV
Open circuit	0.12	Short circuit	40 MVA and 11kV
Short circuit	Open circuit	0.015	20 MVA and 3.3 kV

(a) Draw the equivalent impedance diagram. Mark the reactance/impedance of each component including the load in p.u., and use a **base of 33 kV, 100 MVA in the transmission line (T.L.) circuit** (Neglect resistance, transformer phase shifts)

(b) At a certain operating condition, the motor draws 8 MW at 0.8 leading PF and the motor terminal voltage at bus 5 is 3.3 kV. Use the p.u., system to calculate the terminal voltage at bus 1. (Assume that the impedance of static load remains constant as in (a), neglect resistance, transformer phase shifts)

Problem 3 (25 pts): A 60Hz, 3-phase transmission line is 300km long. The line parameters are: R=.066Ω/km, L=1.22mH/km, C=.0088μF/km

(a) Determine A, B, C and D constants of the line

(b) Determine the parameters of the Π-equivalent circuit of the line.

Problem 4 (25 pts): A long 220 kV transmission line has $A=0.93\angle 1^{\circ}$, $B=136\angle 82^{\circ}\,\Omega$.

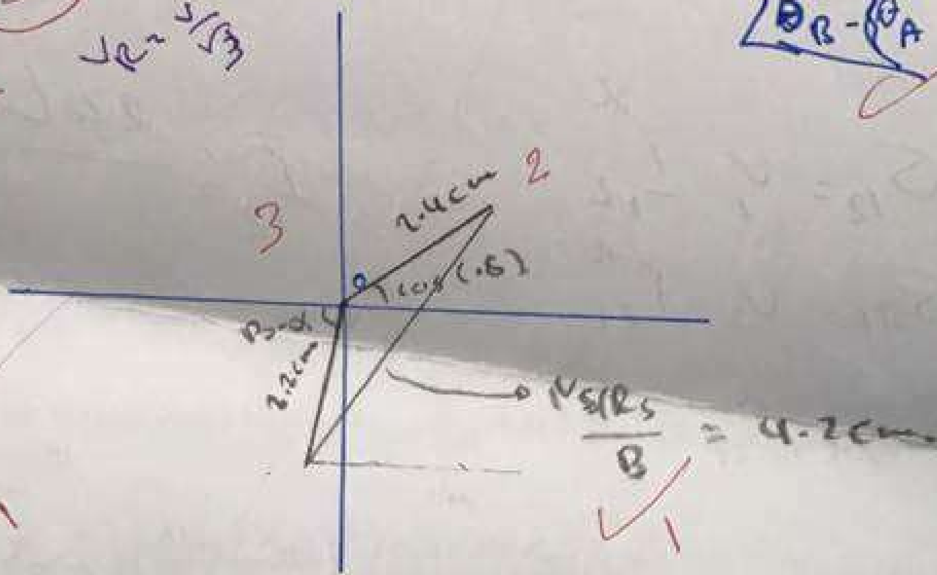
(a) A 120 MW, 0.8 pf lagging load is connected at the receiving end. Use the **circle diagram** to calculate the sending end voltage (magnitude and the power angle) required to achieve a receiving end voltage of 220 kV.

(b) If 50 Mvar shunt capacitor bank is connected at the receiving end in addition to the load in part (a), use the **circle diagram** to determine the sending end voltage magnitude required to maintain the receiving end voltage at 220 kV.

$= \frac{220\,k}{\sqrt{3}} = 127.01\,k$

$\angle\theta_B - \theta_A = \angle 81^{\circ}$

$V_R^2 = 110$ MVA



$\frac{10}{50} = 2.2$ cm

$\frac{20}{50} = 2.4$ cm

$\theta \rightarrow \cos^{-1}(0.8) = 36.8$