

Massachusetts Institute of Technology
Department of Electrical Engineering and Computer Science
 6.061/6.690 Introduction to Power Systems

Quiz 1

March 16, 2011

Closed Book: One Handwritten Crib Sheet Allowed

Please put your answers in the spaces provided on the quiz. You may, if you wish, turn in your work on additional sheets of paper. Hopefully you will get all the answers correct so I don't have to look at those sheets.

Problem 1: A three-phase transformer is shown in Figure 1. It is connected to an ordinary three-phase voltage source on the primary side and loaded by a single resistor on the secondary side. The RMS amplitude of voltage on the primary side is 100 V. The resistor has value $R = 30,000\Omega$. The transformer turns ratio is $\frac{N_s}{N_1} = 10$. Assume that the primary side voltages are:

$$\underline{V}_a = V \quad \underline{V}_b = V e^{-j\frac{2\pi}{3}} \quad \underline{V}_c = V e^{j\frac{2\pi}{3}}$$

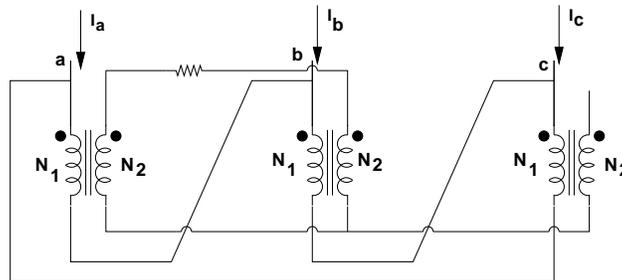


Figure 1: Three Phase Transformer with load resistor

1. Find the currents I_a , I_b and I_c and draw them on the template shown in Figure 2. Be sure to label each current and show its RMS magnitude and angle. Note the lines on the template are spaced 15° apart.
2. What are real and reactive power from each of the three voltage sources?

$$(P + jQ)_A =$$

$$(P + jQ)_B =$$

$$(P + jQ)_C =$$

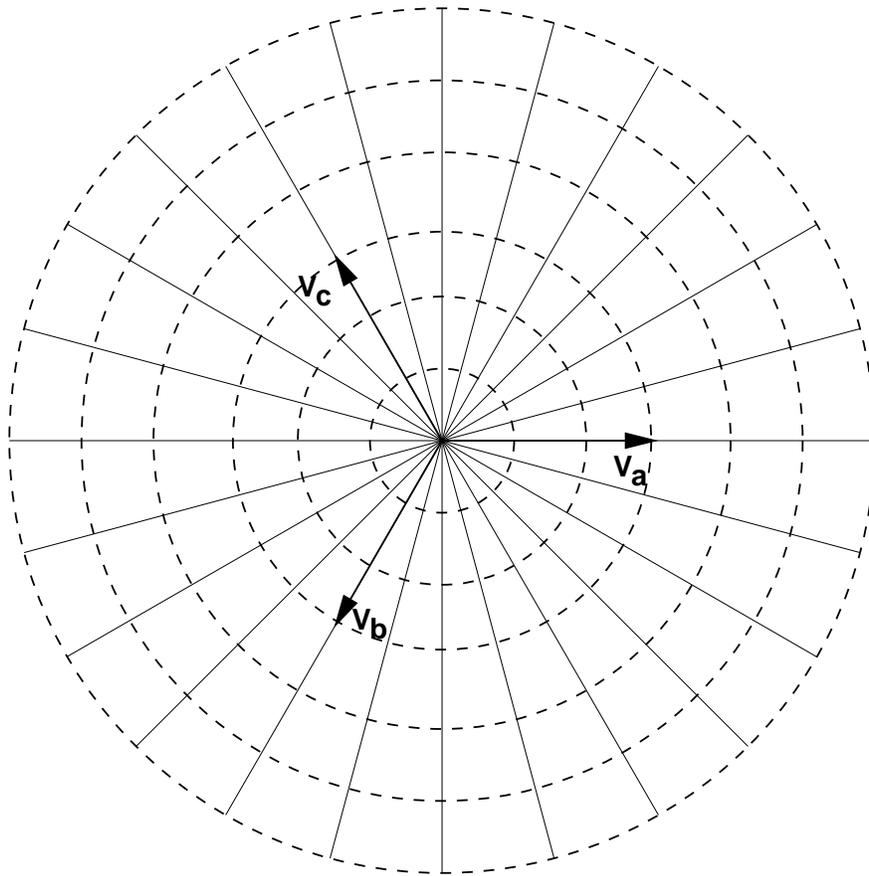


Figure 2: Your answer to Problem 1 goes here

Problem 2: This problem concerns a simple transmission line model as shown in Figure 3. Two polyphase voltage sources are connected by a transmission line. Both sources have magnitude of 1000 V, RMS, line to line. The source on the left, V_1 leads the source on the right by 30° . The transmission line is lossless and has reactance $\omega(L - M) = 1\Omega$.

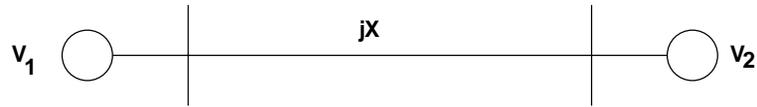


Figure 3: Transmission Line Problem

1. What are real and reactive power *into* the line at each end:

$$(P + jQ)_{\text{left}} =$$

$$(P + jQ)_{\text{right}} =$$

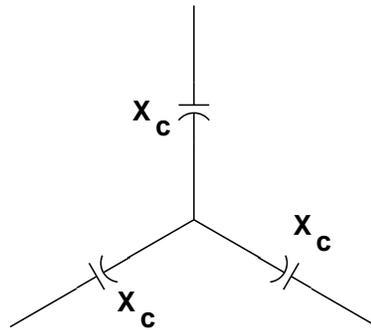


Figure 4: Power Factor Correcting Capacitors

2. To correct the power factor, a three-phase capacitance such as is shown in Figure 4 is placed in parallel with the line at each end. What value should the capacitive reactance be to correct the sending end power factor to unity? (That is, to set $Q = 0$)

$$X_c =$$

Problem 3: A single phase transmission line is shown in Figure 5. The line is 300 km long and is, perhaps implausibly, lossless. It has characteristic impedance Z_0 . It is driven at the left by a voltage source in series with a resistance equal to the line's characteristic impedance. The line is shorted at the right-hand end. The voltage source is a pulse of 2 kV lasting $100\mu S$. An observer with an oscilloscope is located exactly half-way down the line. Sketch and label, on Figure 6 the voltage that observer will see.

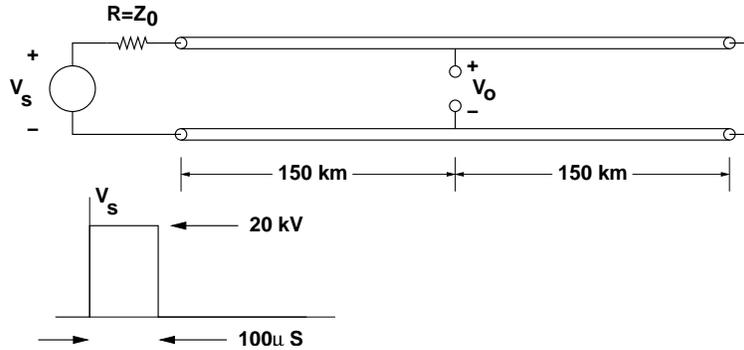


Figure 5: Single Phase Transmission Line

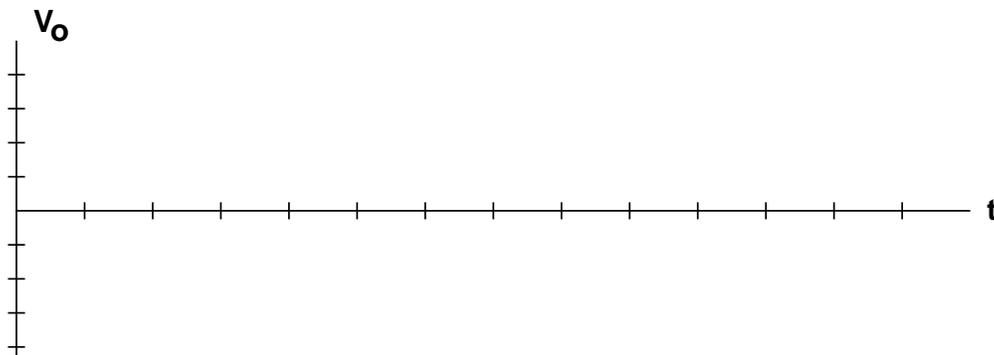


Figure 6: Your answer to Problem 3 goes here

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