

MIT OpenCourseWare
<http://ocw.mit.edu>

6.061 / 6.690 Introduction to Electric Power Systems
Spring 2007

For information about citing these materials or our Terms of Use, visit: <http://ocw.mit.edu/terms>.

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

Problem Set 4

Issued: **Ses #7**

Due: **Ses #9**

Problem 1: A lossy transmission line problem is shown in Figure 1. Assume that the magnitude of voltage at the sending and receiving ends is the same: $|V_s| = |V_r| = 1000\text{V}$, RMS, and that the resistance R is one ohm and the reactance X is 10 ohms. The phase shift from sending to receiving end is δ .

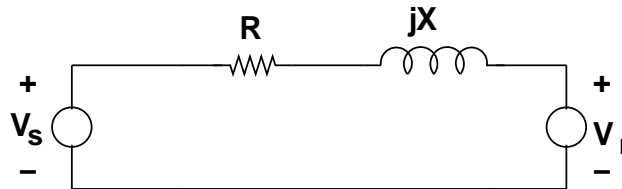


Figure 1: Compensated Transmission Line

1. Construct and sketch the sending end and receiving end power circle (P vs. Q with $0 < \delta < \pi/2$). Use the convention that complex power flow is from the source to the line at the sending end and from the line to the source at the receiving end.
2. (for 6.960) What is the phase shift δ across the line when 50 kW is the real power flow at the receiving end? What is power at the sending end? What are reactive flows for that case?

Problem 2: Shown in Figure 2 is a three-phase voltage source. The three phase voltages are:

$$\begin{aligned} v_a &= \sqrt{2} \cdot 120 (\cos \omega t) \\ v_b &= \sqrt{2} \cdot 120 \left(\cos \omega t - \frac{2\pi}{3} \right) \\ v_c &= \sqrt{2} \cdot 120 \left(\cos \omega t + \frac{2\pi}{3} \right) \end{aligned}$$

and note that the center point of this source is grounded.

For each of the six loads shown in Figure 3, find currents drawn from the three sources.

Problem 3: The situation is as shown in Figure 4. A three phase *current* source is feeding a three-phase resistive load. The currents are actually square waves, as shown in Figure 5. Assume the amplitude of the currents is 100 A and that each of the resistances in Figure 4 is 5Ω . Estimate and draw a dimensioned sketch of each of the four voltages: v_a, v_b, v_c, v_g .

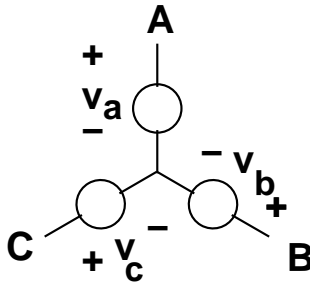


Figure 2: Three-Phase Voltage Source

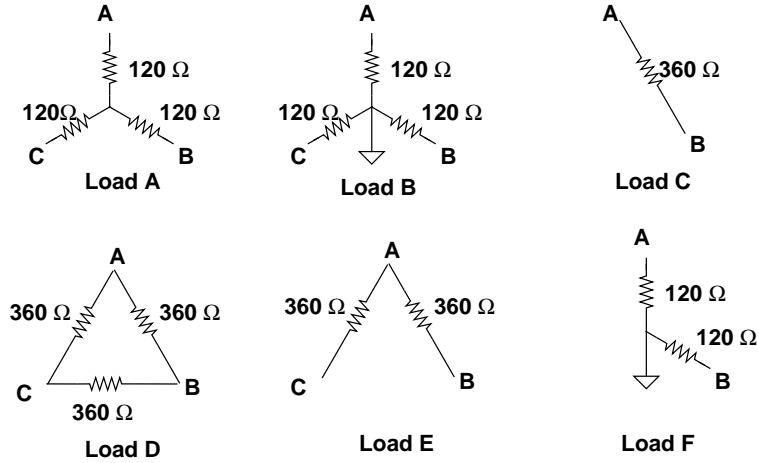


Figure 3: Resistive loads for Problem 2

Problem 4: For 6.690 A three-phase *ungrounded* voltage source is shown in Figure 6 It is connected to a balanced wye connected load consisting of 1Ω resistors. Assume the voltage source is made up of square waves as shown in Figure 7, with amplitude of 100 V.

1. Find the three lead currents and draw a dimensioned sketch of their time behavior.
2. What is the voltage between the neutral of the wye connected resistors and then neutral of the voltage source?

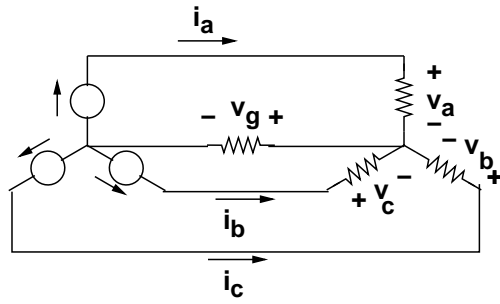


Figure 4: Current Source Feeding Resistive Load

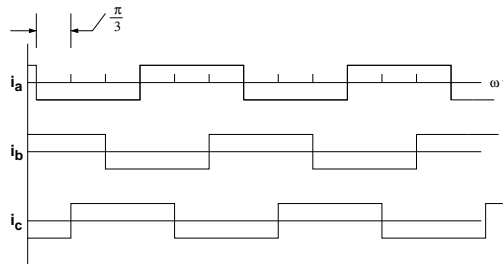


Figure 5: Currents

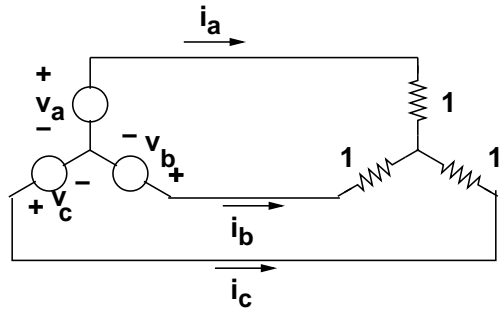


Figure 6: Voltage Source and Load

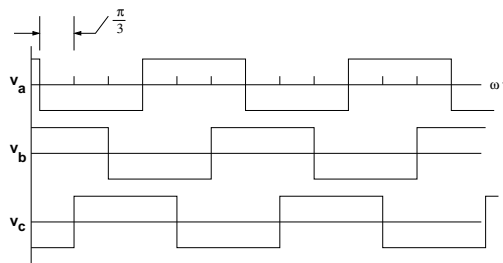


Figure 7: Voltage Source Waveforms