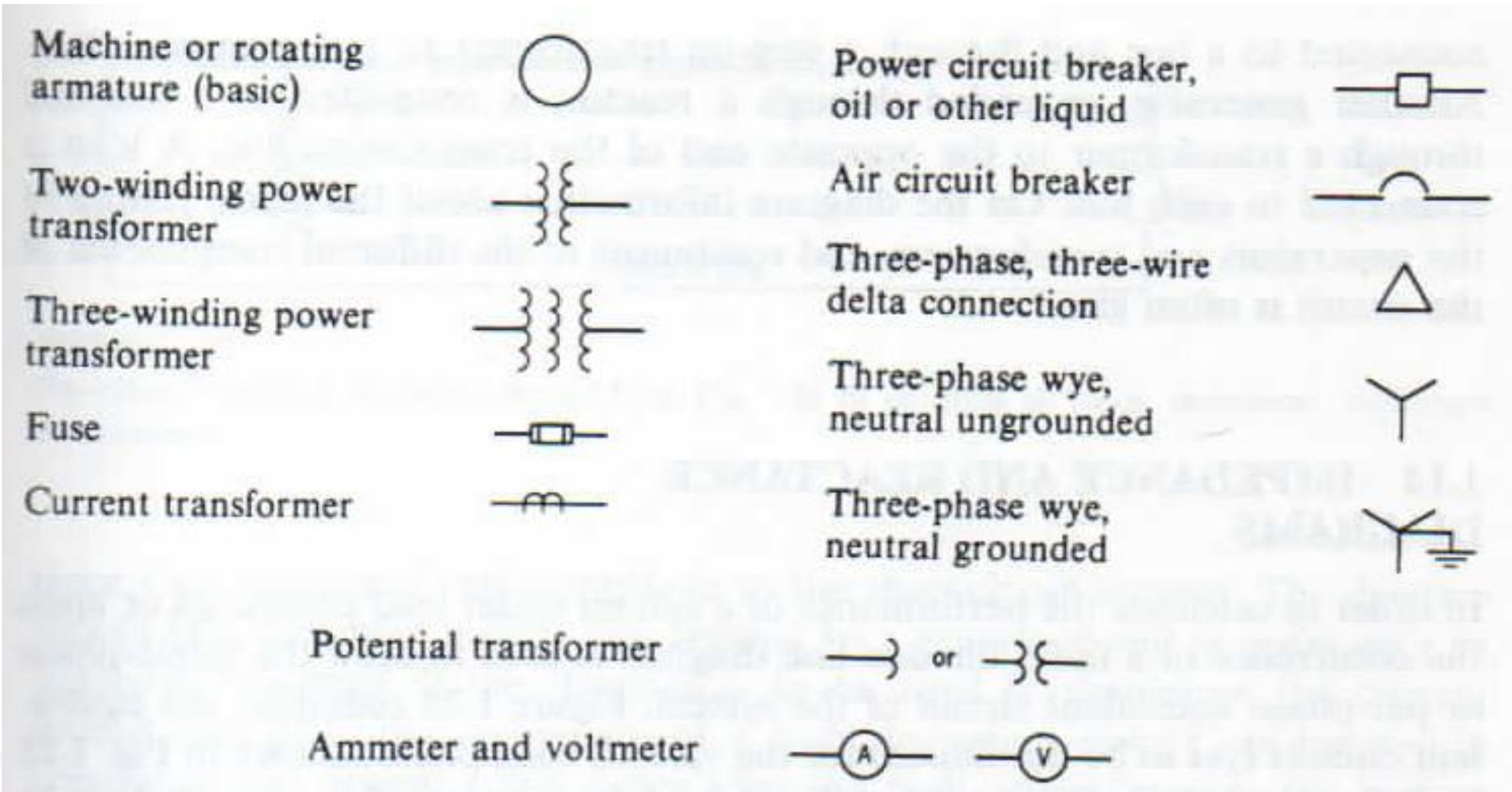
DIAGRAM SEGARIS



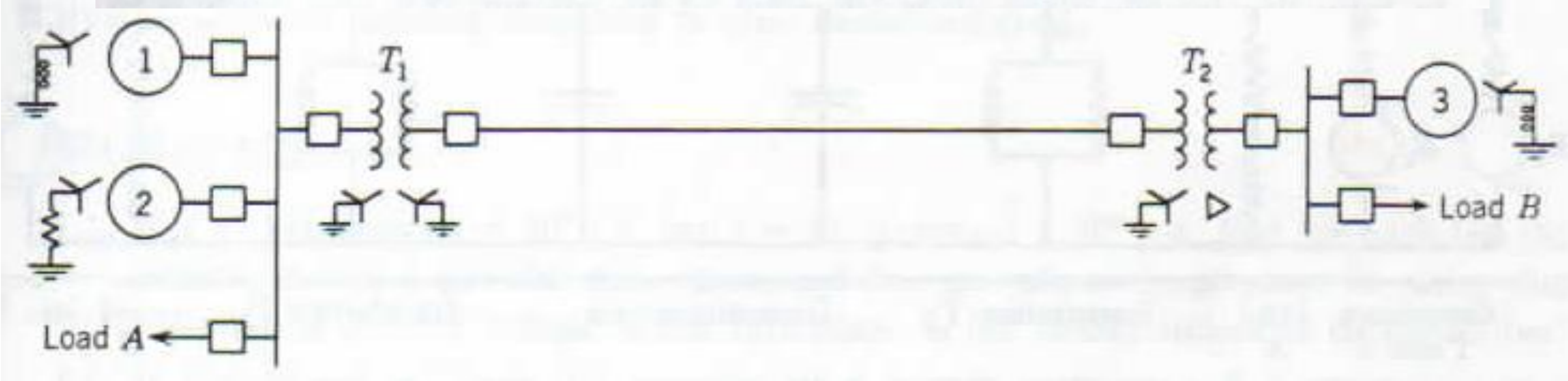


DIAGRAM IMPEDANSI

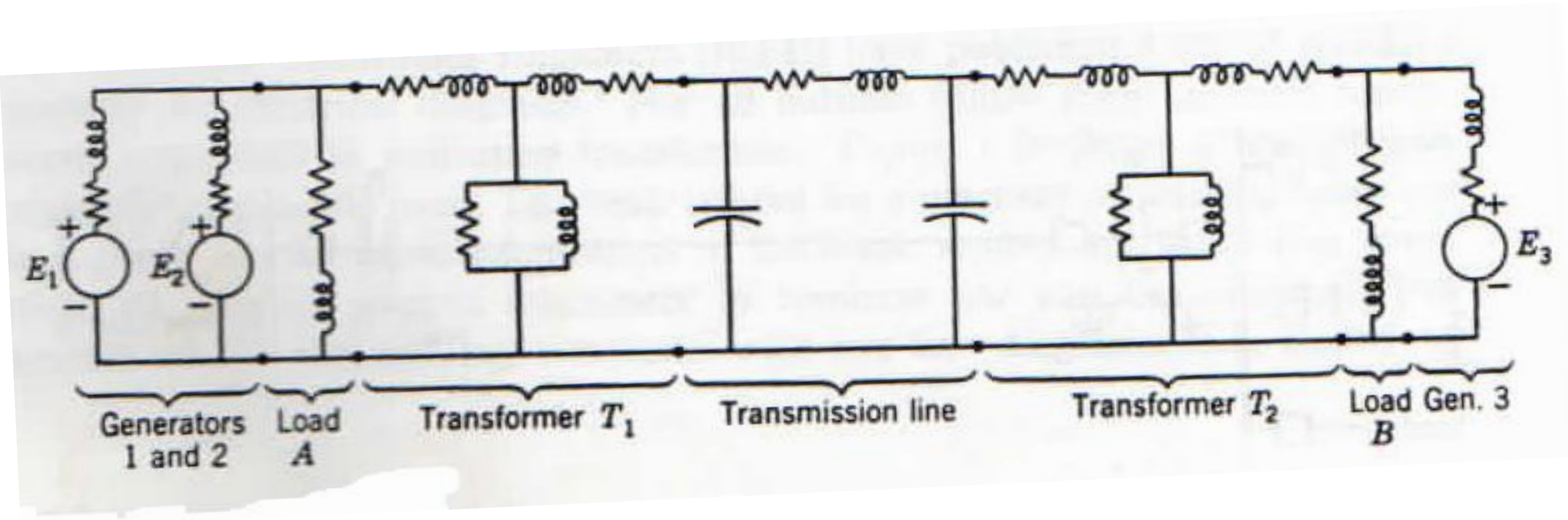
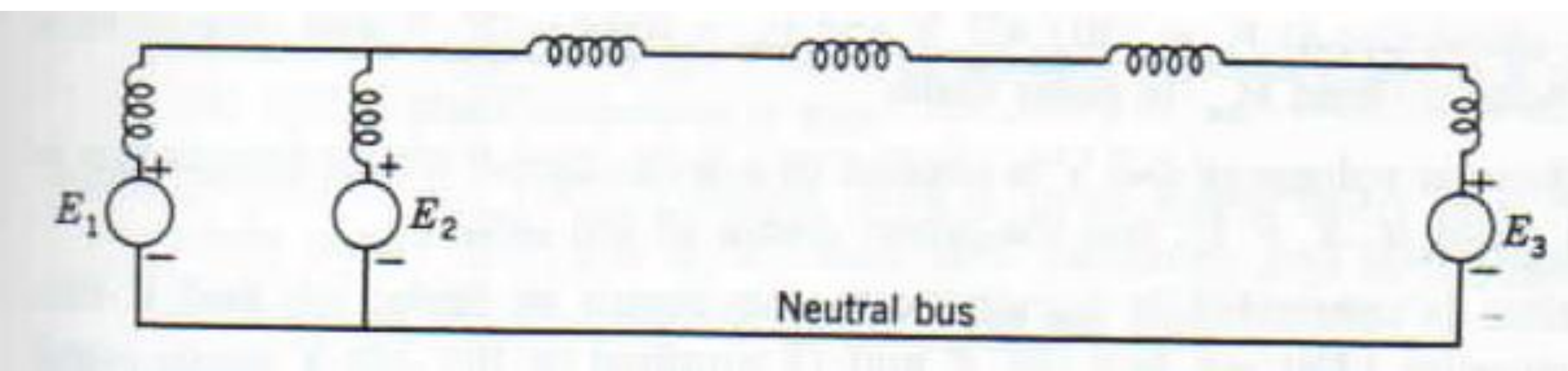


DIAGRAM REAKTANSI



PERHITUNGAN PER UNIT (PU)

$$\text{Base current, A} = \frac{\text{base kVA}_{1\phi}}{\text{base voltage, kV}_{LN}}$$

$$\text{Base impedance, }\Omega = \frac{\text{base voltage, V}_{LN}}{\text{base current, A}}$$

$$\text{Base impedance, }\Omega = \frac{(\text{base voltage, kV}_{LN})^2 \times 1000}{\text{base kVA}_{1\phi}}$$

$$\text{Base impedance, }\Omega = \frac{(\text{base voltage, kV}_{LN})^2}{\text{MVA}_{1\phi}}$$

$$\text{Base power, kW}_{1\phi} = \text{base kVA}_{1\phi}$$

$$\text{Base power, MW}_{1\phi} = \text{base MVA}_{1\phi}$$

$$\text{Per-unit impedance of an element} = \frac{\text{actual impedance, }\Omega}{\text{base impedance, }\Omega}$$

MENENTUKAN BASE

$$\text{Base impedance} = \frac{(\text{base voltage, kV}_{LL}/\sqrt{3})^2 \times 1000}{\text{base kVA}_{3\phi}/3}$$

$$\text{Base impedance} = \frac{(\text{base voltage, kV}_{LL})^2 \times 1000}{\text{base kVA}_{3\phi}}$$

$$\text{Base impedance} = \frac{(\text{base voltage, kV}_{LL})^2}{\text{base MVA}_{3\phi}}$$

MENGUBAH DASAR DARI KUANTITAS PER UNIT

$$\text{Per-unit } Z_{\text{new}} = \text{per-unit } Z_{\text{given}}\left(\frac{\text{base kV}_{\text{given}}}{\text{base kV}_{\text{new}}}\right)^2\left(\frac{\text{base kVA}_{\text{new}}}{\text{base kVA}_{\text{given}}}\right)$$

The advantages of the per-unit system for analysis are described below.

- The per-unit system gives us a clear idea of relative magnitudes of various quantities, such as voltage, current, power and impedance.
- The per-unit impedance of equipment of the same general type based on their own ratings fall in a narrow range regardless of the rating of the equipment. Whereas their impedance in ohms vary greatly with the rating.
- The per-unit values of impedance, voltage and current of a transformer are the same regardless of whether they are referred to the primary or the secondary side. This is a great advantage since the different voltage levels disappear and the entire system reduces to a system of simple impedance.
- The per-unit systems are ideal for the computerized analysis and simulation of complex power system problems.
- The circuit laws are valid in per-unit systems, and the power and voltage equations as given by (3.82) and (3.83) are simplified since the factors of $\sqrt{3}$ and 3 are eliminated in the per-unit system.

Example 3.7

The one-line diagram of a three-phase power system is shown in Figure 3.29. Select a common base of 100 MVA and 22 kV on the generator side. Draw an impedance diagram with all impedances including the load impedance marked in per-unit. The manufacturer's data for each device is given as follow:

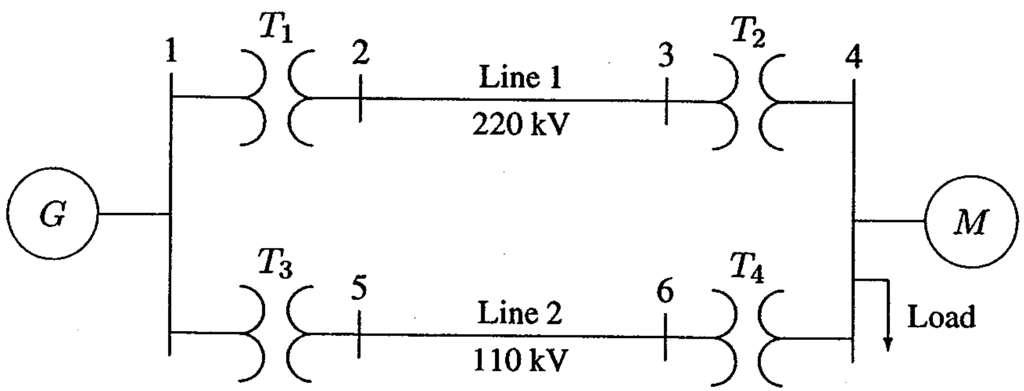


FIGURE 3.29
One-line diagram for Example 3.7.

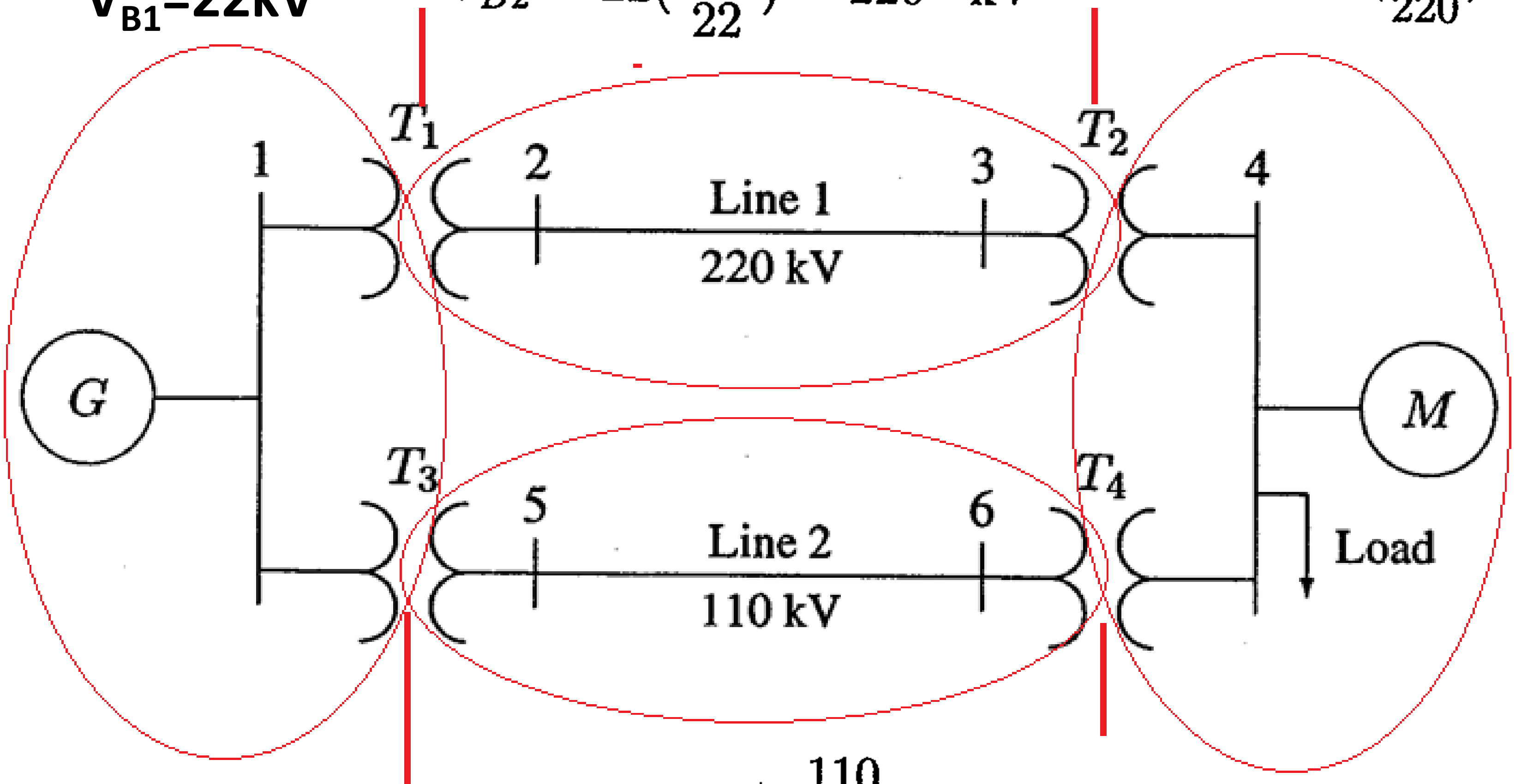
G:	90 MVA	22 kV	$X = 18$ %
T_1:	50 MVA	22/220 kV	$X = 10$ %
T_2:	40 MVA	220/11 kV	$X = 6.0$ %
T_3:	40 MVA	22/110 kV	$X = 6.4$ %
T_4:	40 MVA	110/11 kV	$X = 8.0$ %
M:	66.5 MVA	10.45 kV	$X = 18.5$ %

The three-phase load at bus 4 absorbs 57 MVA, 0.6 power factor lagging at 10.45 kV. Line 1 and line 2 have reactances of 48.4 and 65.43 Ω, respectively.

V_{B1}=22kV

$$V_{B2} = 22(\frac{220}{22}) = 220 \quad \text{kV}$$

$$V_{B4} = 220(\frac{11}{220}) = 11 \quad \text{kV}$$



$$V_{B5} = V_{B6} = 22(\frac{110}{22}) = 110 \quad \text{kV}$$

$$G: \quad X = 0.18\left(\frac{100}{90}\right) = 0.20 \quad \text{pu}$$

$$T_1: \quad X = 0.10\left(\frac{100}{50}\right) = 0.20 \quad \text{pu}$$

$$T_2: \quad X = 0.06\left(\frac{100}{40}\right) = 0.15 \quad \text{pu}$$

$$T_3: \quad X = 0.064\left(\frac{100}{40}\right) = 0.16 \quad \text{pu}$$

$$T_4: \quad X = 0.08\left(\frac{100}{40}\right) = 0.2 \quad \text{pu}$$

The motor reactance is expressed on its nameplate rating of 66.5 MVA and 10.45 kV. However, the base voltage at bus 4 for the motor is 11 kV. From (3.91) the motor reactance on a 100 MVA, 11-kV base is

$$M\colon\ \ X = 0.185\left(\frac{100}{66.5}\right)\left(\frac{10.45}{11}\right)^2 = 0.25 \quad \text{pu}$$

Impedance bases for lines 1 and 2, from (3.81) are

$$Z_{B2} = \frac{(220)^2}{100} = 484 \quad \Omega$$

$$Z_{B5} = \frac{(110)^2}{100} = 121 \quad \Omega$$

Line 1 and 2 per-unit reactances are

$$\text{Line 1:}\ \ X = \left(\frac{48.4}{484}\right) = 0.10 \quad \text{pu}$$

$$\text{Line 2:}\ \ X = \left(\frac{65.43}{121}\right) = 0.54 \quad \text{pu}$$

The load apparent power at 0.6 power factor lagging is given by

$$S_{L(3\phi)} = 57\angle 53.13^\circ \quad \text{MVA}$$

Hence, the load impedance in ohms is

$$Z_L = \frac{(V_{L-L})^2}{S^*_{L(3\phi)}} = \frac{(10.45)^2}{57\angle -53.13^\circ} = 1.1495 + j1.53267 \quad \Omega$$

The base impedance for the load is

$$Z_{B4} = \frac{(11)^2}{100} = 1.21 \quad \Omega$$

Therefore, the load impedance in per-unit is

$$Z_{L(pu)} = \frac{1.1495 + j1.53267}{1.21} = 0.95 + j1.2667 \quad \text{pu}$$

The per-unit equivalent circuit is shown in Figure 3.30.

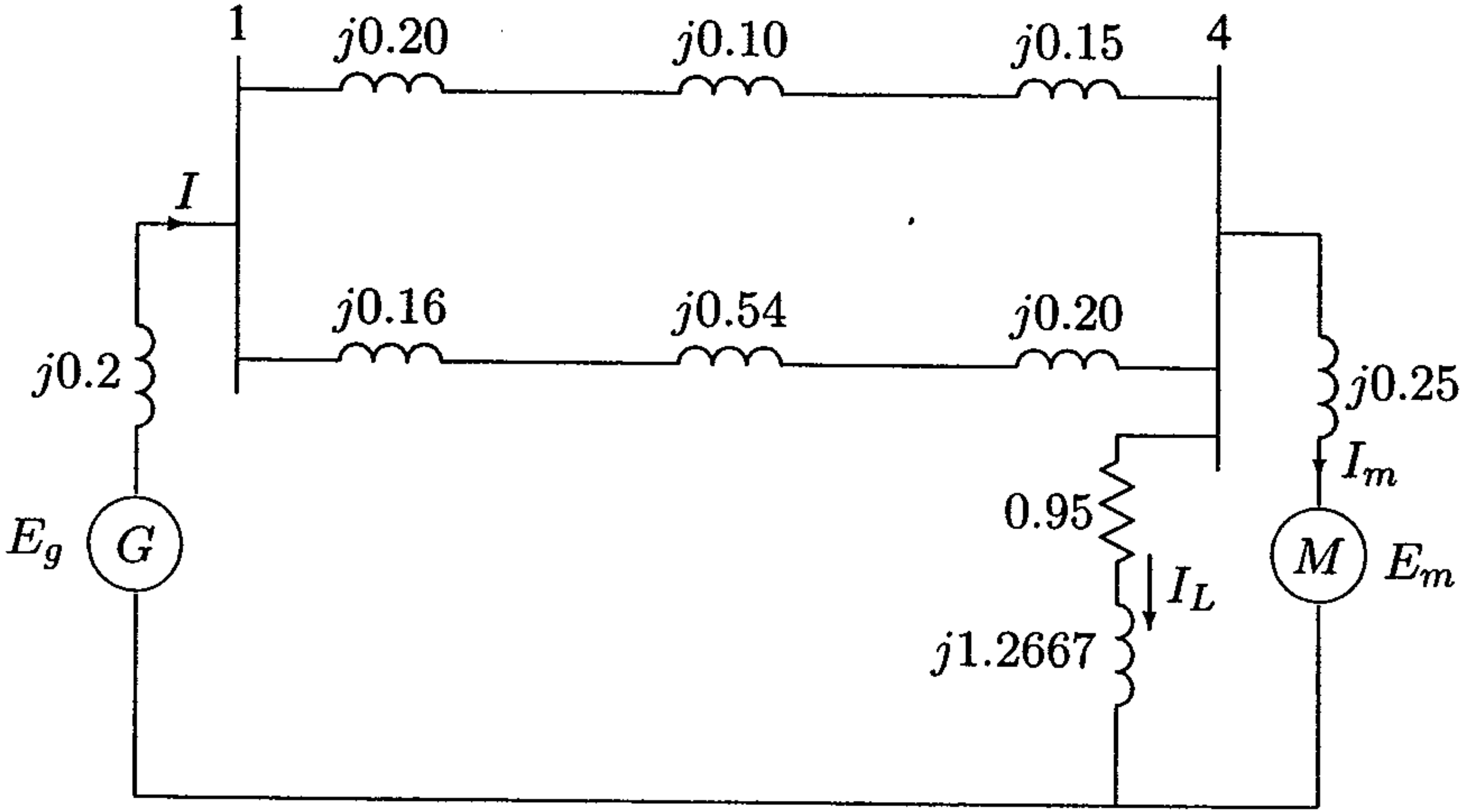


FIGURE 3.30
Per-unit impedance diagram for Example 3.7.

TUGAS

3.13. Draw an impedance diagram for the electric power system shown in Figure 26 showing all impedances in per unit on a 100-MVA base. Choose 20 kV as the voltage base for generator. The three-phase power and line-line ratings are given below.

G_1 :	90 MVA	20 kV	$X = 9\%$
T_1 :	80 MVA	20/200 kV	$X = 16\%$
T_2 :	80 MVA	200/20 kV	$X = 20\%$
G_2 :	90 MVA	18 kV	$X = 9\%$
Line:		200 kV	$X = 120\ \Omega$
Load:		200 kV	$S = 48\text{ MW} + j64\text{ Mvar}$

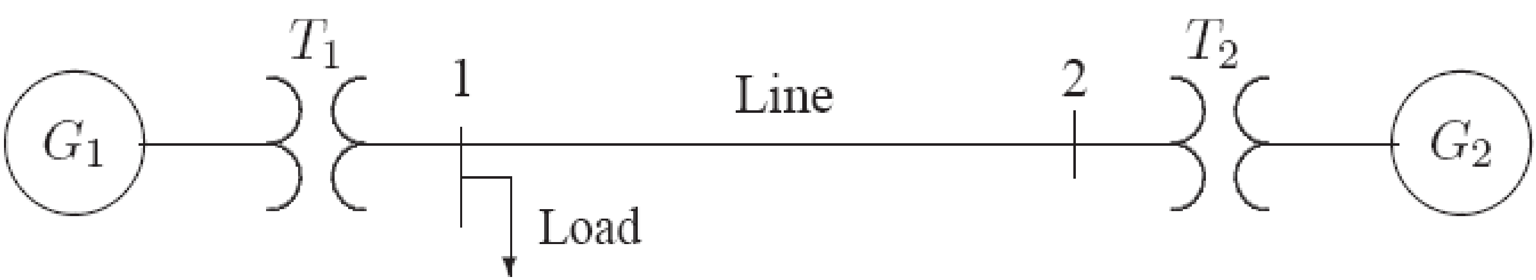


FIGURE 26
One-line diagram for Problem 3.13