

EE303 — Energy Systems and Power Electronics

Lecture 12. Per unit analysis

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Electrical & Computer Engineering

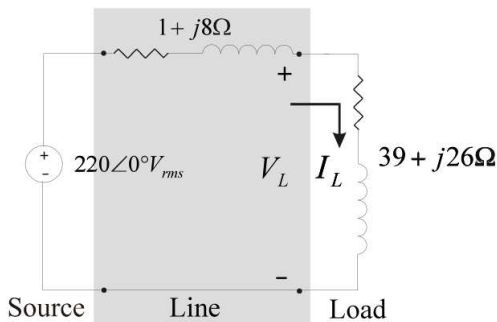
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Today's objectives

- **LIST** advantages and disadvantages of the “per unit” transformation
- **DEFINE** per unit voltage, current, power, and impedance in single-phase and three-phase circuits
- **DERIVE** the equation of power in per unit quantities
- **COMPUTE** the per unit impedance of transformers
- **OUTLINE** a methodology for analyzing large power systems using per unit quantities
- **DESCRIBE** how to “change base” for a per unit impedance

Problem B4.1, p. 28

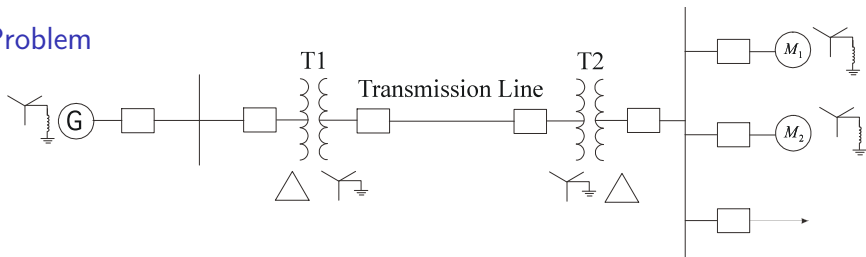
Problem



- ① Calculate the load current and voltage.
- ② Calculate the real and reactive power delivered to the load.
- ③ Repeat the above calculation in per-unit choosing a base of 220 V for the voltage, and a base of 1500 VA for the power.
- ④ Verify the values obtained in (3) with those obtained in (1), (2).

Problem B4.2, p. 33

Problem



We select a **base voltage** of 161 kV for the transmission line, and a **base volt-ampere** of 20 MVA. Find the per-unit impedances of all components referred to these bases. The components have ratings as follows: **Generator G**: 15 MVA, 13.8 kV, $x = 0.15$ per-unit (p.u.); **Motor M1**: 5 MVA, 13.2 kV, $x = 0.15$ p.u.; **Motor M2**: 5 MVA, 13.2 kV, $x = 0.15$ p.u.; **Transf. T1**: 25 MVA, 13.2/161 kV, $x = 0.10$ p.u.; **Transf. T2**: 15 MVA, 13.8/161 kV, $x = 0.10$ p.u.; **Load**: 4 MVA at 0.8 pf lagging; **Transm. Line**: $x = j100 \Omega$

Problem B4.3, p. 34 (a very simple application)

Problem

A balanced Y-connected voltage source with $\tilde{V}_{ab} = 480 + j0$ V is applied to a balanced Δ -connected load, $Z_{\Delta} = 45\angle 40^{\circ}$ Ω . The impedance between the source and the load is $Z_L = 1\angle 86^{\circ}$ Ω . Calculate the per-unit current and actual current in phase "a" of the line using $S_b = 15$ kVA and $V_b = 480$ V.

Reading material

The material we covered today corresponds to:

- Module B4, pp. 25–39 of the class notes