EE303 — Energy Systems and Power Electronics

Lecture 16. Electric power generation

Prof. Dionysios Aliprantis

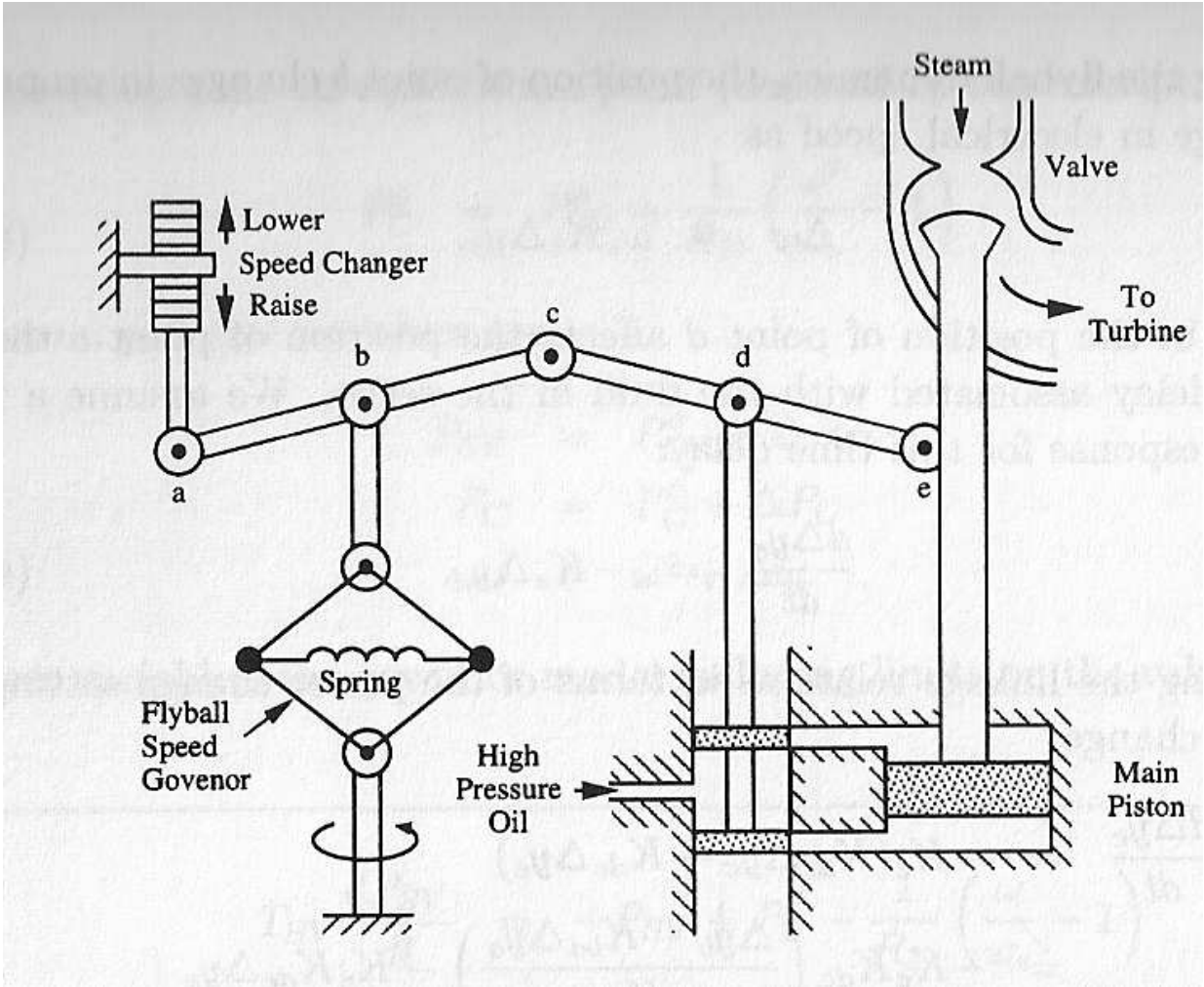
Electrical & Computer Engineering

Oct. 15, 2009

Today's objectives

- LEARN principles of multi-pole electric machines
- DISCUSS generators' voltage and speed control systems

Mechanical-hydraulic speed governor



Source: P. W. Sauer and M. A. Pai, "Power System Dynamics and Stability," Stipes Publishing, 2006

Example G1.1, p. 45

Example

A 10 MVA, 3 phase, Y-connected, two pole, 60 Hz, 13.8 kV (line to line) generator has a synchronous reactance of 20 ohms per phase. Find the excitation voltage E_f if the generator is operating at rated terminal voltage and supplying:

- 300 Amperes at 30 degrees lagging
- 300 Amperes at 30 degrees leading

Example G1.2, p. 47

Example

Find P_{out} and Q_{out} for the two conditions described in the previous example.

Problem 1, p. 55

Problem

A three-phase, 60 Hz generator has a synchronous reactance of $0.9\ \Omega/\phi$ *and negligible resistance. The generator is delivering 50 MW at 0.8 power factor lagging. The terminal voltage remains constant at 30 kV line to line throughout this problem.*

- *Determine the excitation voltage per phase (angle and magnitude) and the reactive power out of the machine.*
- *With the field current held constant at the level of part (a), the mechanical power into the machine is reduced to 25 MW. Determine the reactive power out of the machine.*
- *With the machine initially generating 50 MW at 0.8 power factor lagging, as in part (a), a change is made so that the excitation voltage is reduced to 79.2% of its value. Determine the reactive power out of the machine.*

Problem 2, p. 55

Problem

A three-phase, 6-pole, 60 Hz, Y-connected synchronous generator has a synchronous reactance of $X_s = 2\ \Omega/\phi$. It is operating so that the terminal voltage is constant at 13.8 kV line-to-line. The three-phase real power output of the machine is 6 MW.

- *What is the synchronous speed of this generator in RPM?*
- *The excitation voltage magnitude is 19 kV line-to-line. What is the power angle δ? Based on this answer, indicate whether the generator is operating leading or lagging, and how you can tell.*
- *What is the magnitude and angle of the current I_a? Based on this answer, indicate whether the generator is operating leading or lagging and how you can tell.*
- *Compute the three phase reactive power out of the machine. Based on this answer, indicate whether the generator is ...*

Reading material

The material we covered today corresponds to:

- Module G1, pp. 40–58 of the class notes
- Chapter 12.1, pp. 309–313 of textbook
- Chapter 12.4, pp. 339–358 of textbook
- Supplementary notes on synchronous generators (available online)