COLORADO SCHOOL OF MINES

ELECTRICAL ENGINEERING DEPARTMENT

EENG577 Advanced Electric Machine Dynamics for Smart-Grid Systems

M3 Assignment 1: Synchronous Generators

4-2 (a-d, 20 pts)

A 13.8-kV, 50-MVA, 0.9-power-factor-lagging, 60-Hz, four-pole Y-connected synchronous generator has a synchronous reactance of 2.5 Ω and an armature resistance of 0.2 Ω. At 60 Hz, its friction and windage losses are 1 MW, and its core losses are 1.5 MW. The field circuit has a dc voltage of 120 V, and the maximum I_F is 10 A. The current of the field circuit is adjustable over the range from 0 to 10 A. The OCC of this generator is shown in Figure P4-1.

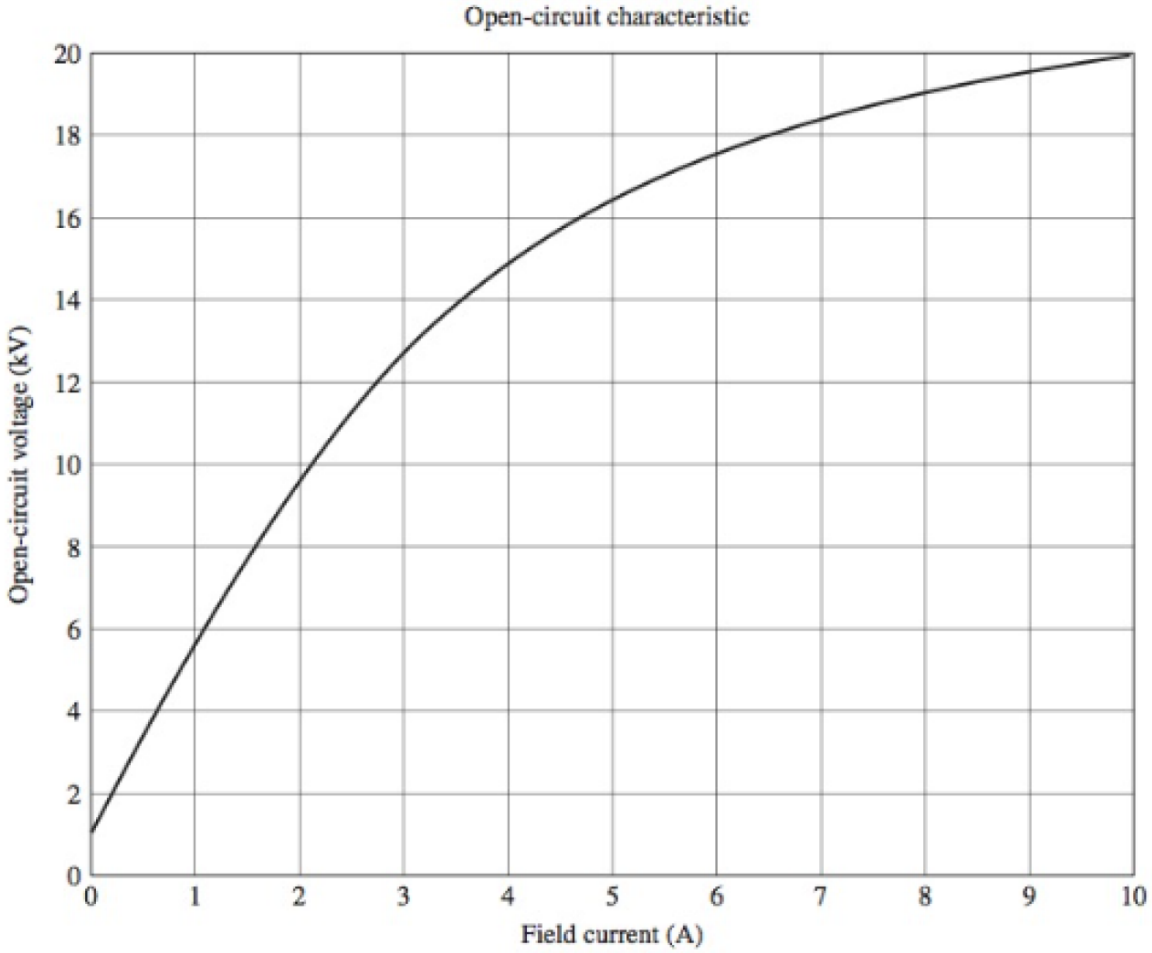

Figure P4-1
Open-circuit characteristic curve for the generator in Problem 4-2.

From required textbook: *Electric Machinery Fundamentals,* by Stephen J. Chapman, 5th Edition, © 2012.

a) How much field current is required to make the terminal voltage V_T (or line voltage V_I) equal to 13.8 kV when the generator is running at no load?
b) What is the internal generated voltage E_A of this machine at rated conditions?
c) What is the phase voltage V_Φ of this generator at rated conditions?
d) How much field current is required to make the terminal voltage V_T equal to 13.8 kV when the generator is running at rated conditions?

4-6 (a-d, 20 pts)

The internal generated voltage E_A of a 2-pole Δ-connected, 60 Hz, three phase synchronous generator is 14.4 kV, and the terminal voltage V_T is 12.8 kV. The synchronous reactance of this machine is 4 Ω, and the armature resistance can be ignored.

a. If the torque angle of the generator $\delta = 18°$, how much power is being supplied by this generator at the current time?
b. What is the power factor of the generator at this time?
c. Sketch the phasor diagram under these circumstances?
d. Ignoring losses in this generator, what torque must be applied to its shaft by the prime mover at these conditions?

4-7 (a-c, 15 pts)

A 100-MVA, 14.4-kV, 0.8-PF-lagging, 50-Hz, two-pole, Y-connected synchronous generator has a per-unit synchronous reactance of 1.1 and a per-unit armature resistance of 0.011.

a) What are its synchronous reactance and armature resistance in ohms?
b) What is the magnitude of the internal generated voltage E_A at the rated conditions? What is its torque angle δ at these conditions?
c) Ignoring losses in the generator, what torque must be applied to its shaft by the prime mover at full load?

4-8 (a-e, 25 pts)

A 200-MVA, 12-kV, 0.85-PF-lagging, 50-Hz, 20-pole, Y-connected water turbine generator has a per-unit synchronous reactance of 0.9 and a per-unit armature resistance of 0.1. This generator is operating in parallel with a large power system (infinite bus).

a) What is the speed of rotation of this generator's shaft?
b) What is the magnitude of the internal generated voltage E_A at rated conditions?
c) What is the torque angle of the generator at rated conditions?
d) What are the values of the generator's synchronous reactance and armature resistance in ohms?
e) If the field current is held constant, what is the maximum power possible out of this generator? How much reserve power or torque does this generator have at full load?

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