ELEC-E8422 An Introduction to Electric Energy

Exercises - Lecture 11 Synchronous Machine

EX 1 Equivalent circuit

We consider a 14 kV, 10 MVA, 50 Hz, 2 poles, star-connected generator. The generator is running at its rated condition (rated current and complex power) at a lagging power factor of 0.85.

a) calculate the real (active) and imaginary (reactive) power of the generator (P and Q)
b) Calculate the rated current of the generator and write it as a phasor (complex number)
c) The equivalent circuit of the synchronous generator with a typical phasor diagram is shown in the figure below. $X_s = 20\Omega$ per phase and the resistance can be neglected. Use the equivalent circuit and calculate the excitation voltage E_f (complex number).
d) Under a request from the grid operator, to increase the reactive power, the excitation voltage is increased by 10%, while the active power is kept at its previous value. Calculate the new value of the load angle
e) calculate the new value of the current (amplitude and phase)
f) calculate the new value of the reactive power
g) Is this an operation point of the generator in which it can run continuously? why?

Below is a figure for the reactive power control of the synchronous machine and some equations that might help to solve the exercise

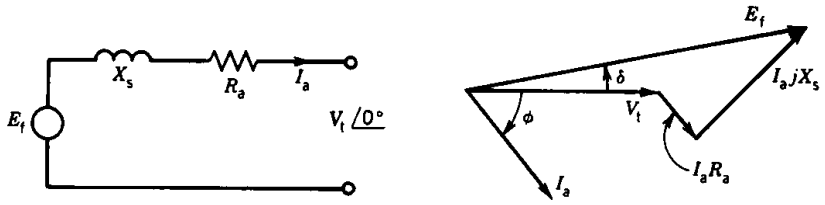
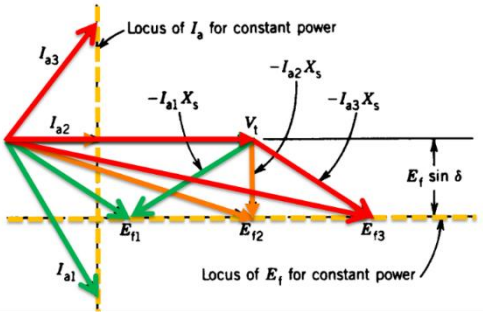


Figure: equivalent circuit of a synchronous generator and a typical phasor diagram.



$$P = 3V_t I_a \cos\phi$$

$$P = 3\frac{V_t E_f}{X_s}\sin\delta$$