EEP 225 : Electric Machines

Problem on Synchronous Machines

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Take home exam 2019-2020

I solved the problem on my own, so mistakes are ***highly*** probable

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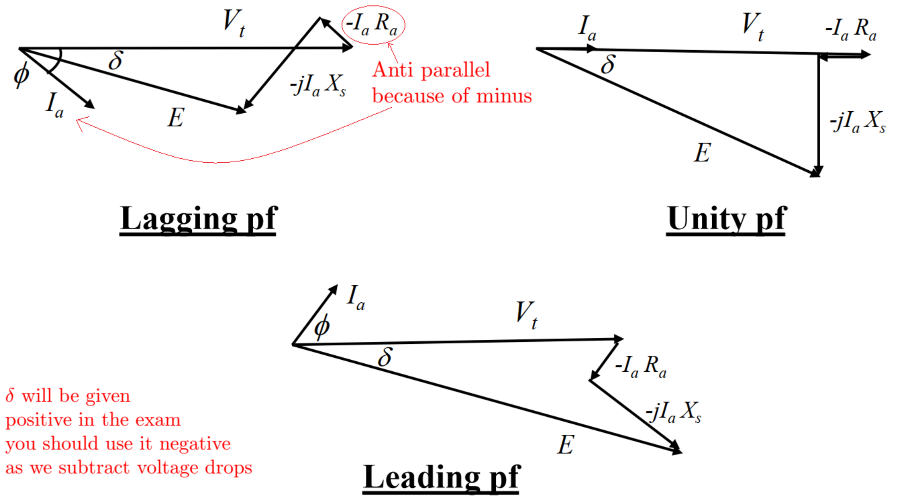
$\boxed{1.\ \mathrm{Q}}$ — Using neat sketches, discuss the effect of excitation on synchronous motors then explain what is meant by V-curves.

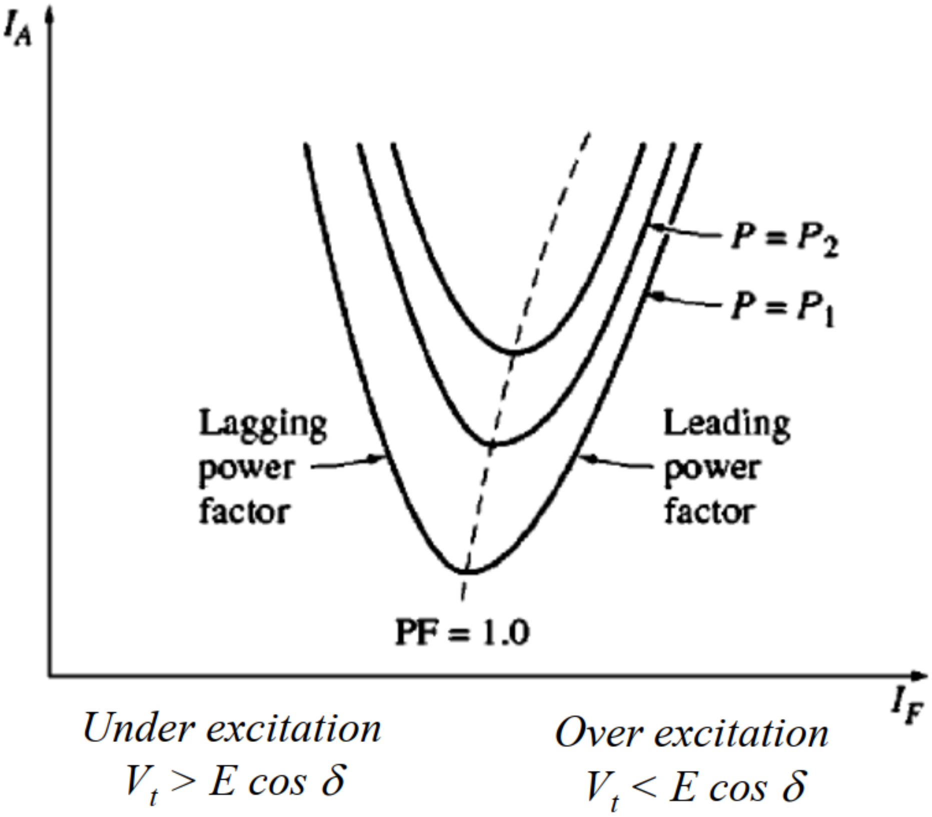
1.

A —



As seen, synchronous motor are the only motors in which changing the excitation changes the power factor

2.



V-curves represents the relationship between the field current I_f and armature current I_a for different values of load power

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2. Q — A 3-phase, Y-connected alternator is connected to 6600 V infinite bus-bars to which it delivers a current of 150 A at 0.8 pf lagging. The synchronous reactance is 12 Ω / phase and armature resistance is neglected. If the steam admission is increased by 25% and the excitation is decreased by 40%.

Draw the electrical load diagram with 1cm represents 500V and determine:

(i) The new values of machine current, power factor and load angle.

(ii) The maximum developed power the machine can supply at the new value of excitation and the corresponding current and power factor.

A —

Given Line voltage, we want to get phase voltage.

$$V_{\text{tphase}} = \frac{6600}{\sqrt{3}} = 3810\,V$$

Let's know the scale:

$$
\begin{aligned}
1\,\text{cm} &= 500 \text{ Volts} \\
1\,\text{cm} &= 3 \times \frac{3810}{12} \times 500 = 476250 \text{ W} \\
1\,\text{cm} &= \frac{500}{12} = 41.6 \text{ Amp}
\end{aligned}
$$

Operating point (1) (before steam increases and excitation decreases):
Power:

$$P = \sqrt{3} \times 6600 \times 150 \times 0.8 = 1371784 \text{ Watt}$$

height of locus of power =

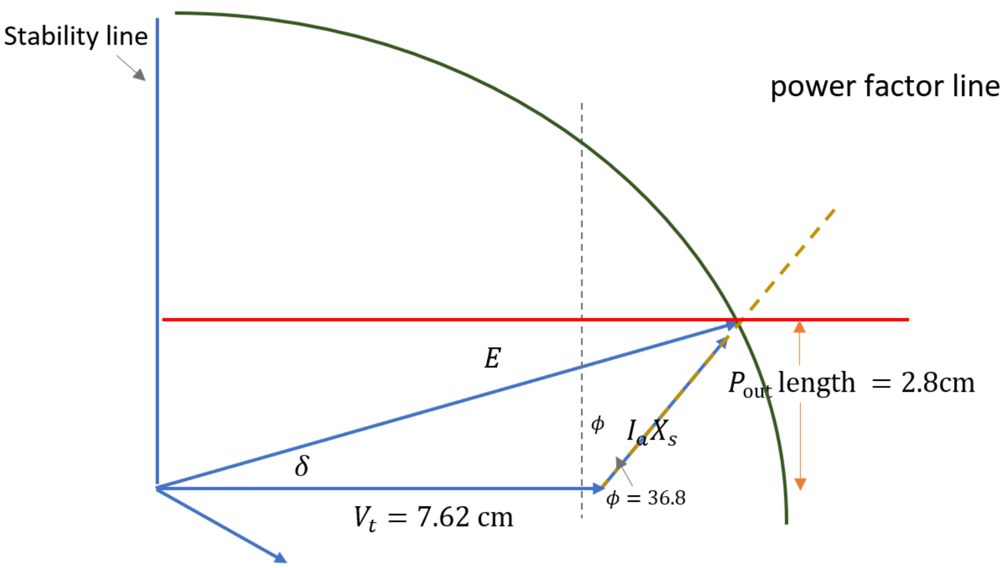
$$\frac{\text{power}}{\text{scale}} = \frac{1371784}{476250} = 2.8\text{cm}$$

length of $V_{t\text{phase}} = \frac{3810}{500} = 7.62\text{cm}$

we will draw $V_t = 7.62\text{cm}$

angle of power factor line $= \cos^{-1}(0.8) = 36.86°$ lagging

we will draw $\phi = 36.86°$ lagging



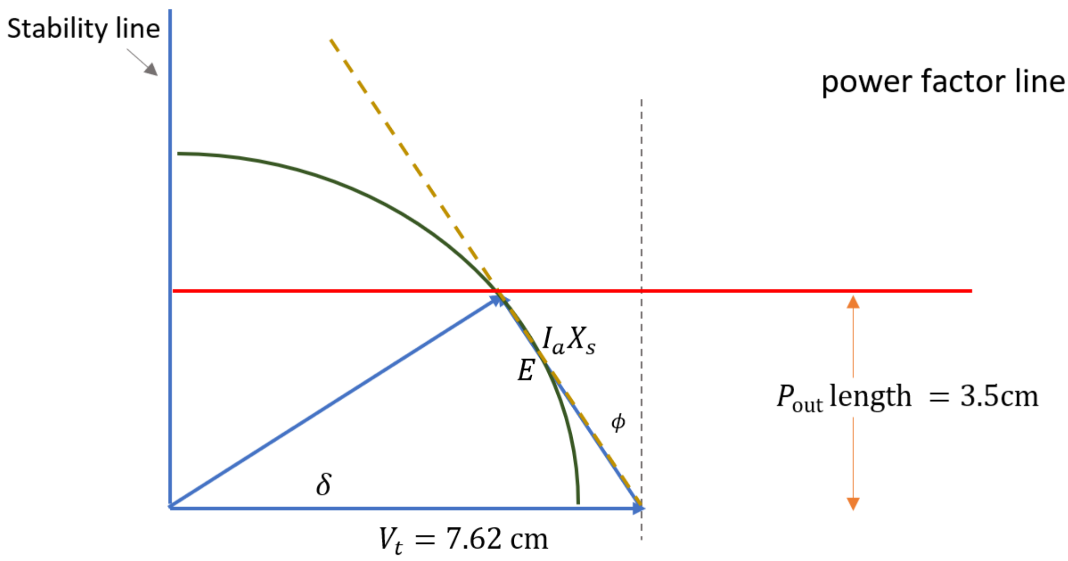
After drawing, we measure the length of E, we will find it (approximately) 10.5 cm, which means that $E = 10.5 \times 500 = 5250V$

Measure power angle, it equals $16.6°$

Remember from lecture 8 :

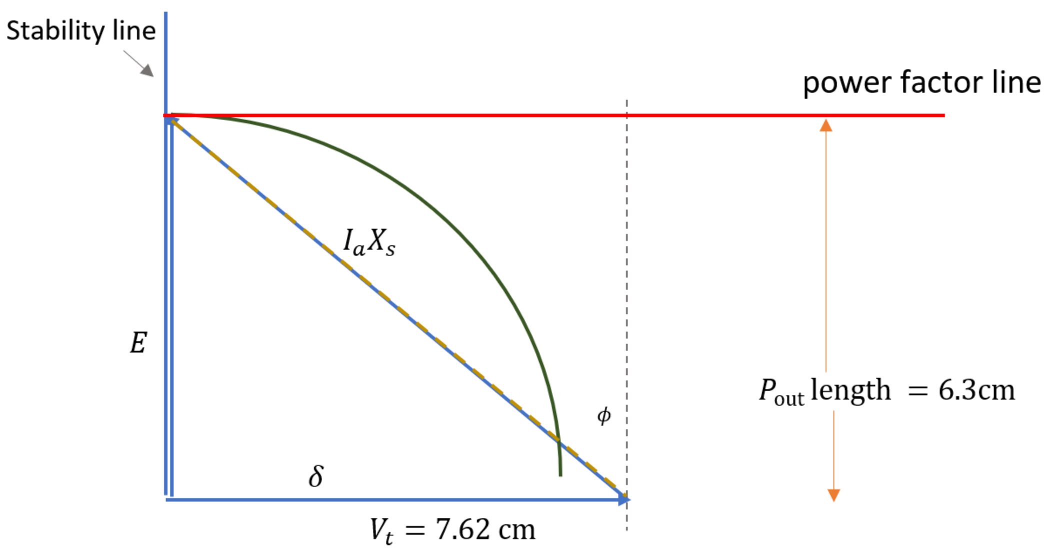
What if I tried to increase the speed of the prime mover by increasing the pressure of the steam?

Speed will not increase because of the constant frequency and voltage, but input torque will increase, which increases the power. If the steam admission is increased by 25% and the excitation is decreased by 40%. Power will be $2.8 \times 1.25 = 3.5$ cm and excitation will be $10.5 \times 0.6 = 6.3$ cm



From figure, $\delta = 33°$ and $\phi = 35°$

Maximum developed power:



$P_{\max} = 6.3 \times 476250 = 3000375$ Watt

From figure $\phi = 50^\circ$ so pf $= \cos(60) = 0.64$ lead.

Try to find the current yourself