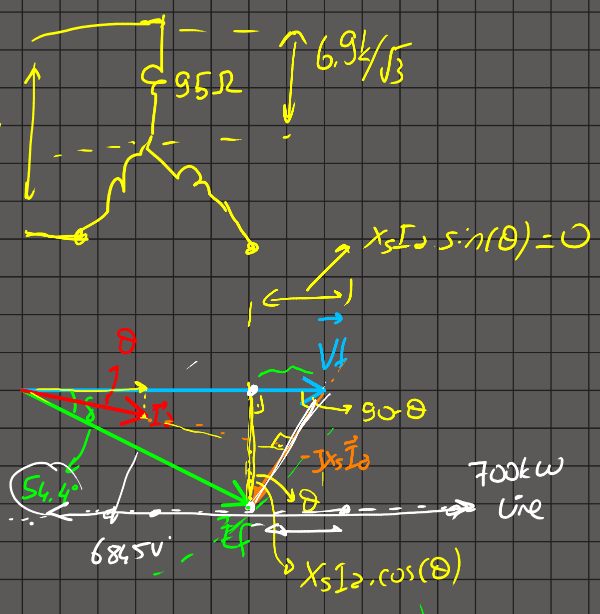
6.9 kV(l-l) 50 Hz synchronous motor has a synchronous reactance of 95 Ohm/phase. For this problem all losses and saturation effect may be neglected. – Y-connected

a) Compute the armature current and pf of the motor when supplying 700kW rated power and the load angle is 54.4 degrees. ✓

b) Compute the maximum power this motor can deliver if its field excitation is kept constant at the value in part a. Compute the power factor and armature current.

c) What should be the minimum percentage increase in the field current for the motor to supply 1 MW power.

d) What should be the excitation voltage for the motor to supply rated power while drawing minimum armature current?



a) $V_{ph} = \frac{6.9kV}{\sqrt{3}} = 3983V$

$P = 3 V_{ph} . I_{ph} . \cos(\theta)$

$700 kW = 3 . 3983 . I_{ph} \cos(\theta)$

$I_{ph} . \cos(\theta) = 58{,}6A$

$\tan(\delta) = \frac{X_s . I_a . \cos(\theta)}{V_t - X_s . I_a . \sin(\theta)}$

$E_f . \sin(\delta) = X_s . I_a . \cos(\theta)$ (54.4°, 95 Ω)

$V_t - X_s I_a . \sin(\theta) = \frac{95 . 58.6}{\tan(54.4)} =$

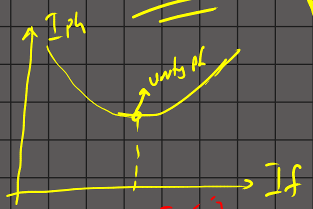
$|E_f| = 6845V$

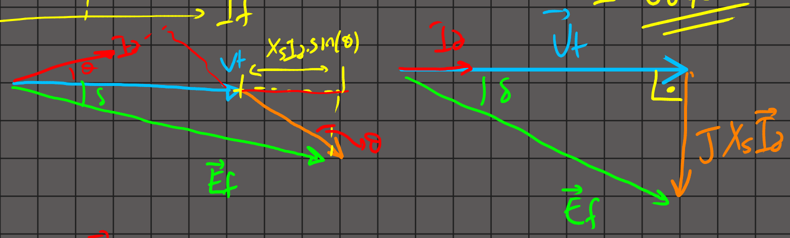
assume unity pf

$X_s I_a \sin(\theta) = 0 \Rightarrow \sin(\theta) = 0, \cos(\theta) = 1$

$E_f = \sqrt{(58.6 . 95)^2 + 3983^2}$

$= 6845 V$

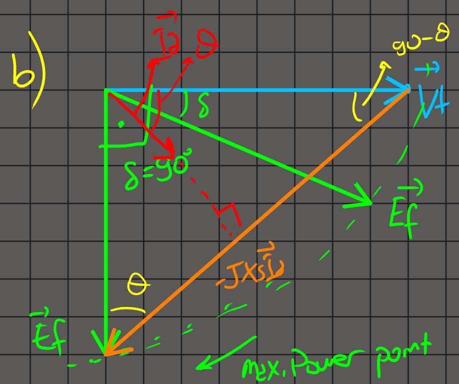




$\sqrt{V_t^2 + X_s I_a^2} = E_f$

$\sqrt{(3983)^2 + (58.6 . 95)^2} = 6845V$

b)



$|I_f|$ constant $\Rightarrow |E_f|$ constant $= 6845V$

$P_{max} \Rightarrow \delta = 90°$

$|X_s I_a| = \sqrt{V_t^2 + E_f^2} = \sqrt{3983^2 + 6845^2}$

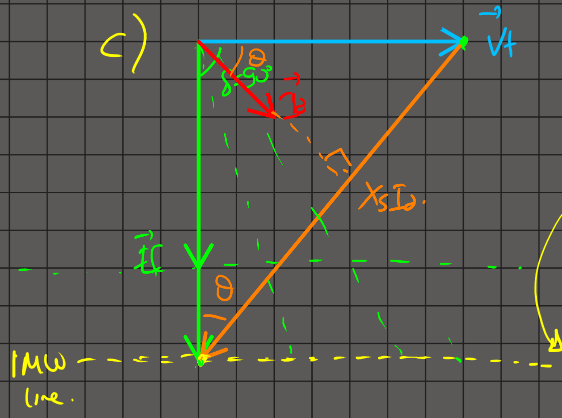
$X_s I_a = 7920 \Rightarrow I_a = 83{,}36A$

$\cos(\theta) = \frac{|E_f|}{X_s I_a} \Rightarrow 0{,}864$ (lagging)

$P = 3 V_{ph} . I_{ph} . \cos(\theta)$

$= 3 . \frac{6900}{\sqrt{3}} . 83{,}36 . \cos(\theta) = 860{,}7 kW$

c)



$P = \dfrac{3 \cdot V_t \cdot E_f}{X_s} \cdot \sin(\delta)$

$|E_f|$ should be increased by increasing $|I_f|$

$P = 3 V_t \cdot I_a \cdot \cos(\theta) = 1\,MW$

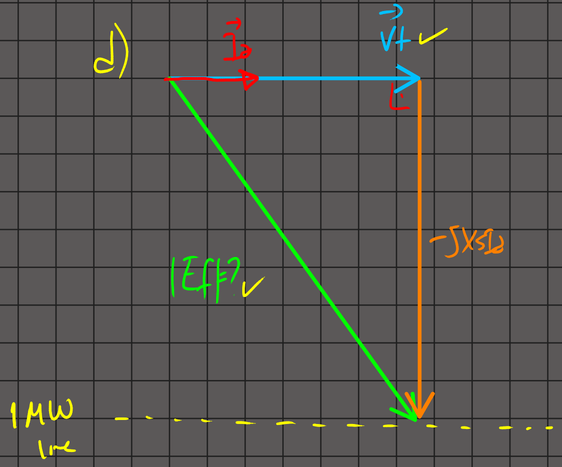
$E_f \cdot \sin(\delta) = X_s \cdot I_a \cdot \cos(\theta)$

$|E_f| = 7948\,V$

$\dfrac{7948}{6845} = 1.16 \Rightarrow I_f$ should be increased by 16%

(6845 ↑ old value)

d)



$3 V_t I_a \cdot \cos(\theta) = 1\,MW$ ($\cos(\theta) = 1$ in unity pf)

$I_a = 83.68\,A$

$E_f = \sqrt{V_t^2 + X_s I_a^2}$

$= \sqrt{3983^2 + (95 \cdot 83.68)^2}$

$|E_f| = 8892\,V$

→ $I_a^2 \cdot R_a$ loss decreased compared to part (c)

$I_f^2 \cdot R_f$ loss increased " " " "

field loss << armature loss