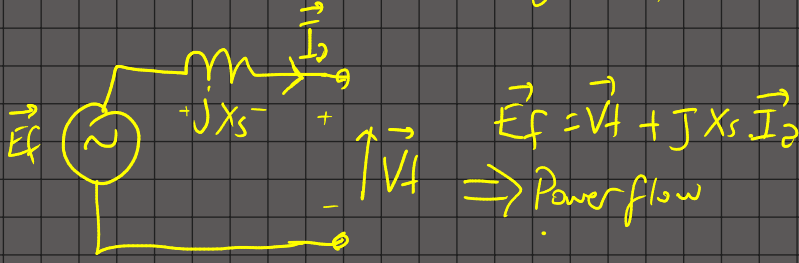
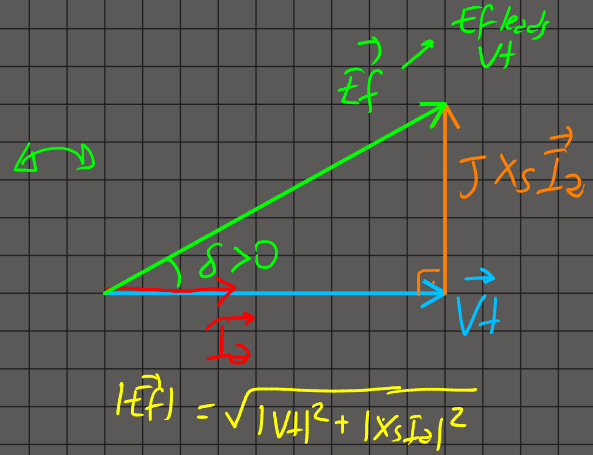
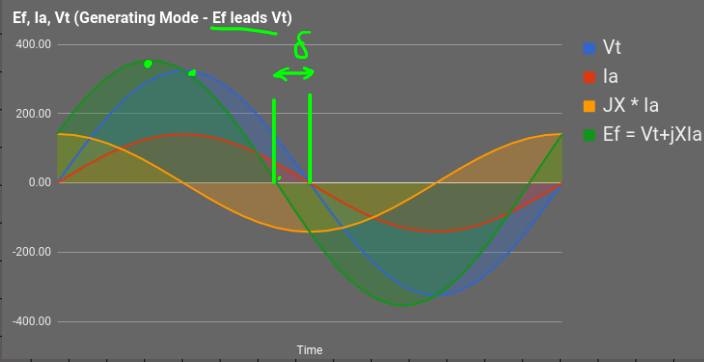


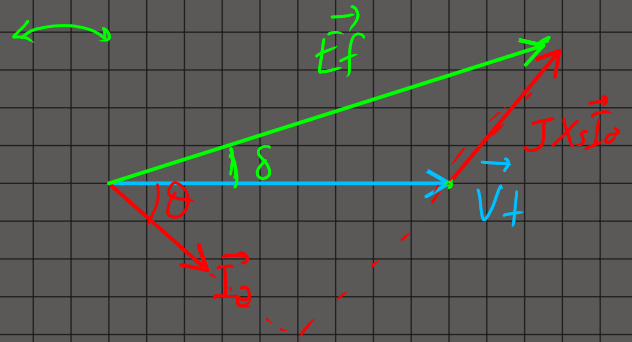
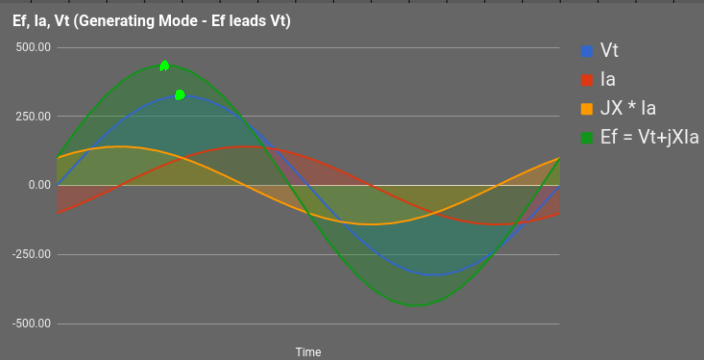
I) Synchronous Machine (Generating Mode)



a) Unity pf. current

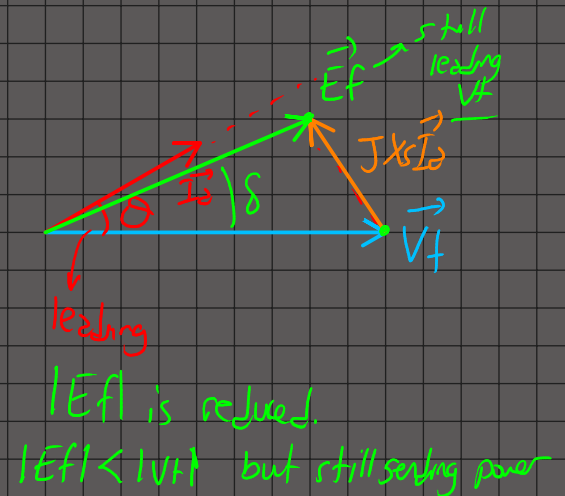
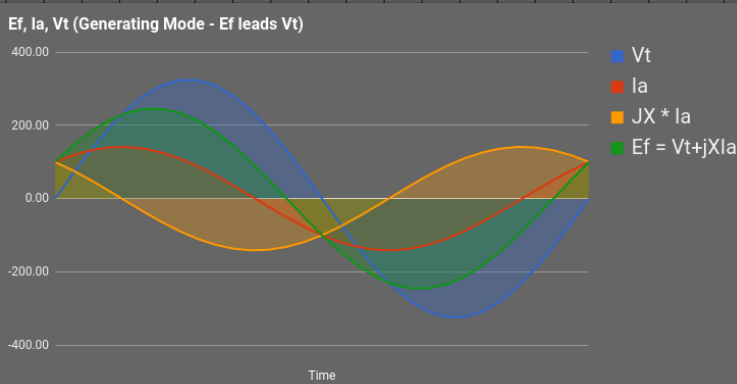


b) Lagging Pf. (generating)

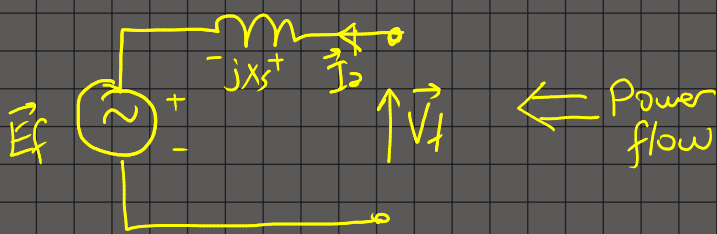


$|\vec{E}_f|$ is increased
 δ is decreased
 $E_f \propto I_f \rightarrow I_f$ is increased

c) Leading pf. (generating mode)



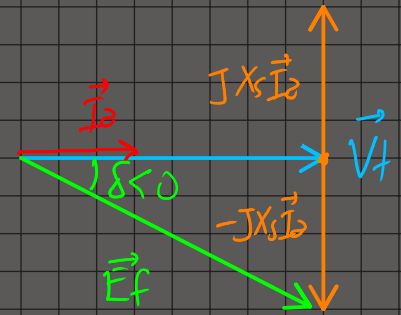
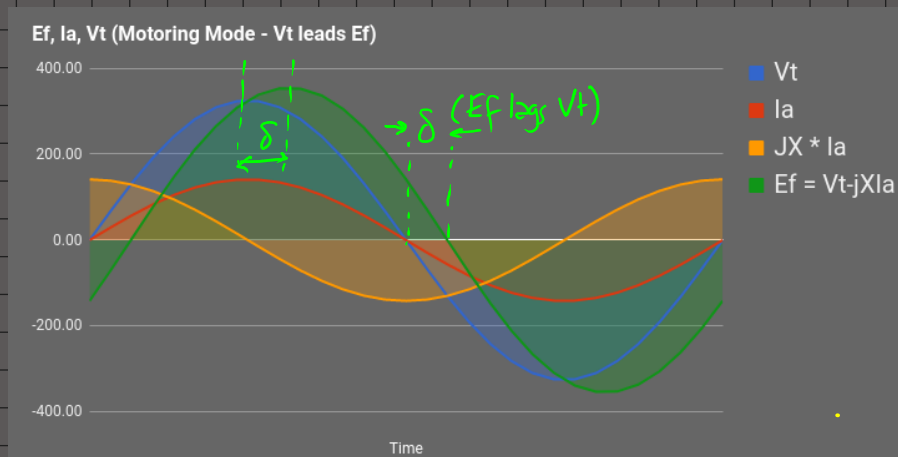
II) Synchronous Machine (Motoring Mode)



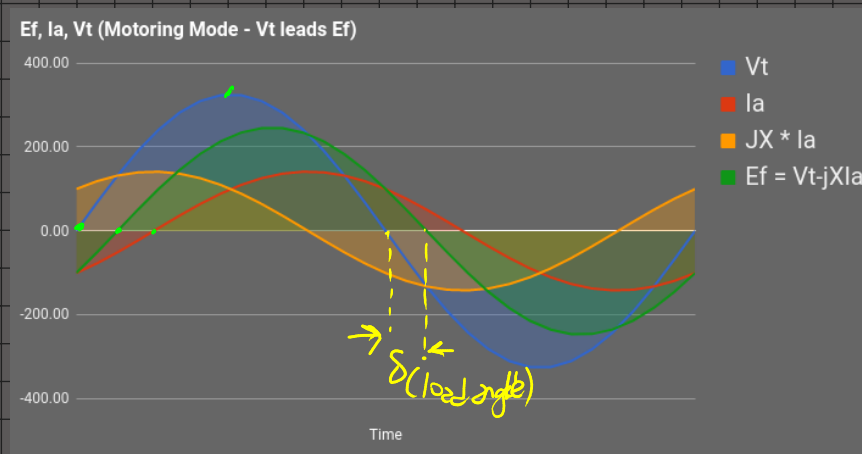
$$\vec{E}_f + jX_s \vec{I}_a = \vec{V}_t$$

$$\vec{E}_f = \vec{V}_t - jX_s \vec{I}_a$$

a) Unity pf. (Motoring mode)



b) Lagging pf (Motoring mode)

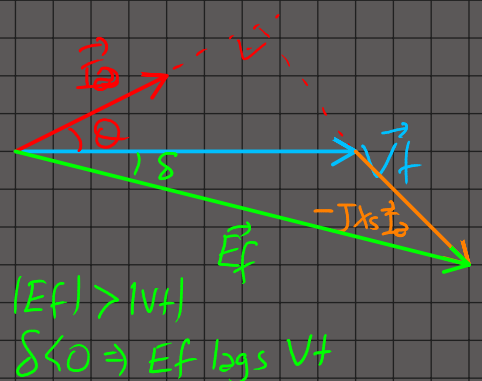
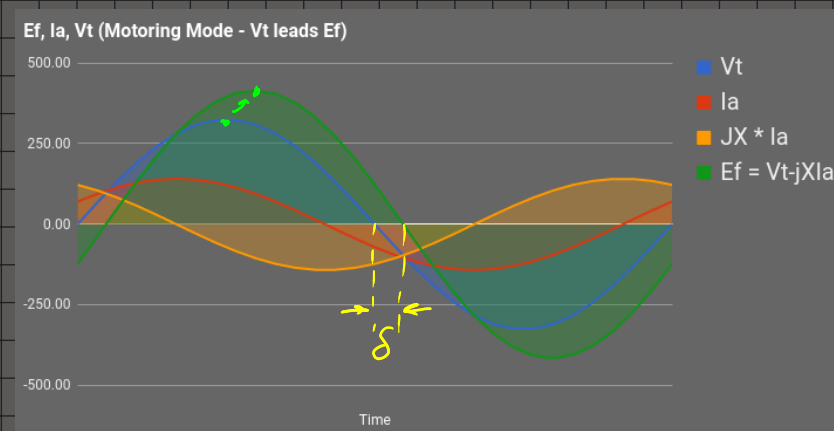


$$|E_f| < |V_t|$$

$$\vec{E}_f \text{ lags behind } \vec{V}_t$$

$$\delta < 0$$

c) Leading pf (Motoring mode)



$$|E_f| > |V_t|$$

$$\delta < 0 \Rightarrow \vec{E}_f \text{ lags } \vec{V}_t$$

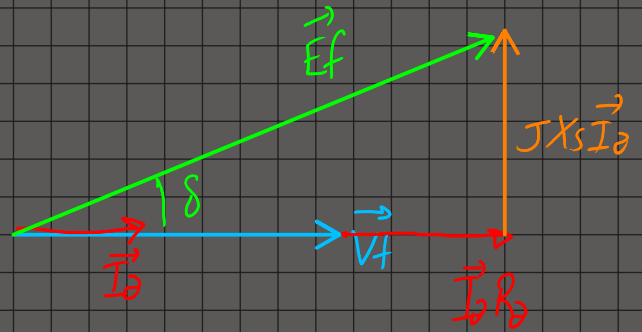
Models with Resistance (R_a)

I) Generating Mode (with R_a)

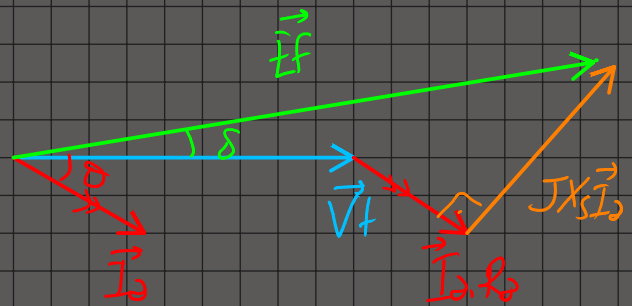


$$\begin{aligned} \vec{E}_f &= \vec{V}_t + \vec{I}_a \cdot R_a + \vec{I}_a JX_s \\ &= \vec{V}_t + \vec{I}_a (R_a + JX_s) \end{aligned}$$

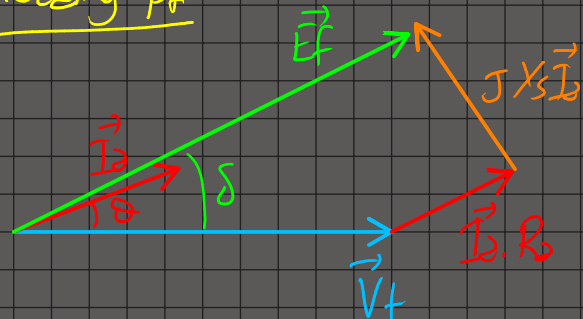
Unity Pf



lagging pf



leading pf



Models with Resistance (R_2)

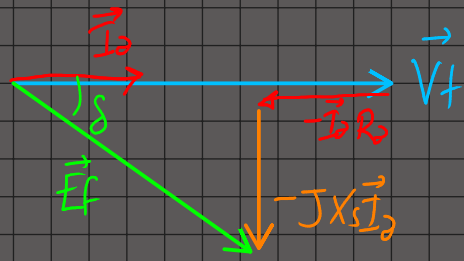
I) Motoring Mode (with R_2)



$$\vec{V}_t = \vec{E}_f + \vec{I}_a (R_2 + jX_s)$$

$$\vec{E}_f = \vec{V}_t - \vec{I}_a R_2 - jX_s \vec{I}_a$$

Unity (pf)



Lagging current



Leading current

