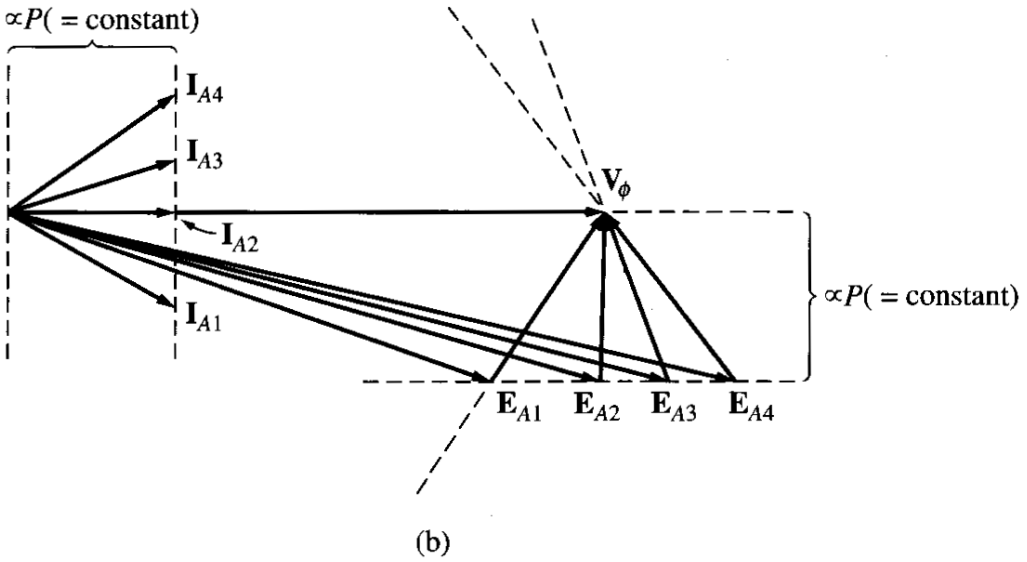
Effect of Field Current Changes on Synchronous Motor w/ constant Load

- The mechanical power out of the motor is roughly proportional to the electrical power into the motor. From earlier

$$P = 3V_\phi I_A \cos\theta = \frac{3V_\phi E_A \sin\delta}{X_S}.$$

- Assume an 'infinite bus' where the terminal voltage V_T for the motor and V_ϕ as well as electrical frequency ω are constant. This implies phasor $\overline{V}_\phi = V_\phi \angle 0°$ is constant.
- If the load P is constant, then $I_A \cos\theta$ and $E_A \sin\delta$ must be as well.
- $E_A = \left|\overline{E}_A\right| = k\phi\omega$ increases when an increase in I_f causes magnetic flux ϕ to increase (ω constant). This implies phasor $\overline{E}_A$ traces a line to maintain constant power $\Rightarrow$ **torque angle δ decreases**. See Figure 5-34b below.

Figure 5–34 (a) A synchronous motor operating at a lagging power factor. (b) The effect of an increase in field current on the operation of this motor.

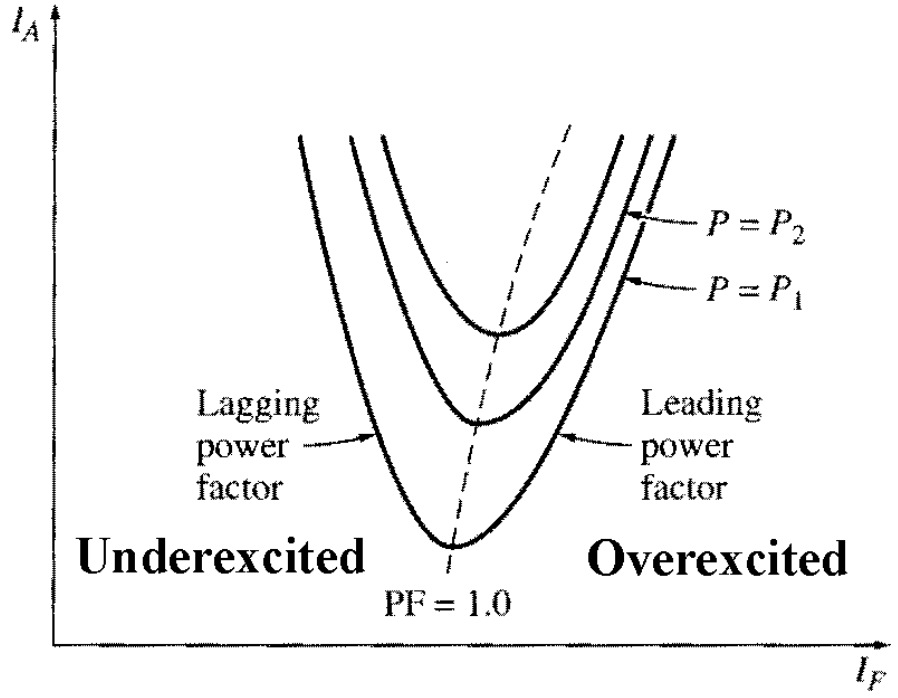


(b)

- On diagram, note when $E_A < V_\phi$, $\overline{I}_A$ will have a **lagging power factor (PF)**, the motor is **underexcited**.
- For $E_A = V_\phi$, $\overline{I}_A$ has a unity PF and I_A is minimized. Motor looks like a purely resistive load.
- When $E_A > V_\phi$, $\overline{I}_A = I_A$ will have a leading PF, the motor is **overexcited**.

- **Synchronous motor PF can be adjusted by changing field current I_f!**
- This is shown in Figure 5-35 where I_A is plotted versus I_f for different loads.

Figure 5–35 | Synchronous motor V curves.



- Big implications as there is an alternative to capacitor banks for PF correction.
- Positives- Overexcited synchronous motor can correct for other lagging PF loads (lower utility costs, smaller transmission lines, …). Motor will have a higher maximum torque τ_{max}.
- Drawbacks- Higher I_f means higher ohmic losses in rotor coil, must be careful with cooling of rotor. Need loads where constant ω is acceptable.