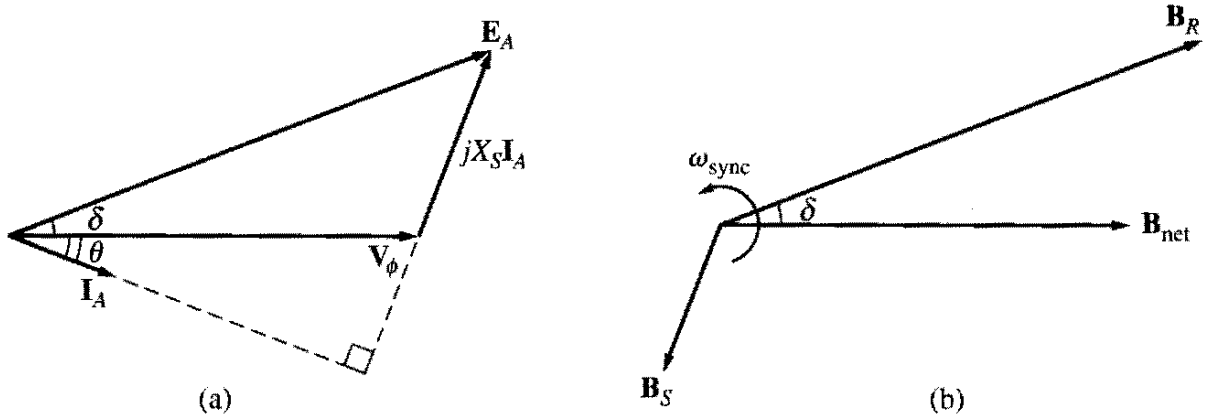
# Synchronous Generator Phasor Diagrams

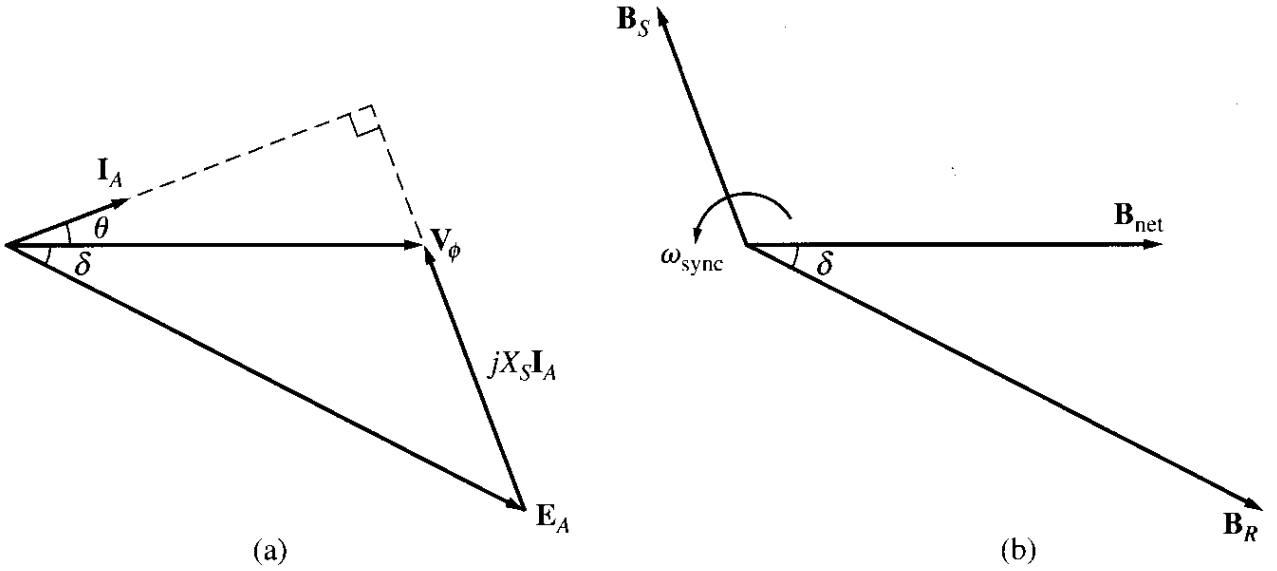
**Figure 5–29** (a) Phasor diagram of a synchronous generator operating at a lagging power factor. (b) The corresponding magnetic field diagram.




- Here, $\overline{E}_A = \overline{V}_\phi + R_A\overline{I}_A + jX_S\overline{I}_A \approx \overline{V}_\phi + jX_S\overline{I}_A$ produces the phasor diagram seen on the left of Figure 5-29 where $\overline{I}_A$ assumes a lagging PF load.
- Note $\overline{E}_A$ **leads** $\overline{V}_\phi$ for a **generator**.
- The phasor diagram on the right of Figure 5-29 shows the magnetic flux density vectors.
- The rotor rotating magnetic flux density $\overline{B}_R$ induces $\overline{E}_A$.
- $\overline{B}_{\text{net}} = \overline{B}_R + \overline{B}_S$ is related to the phase voltage $\overline{V}_\phi$.
- The armature current $\overline{I}_A$ (related to $\overline{E}_{\text{stator}} = -(R_A\overline{I}_A + jX_S\overline{I}_A) \approx -jX_S\overline{I}_A$ ) generates the stator magnetic flux density $\overline{B}_S$ that is smaller than $\overline{B}_R$. Note the direction of $\overline{B}_S$ is orthogonal to $\overline{I}_A$.
- Note $\overline{B}_R$ **leads** $\overline{B}_{\text{net}}$ for a **generator**.
- The induced torque for the generator $\overline{\tau}_{\text{ind}} = k\,\overline{B}_R \times \overline{B}_{\text{net}}$ is in the clockwise direction **opposing** the direction of rotation $\omega_{\text{sync}}$ (and the torque applied by the external prime mover).

# Synchronous Motor Phasor Diagrams

**Figure 5–30** | (a) Phasor diagram of a synchronous motor. (b) The corresponding magnetic field diagram.




- Here, $\overline{V}_\phi = \overline{E}_A + R_A\overline{I}_A = jX_S\overline{I}_A \approx \overline{E}_A + jX_S\overline{I}_A$ produces the phasor diagram seen on the left of Figure 5-30. Remember the assumed direction of the armature current $\overline{I}_A$ is reversed for a motor.
- Note $\overline{E}_A$ **lags** $\overline{V}_\phi$ for a **motor** (as expected).
- The phasor diagram on the right of Figure 5-30 shows the magnetic flux density vectors. Note the direction of $\overline{B}_S$ again is orthogonal to $\overline{I}_A$.
- Note $\overline{B}_R$ **lags** $\overline{B}_{\text{net}}$ for a **motor** (rotor tries to 'catch up').
- The induced torque for the motor $\overline{\tau}_{\text{ind}} = k\,\overline{B}_R \times \overline{B}_{\text{net}}$ is in the counterclockwise direction **same** as the direction of rotation $\omega_{\text{sync}}$.