Induction Motors Drive: Speed Control

- Block Diagram
- Rotor Losses
- Minimizing Slip Speed
- Operating Characteristics at rated flux density
- V/f operation
- Including the drop across the Stator Resistance

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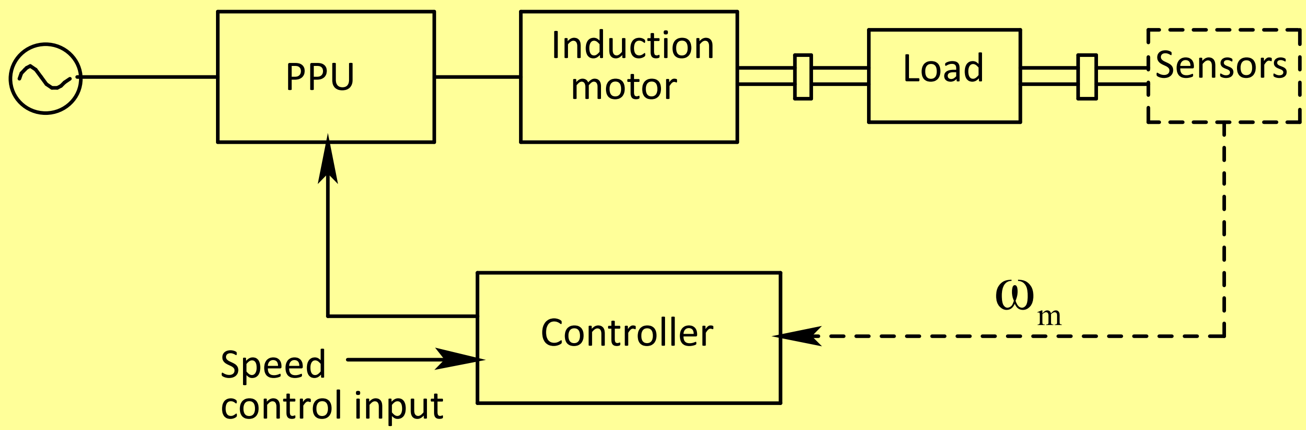
Induction Motor Drives : Speed Control



- Efficient speed control over a wide range
  - Reduced voltage control (inefficient)
  - Frequency control (efficient)
- PPU drives induction motor with variable frequency to maintain low slip
- As frequency decreases, voltage must also decrease to avoid magnetic saturation

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Rotor Losses

Power crossing air gap to rotor:

$$P_r = T_{em}\ \omega_{syn}$$

Power delivered through rotor to load:

$$P_{em} = T_{em}\ \omega_m$$

Power lost in rotor:

$$P_{r,loss} = P_r - P_{em} = T_{em}\ (\omega_{syn} - \omega_m) = T_{em}\ \omega_{slip}$$

Therefore, to minimize rotor losses, ω_{slip} should be small

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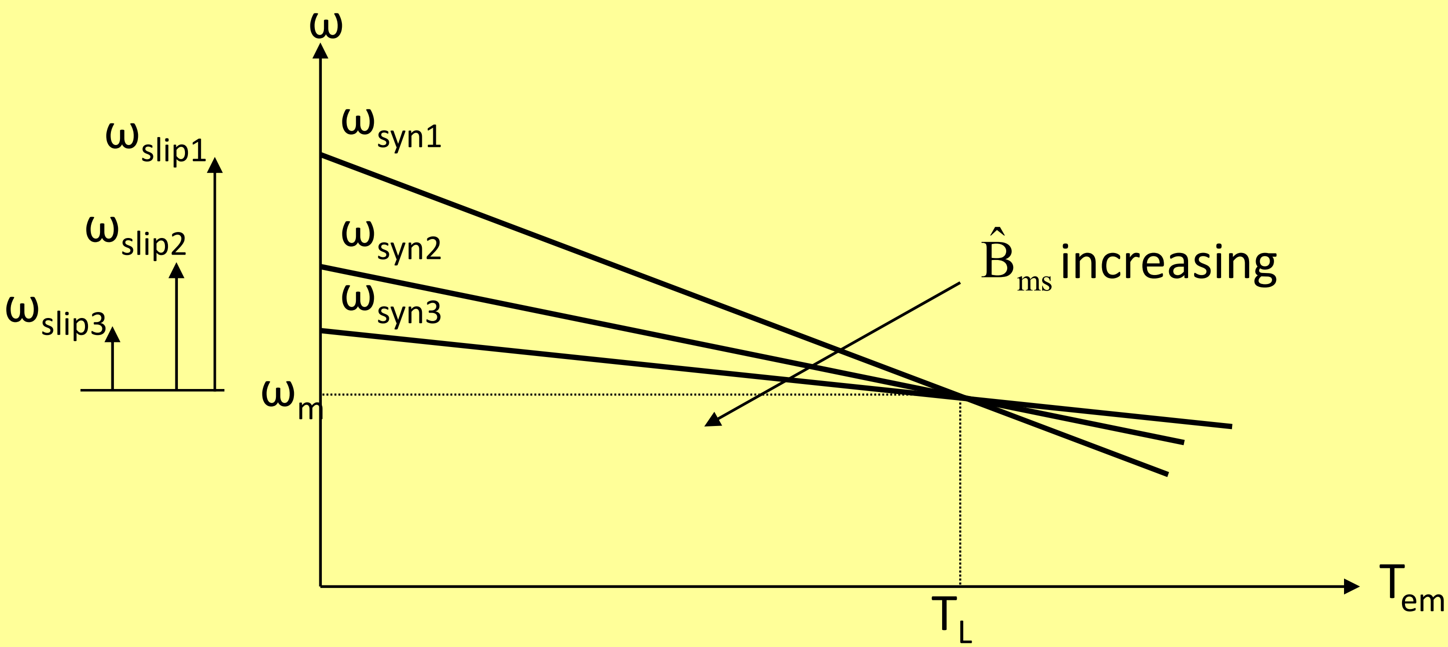
Minimizing ω_{slip} For A Given T_L and ω_m



- Large flux density allows low slip
- Keep $\hat{B}_{ms}$ as large as possible – maintain at $\hat{B}_{ms,rated}$

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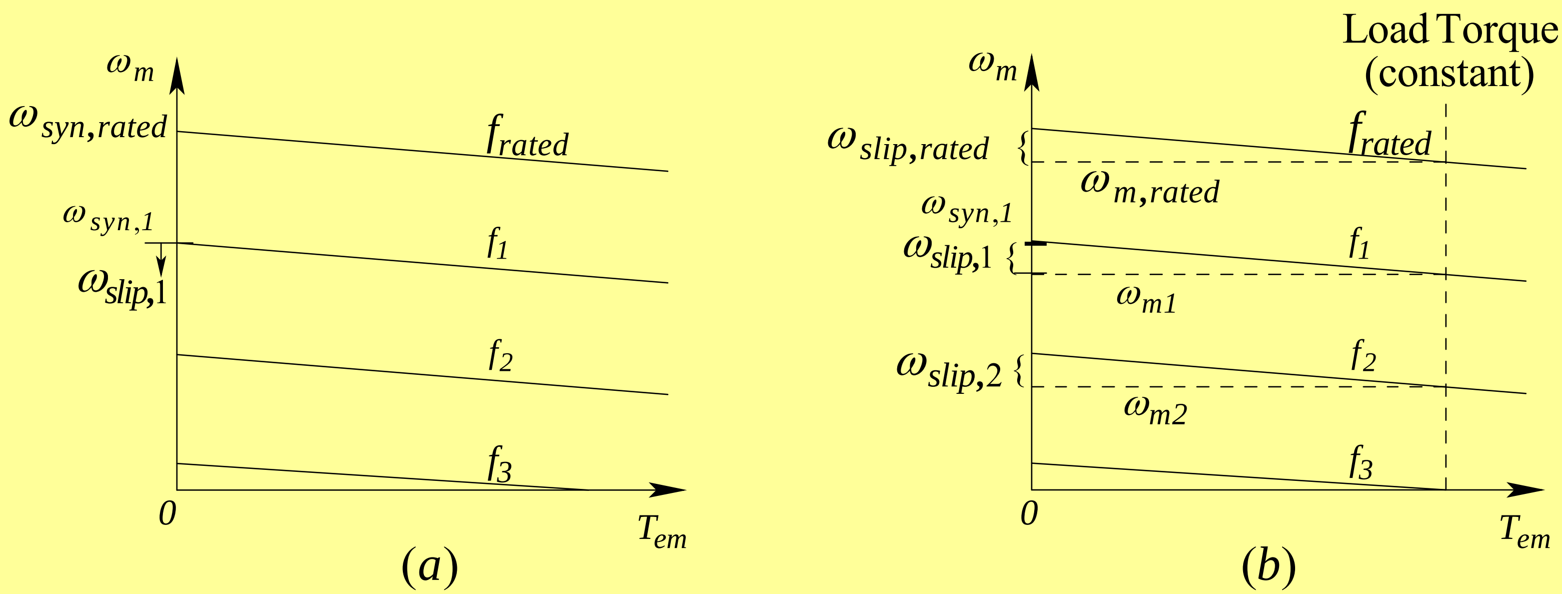
Operating Characteristics with

$$\hat{B}_{ms} = (\hat{B}_{ms})_{rated}$$



- If flux is kept constant, slope will be the same at every frequency
- Load torque and speed are met by adjusting frequency

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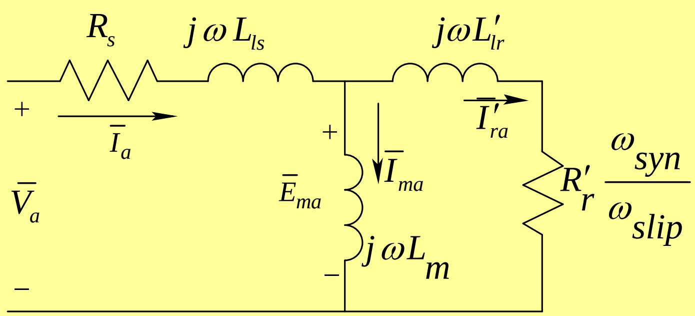
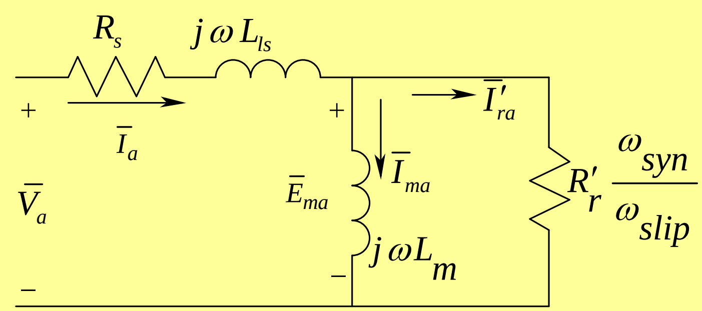
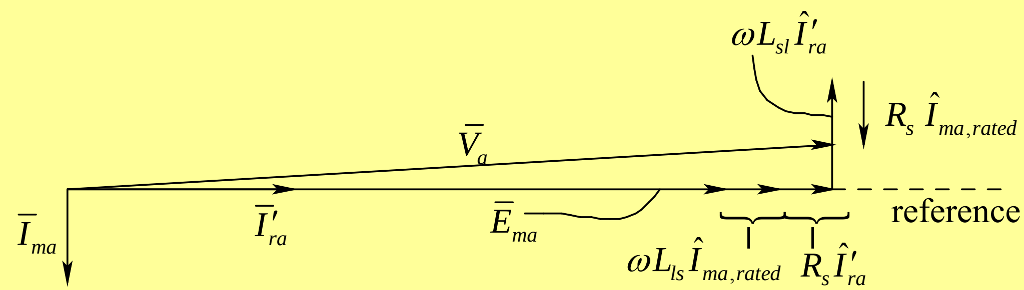
Maintaining $\hat{B}_{ms,rated}$ Over Operating Frequencies and Current Levels by Adjusting Voltage







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Maintaining $\hat{B}_{ms,rated}$ Over Operating Frequencies and Current Levels by Adjusting Voltage (cont…)

- Maintaining constant $\hat{B}_{ms}$ is equivalent to maintaining a constant (magnetizing current)
- Since $\hat{I}_{ma} = \frac{\hat{E}_{ma}}{\omega L_m}$, $\hat{I}_{ma}$ or $\frac{\hat{E}_{ma}}{\omega}$ should be kept constant
- Ignoring R_s and L_{ls}, this means that $\frac{\hat{E}_{ma}}{f}$ is a constant. As f decreases, so should V_a. Constant volts per hertz. $\frac{V_a}{f}$
- This is a good first-order approximation

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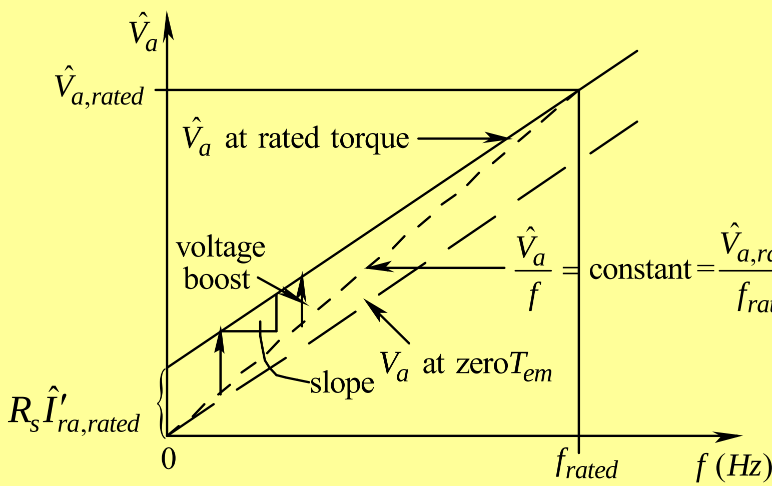
Adjusting Voltage – Stator Resistance Included

- Approximation: $\hat{V}_a = k \cdot f \; ; \; k = \dfrac{\hat{V}_{a,rated}}{f_{rated}}$
- Including voltage drop across R_s: $\hat{V}_a = k \cdot f + R_s \hat{I}'_{ra}$ $\quad k = \dfrac{(\hat{V}_{a,rated} - R_s \hat{I}'_{ra,rated})}{f_{rated}}$



- For large torques, considerable voltage boost is needed at low frequencies. This is the $R_s \hat{I}'_{ra}$ term.

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Summary

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