



ECE330: Power Circuits & Electromechanics
Lecture 24. Variable speed drives and the case for power electronics

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Induction machine: Industrial workhorse

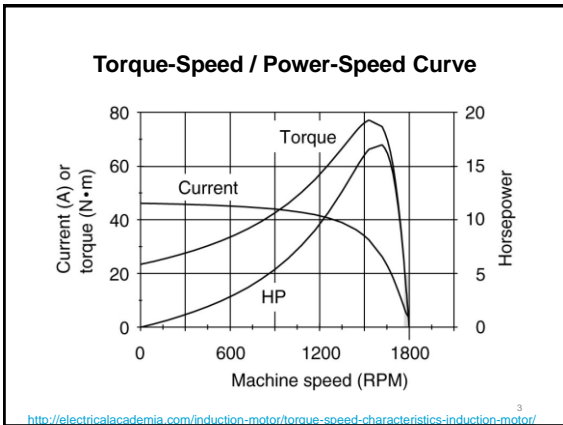


- Pumps
- Fans
- Compressors
- Saws
- Drills
- Turbines
- Elevators
- ...

Cheap Rugged Reliable
 Efficient Powerful
 Compact Low-maintenance

Historically: Difficult to start, difficult to control

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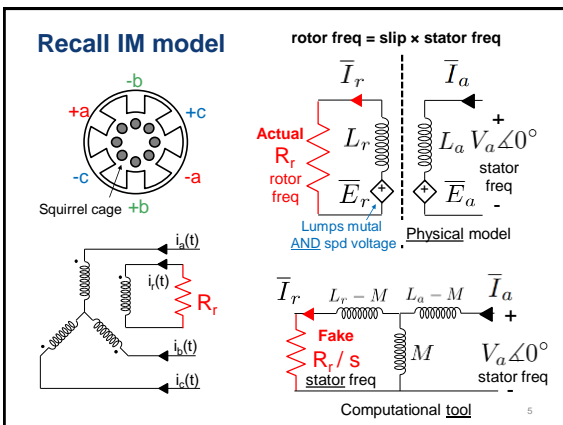


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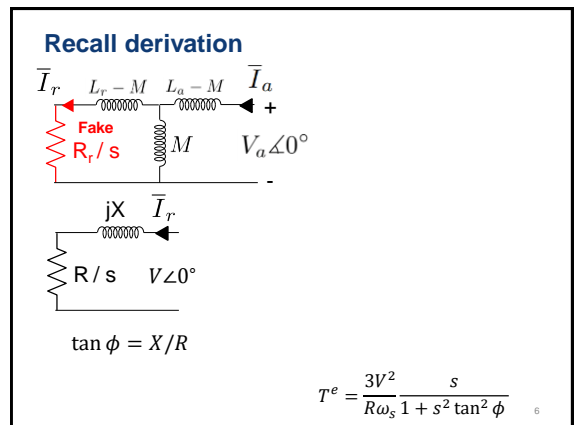
Today

- Speed control without power electronics
- Speed control with power electronics
- Variable speed drives in electric vehicles, robotics, renewable energy, and other applications

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Recall: Max torque

$$T^e = \frac{3V^2}{R\omega_s} \frac{s}{1 + s^2 \tan^2 \phi}$$

$$\tan \phi = X/R$$

Theorem.

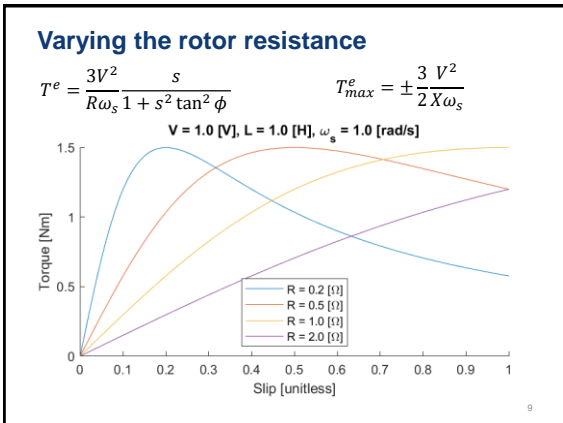
$$s_{max} = \frac{\pm 1}{\tan \phi} \quad T_{max}^e = \pm \frac{3}{2} \frac{V^2}{X\omega_s}$$

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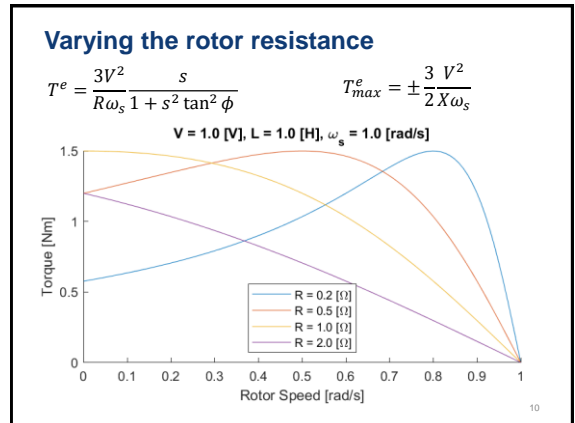
$$T^e = \frac{3V^2}{R\omega_s} \frac{s}{1 + s^2 \tan^2 \phi} \quad T_{max}^e = \pm \frac{3}{2} \frac{V^2}{X\omega_s}$$

Image: Youtube.com/LearnEngineering

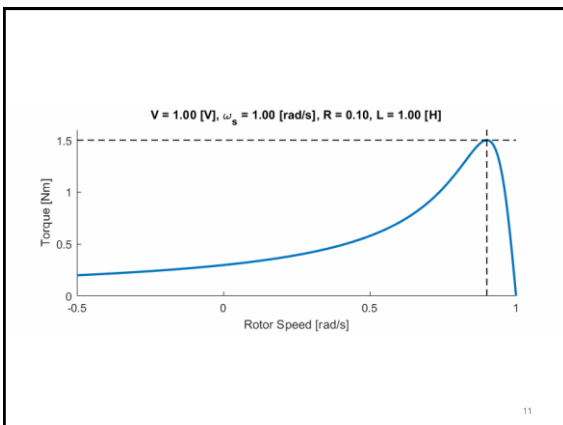
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Variable rotor resistance

Image: Youtube.com/LearnEngineering

Potential issues?

- Brushes + windings
- Slip = 0.5 at ~50%, implies ~50% efficiency!!
- In practice, only used to start the machine.

Legend:

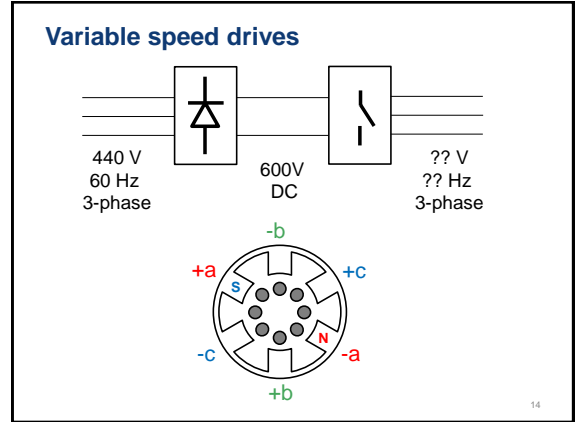
- R = 0.2 [Ω]
- R = 0.5 [Ω]
- R = 1.0 [Ω]
- R = 2.0 [Ω]

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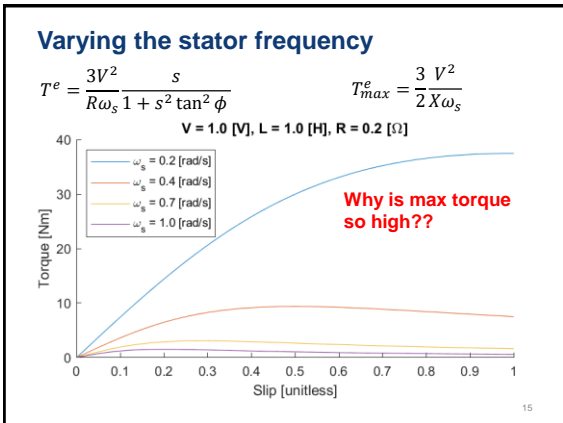
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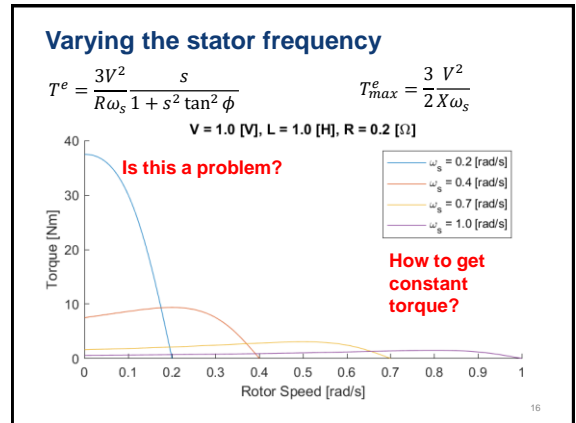
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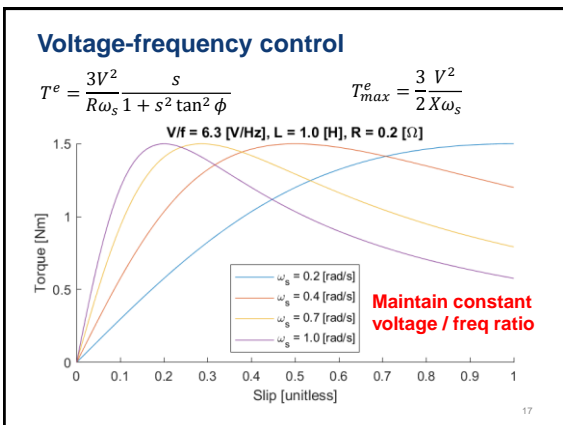
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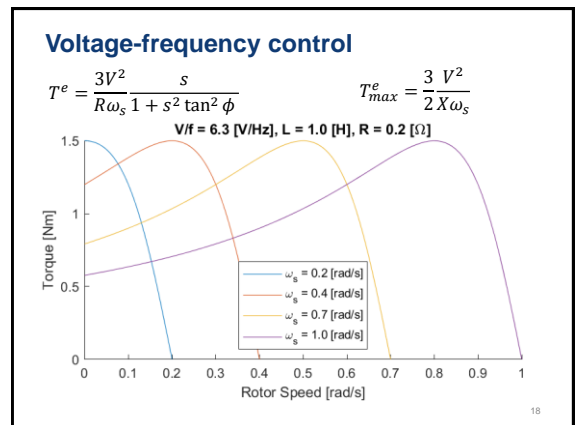
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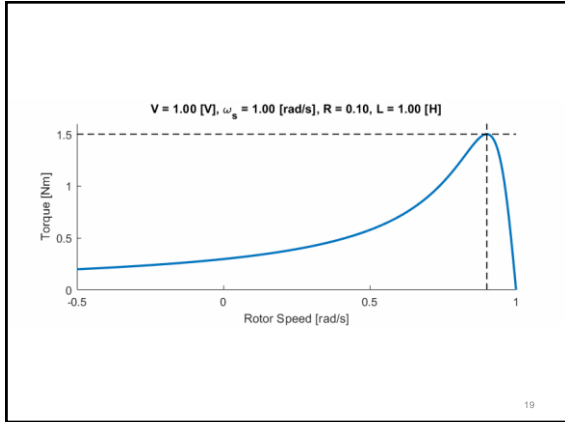
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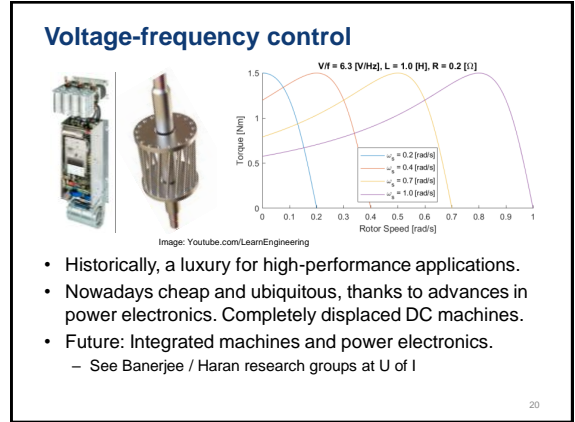
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Original Tesla Roadster (2008)

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Quadcopter drones

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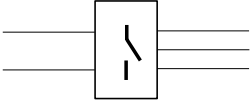
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Off-shore wind farms

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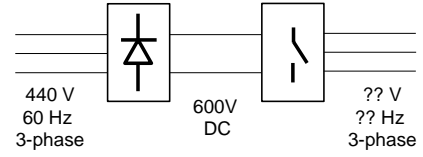
Solar farms



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Next two lectures



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