

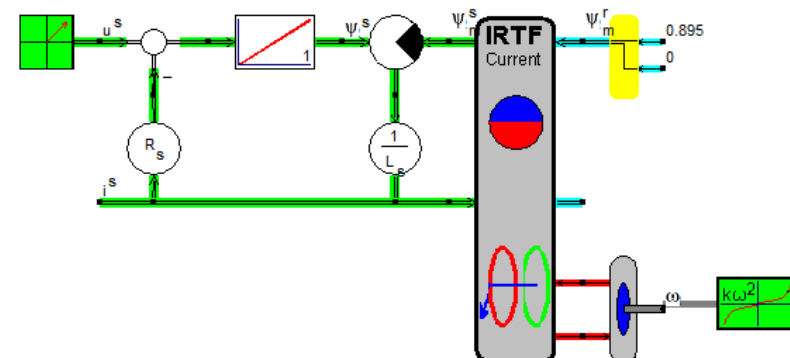
Caspoc, A simulation Experience

Caspoc Electrical Drive Simulation Solutions for Green Energy

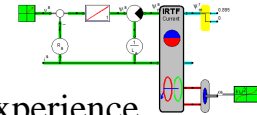
dr ir P.J.van Duijsen

Learning by Simulation

Simulation Research
The Netherlands



© Simulation Research



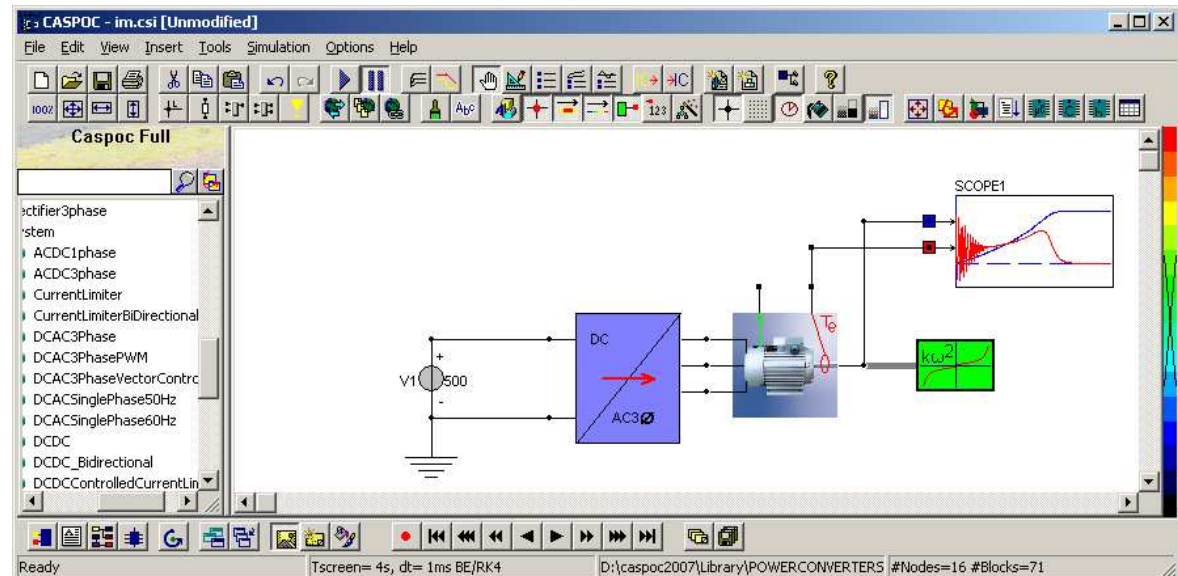
Wind energy / eVehicle

- **Electrical Machines / Drives**
 - Design of Electrical Machines
 - Control of Electrical Drives
- **Power Electronics**
 - Modulation
 - Losses

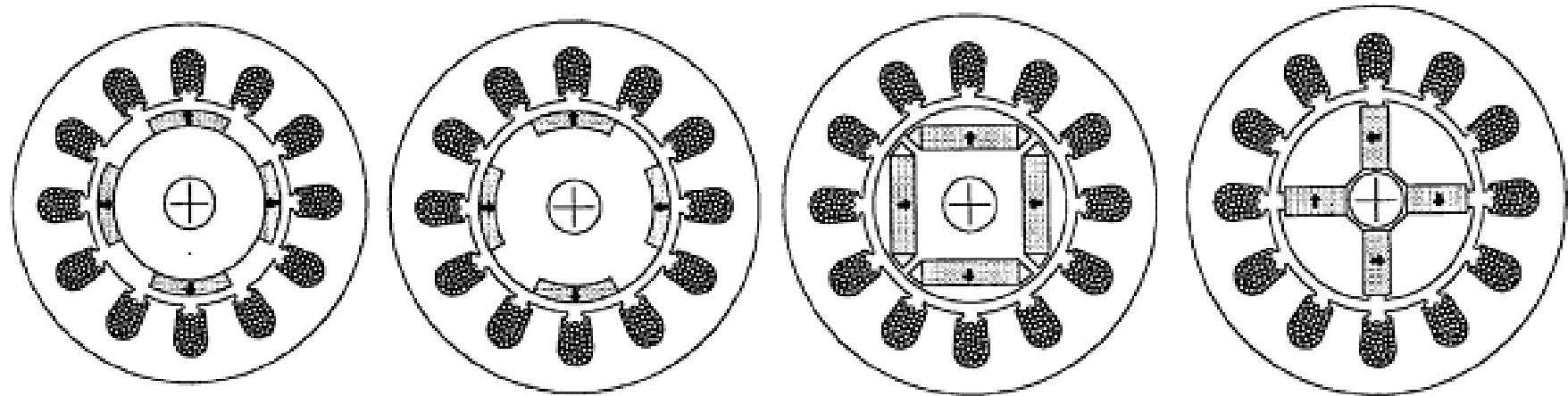
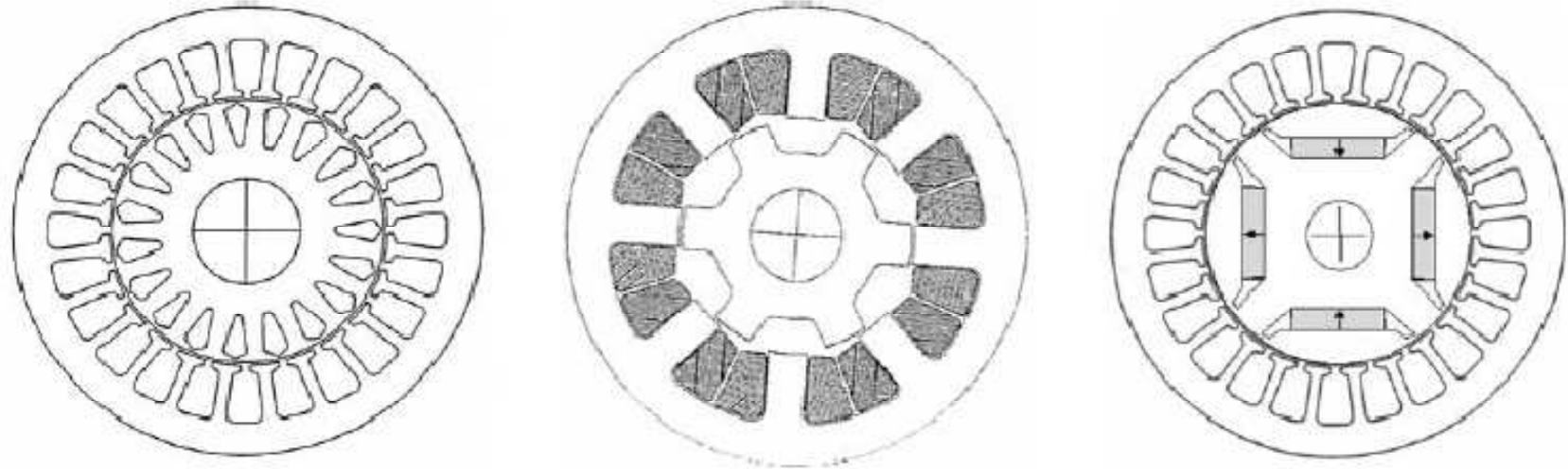
- Electrical Drives
 - Servo / Position
 - Traction (eVehicle / Railway)
 - Variable Speed

Types of machines

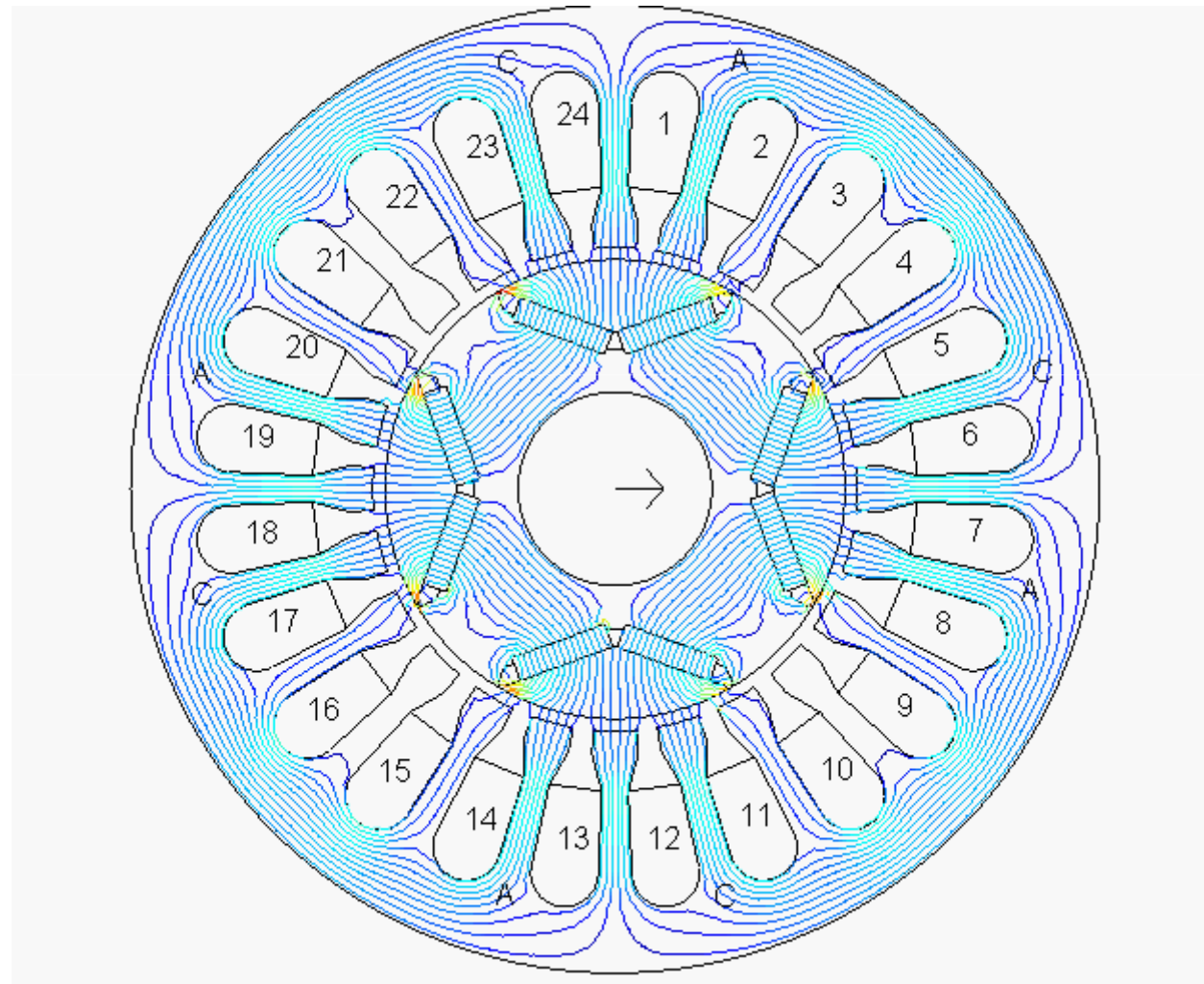
- DC
- Brushless DC machine
 - Trapezoidal back-emf
- Permanent Magnet Synchronous Machine
 - Sinusoidal back-emf
 - Surface Magnets
 - Interior Magnets
- Synchronous machines
- Induction machines
- Switched reluctance



Types of machines

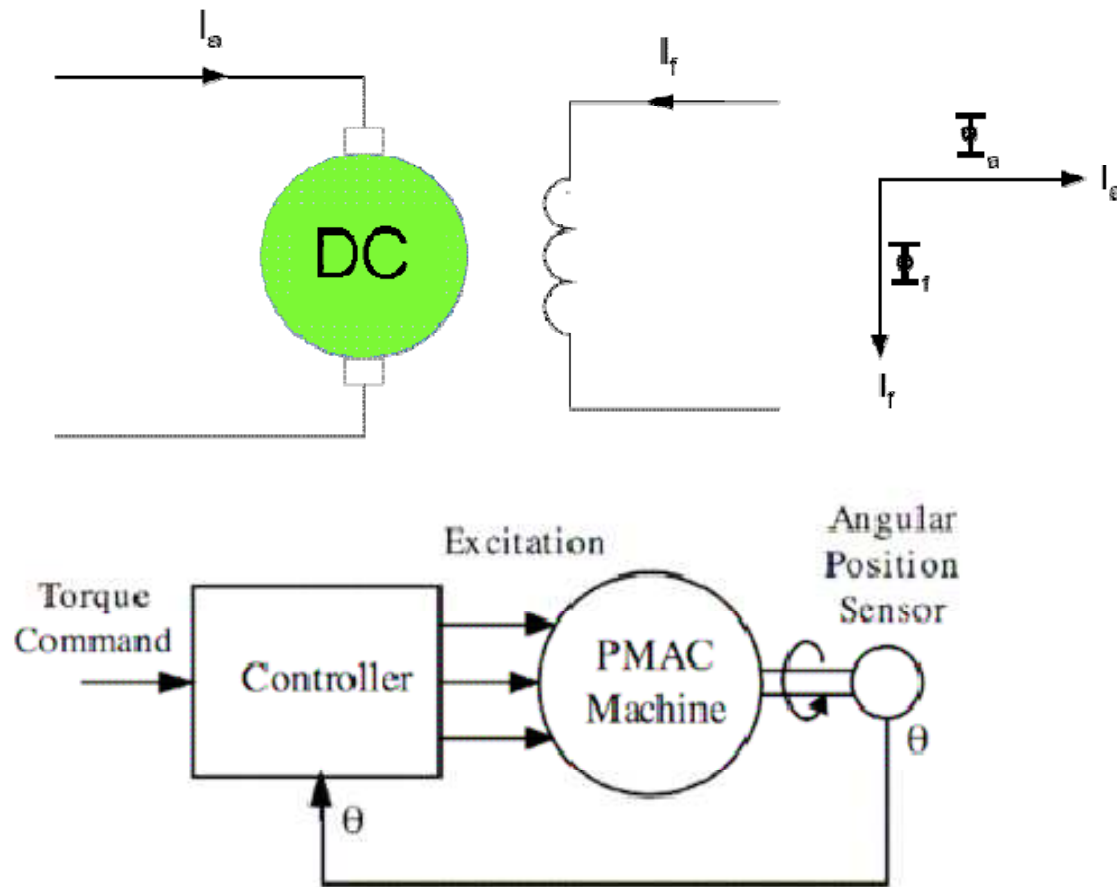


- Analytic
- FEM
- Combined

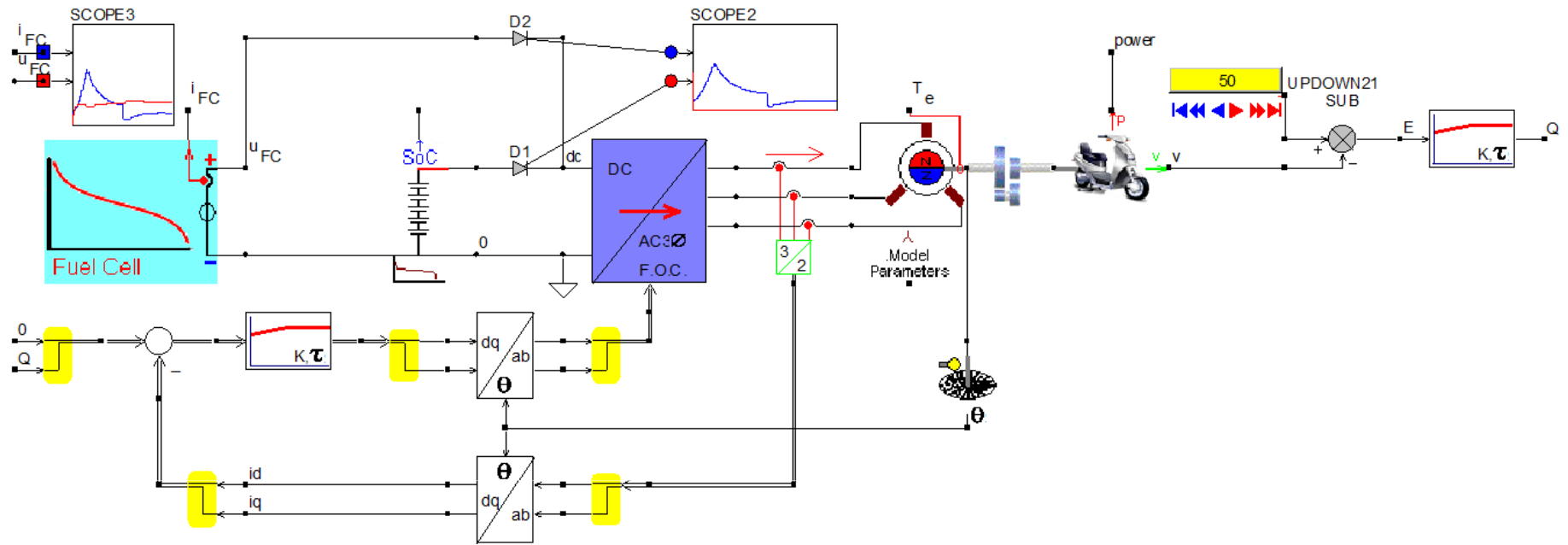


- Sinusoidal waveforms?
- Losses -> Steinmetz? (dB/dt)
- Saturation
- Harmonics windings slot/windings

- $T = k \cdot I$
- $V_{emk} = k \cdot \text{speed}$



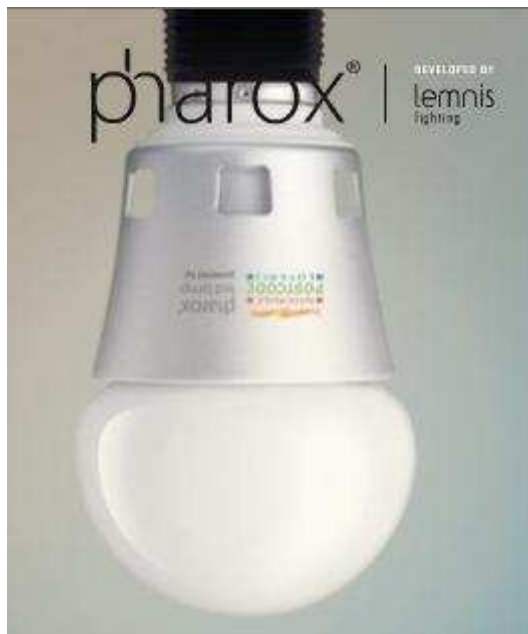
Fuel Cell Scooter



- System simulation is not enough...
- Non-linearities
 - Switching behavior / harmonics
 - Power balance
 - Losses
 - Control and PE-driver response
 - Modulation

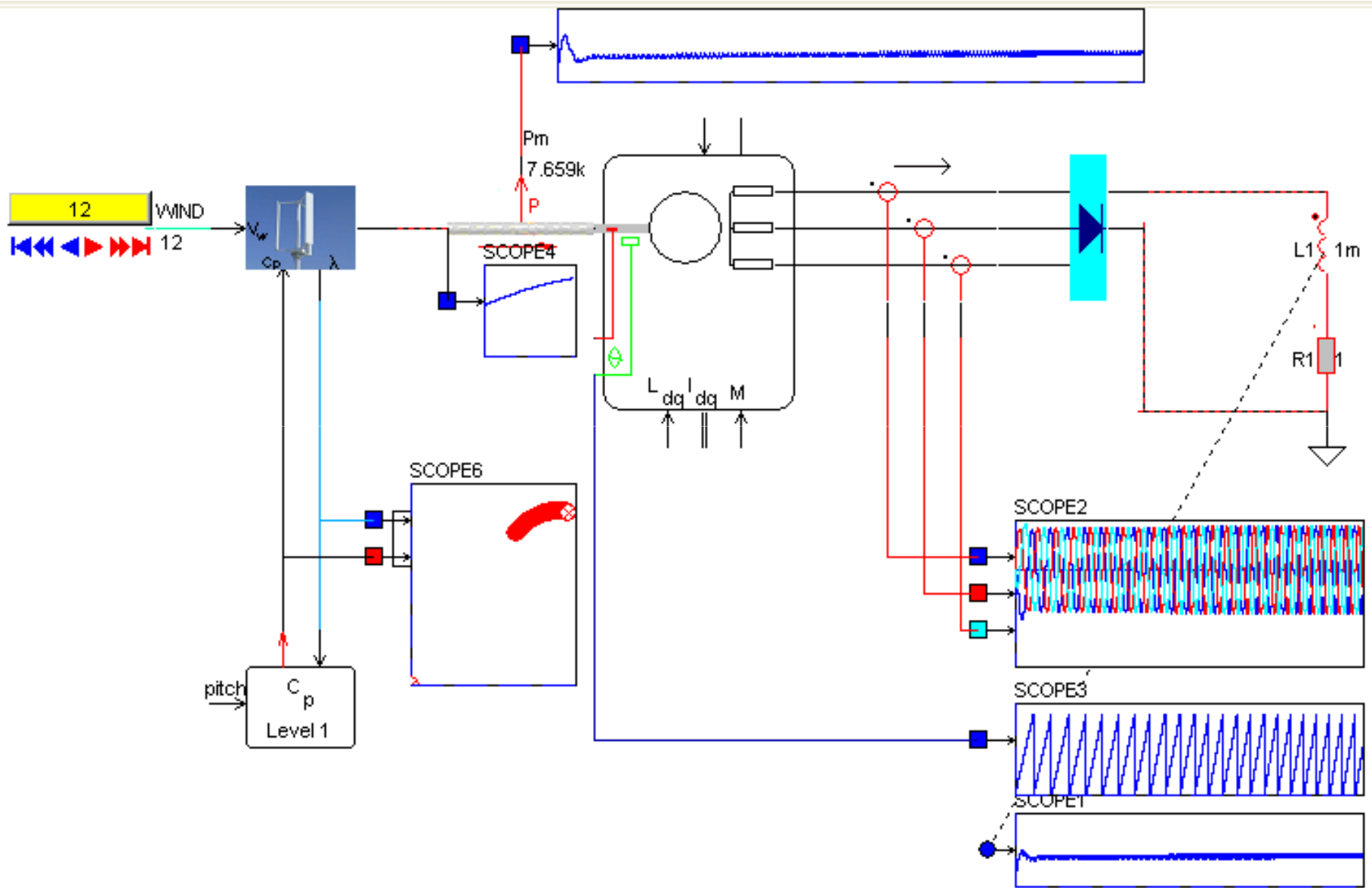
Pharox 6Watt dimmable LED

- Award winning design
- from World Economic Forum
- handed out by former President of the USA: Bill Clinton

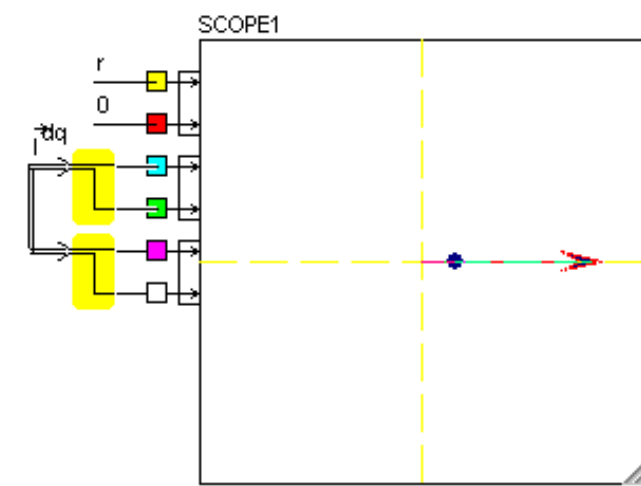
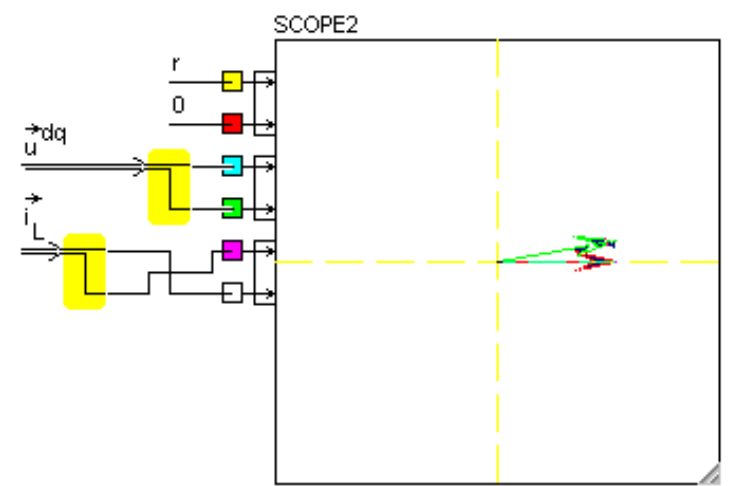
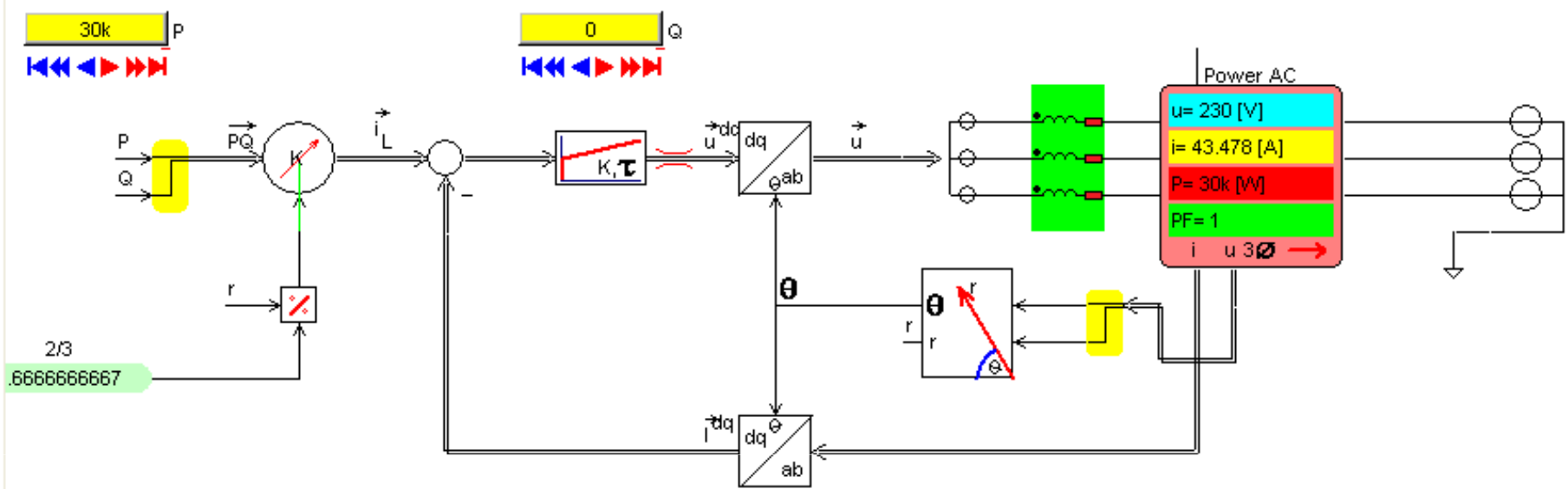
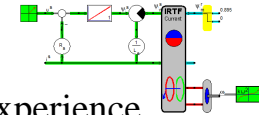


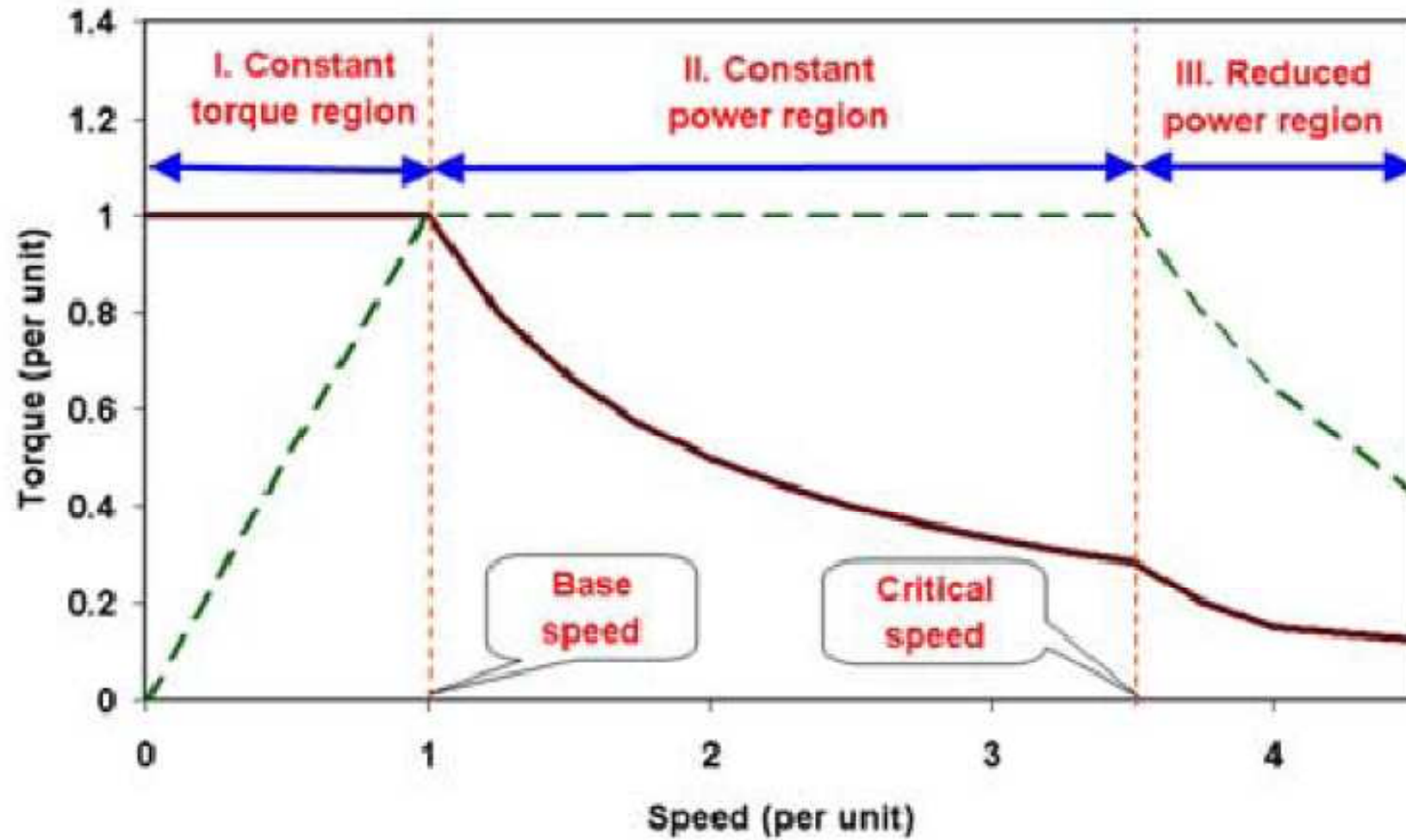
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OF THE WORLD

Vertical Wind Turbine

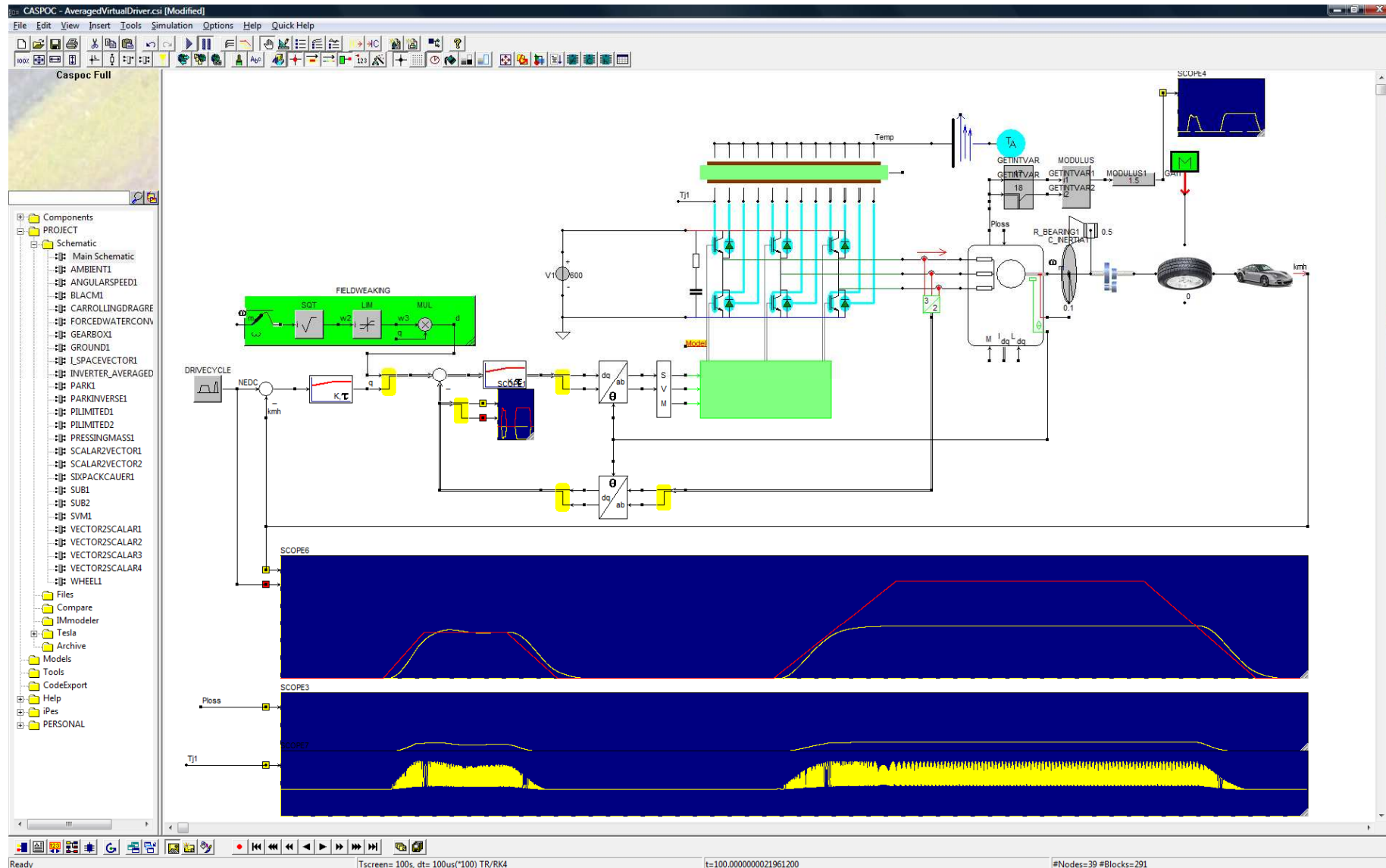


Grid Connection

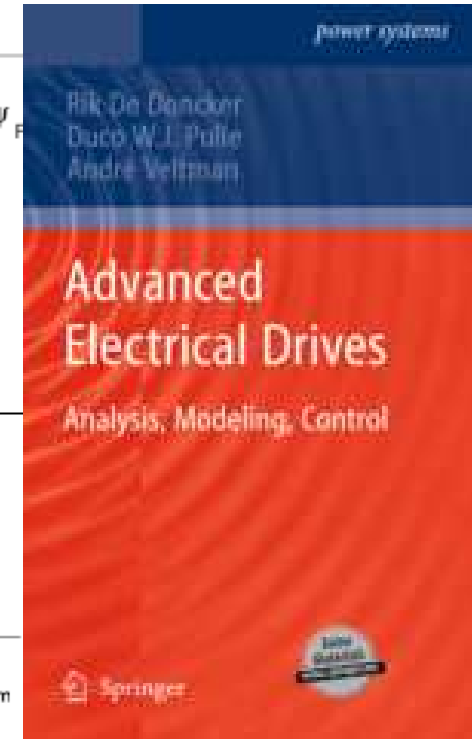
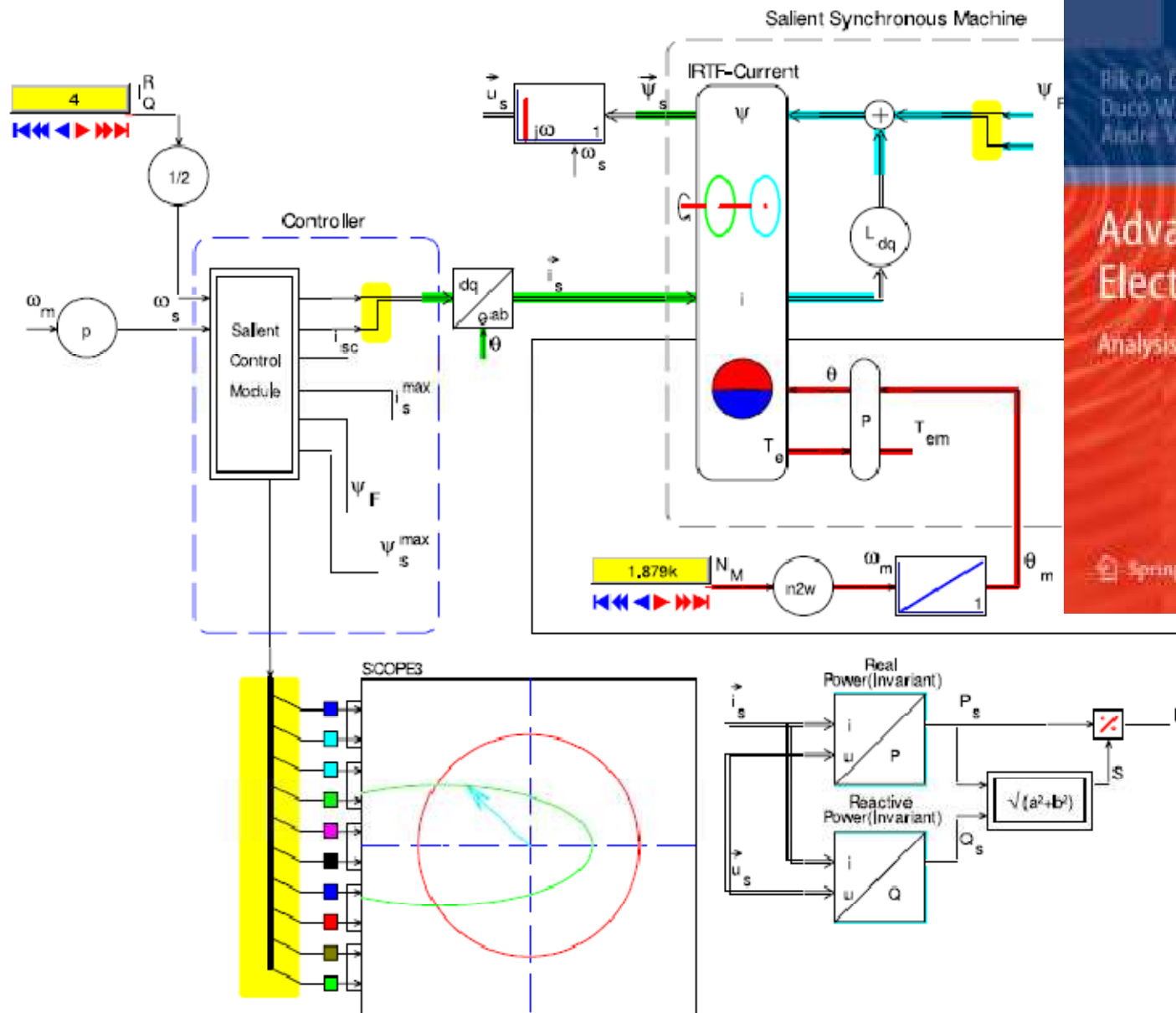
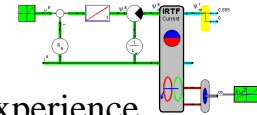




eVehicle Drive cycle

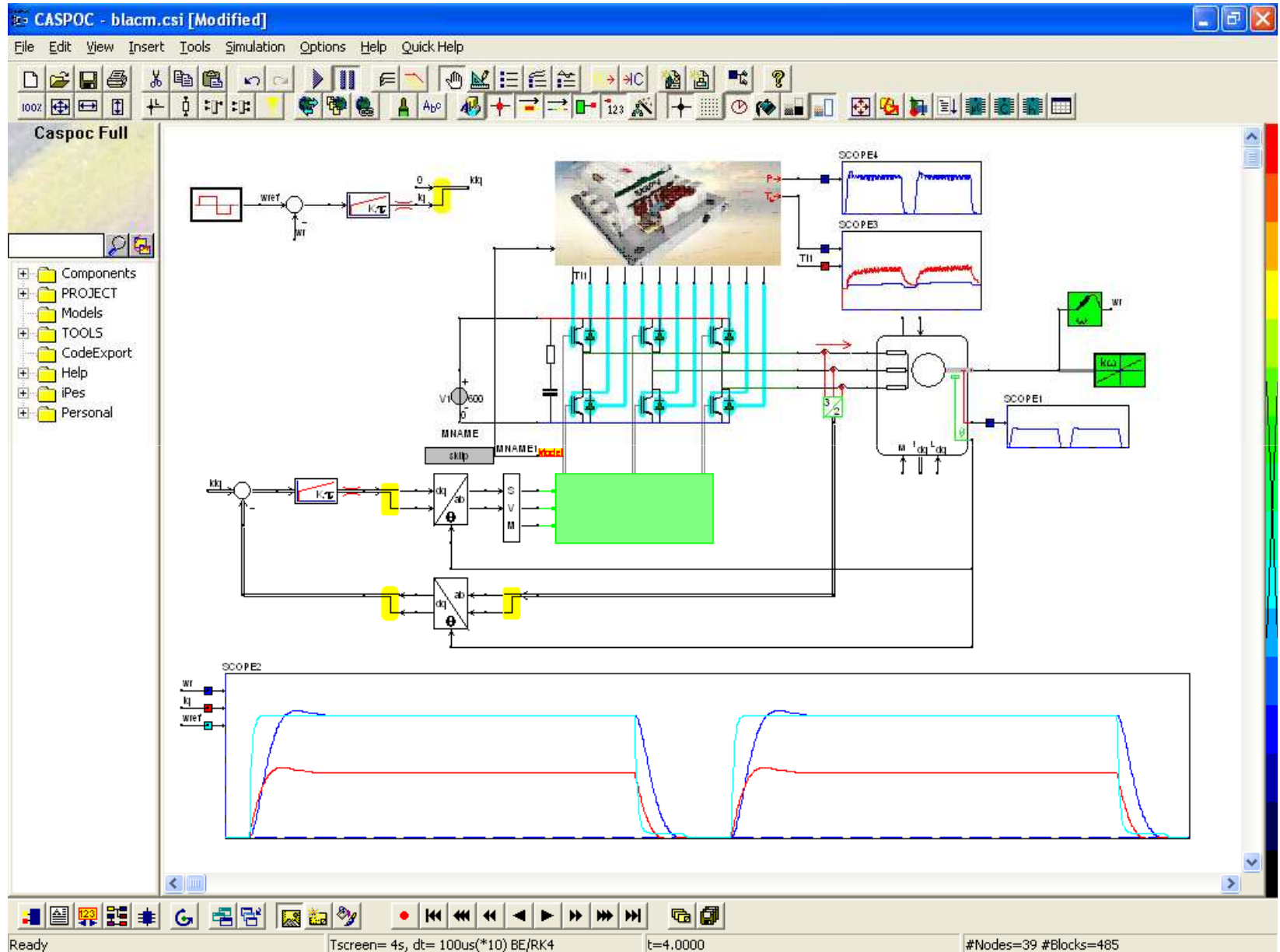


MTPA control

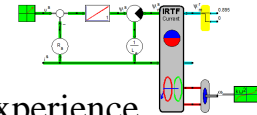


- H-Bridge Switching behavior
- Modulation
- Losses
- Modulation PWM -> SVM
- Deadtime

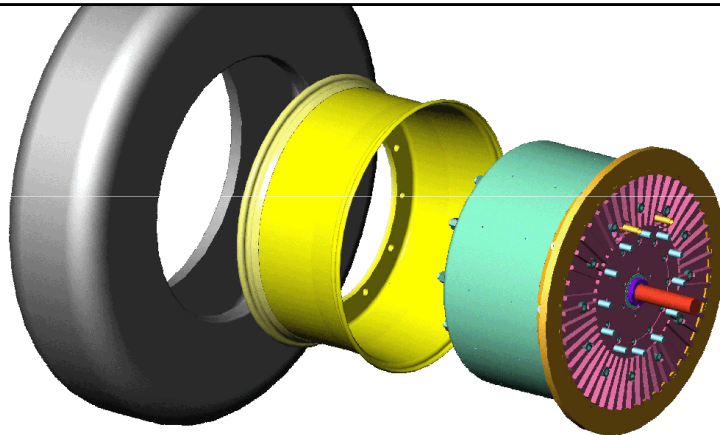
Example drive



Electric Vehicle



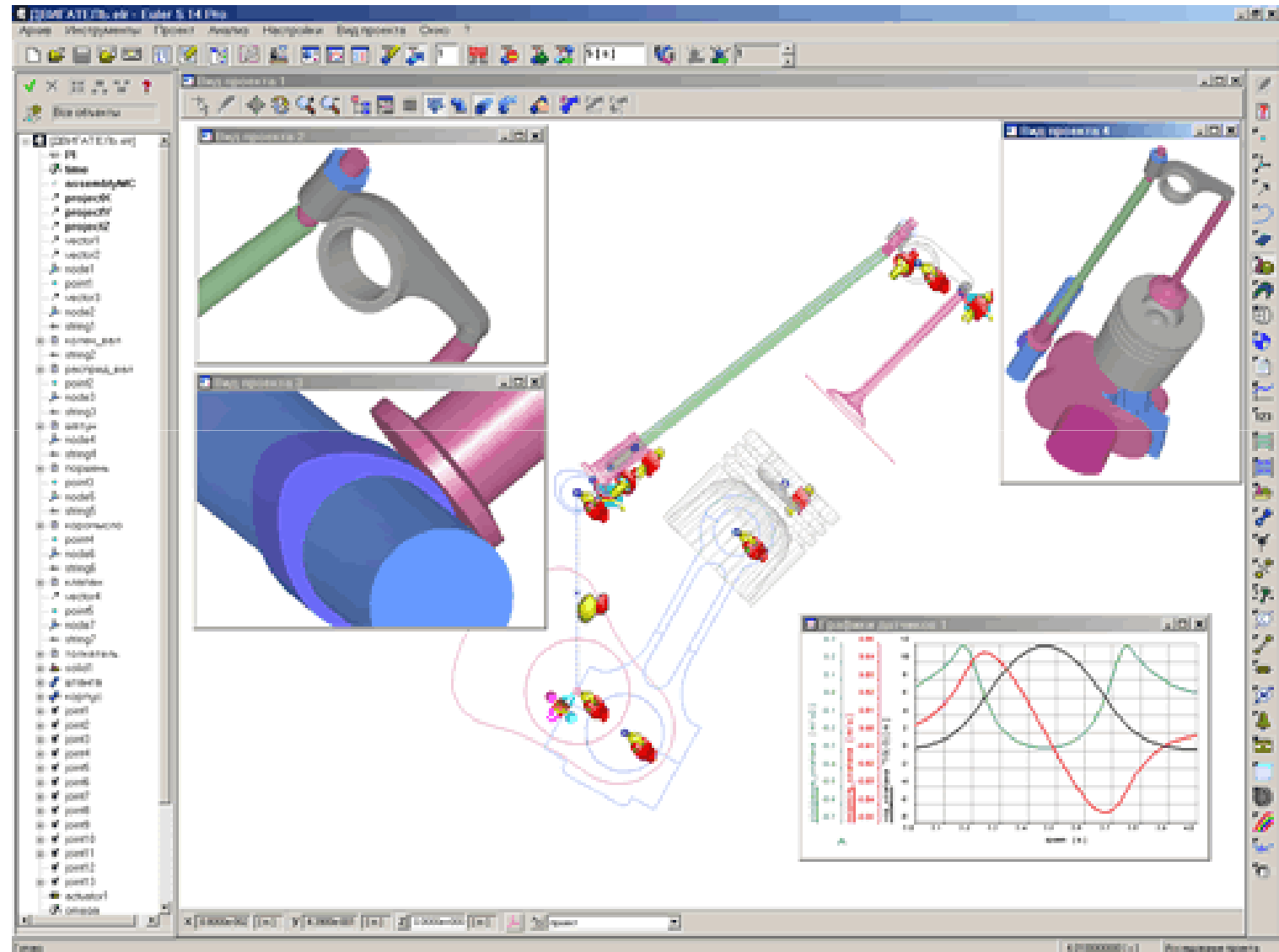
- In wheel hub Motor
- Surface mount permanent magnet
- Li-ion battery powered



- First green bus
- Ordered to replace buses in Seoul
 - source: www.etraction.com



Mechanics of the load



- Caspoc
 - Multilevel simulation
 - Power Electronics
 - Electric machines
 - Control
 - Mechanical load

www.caspoc.com