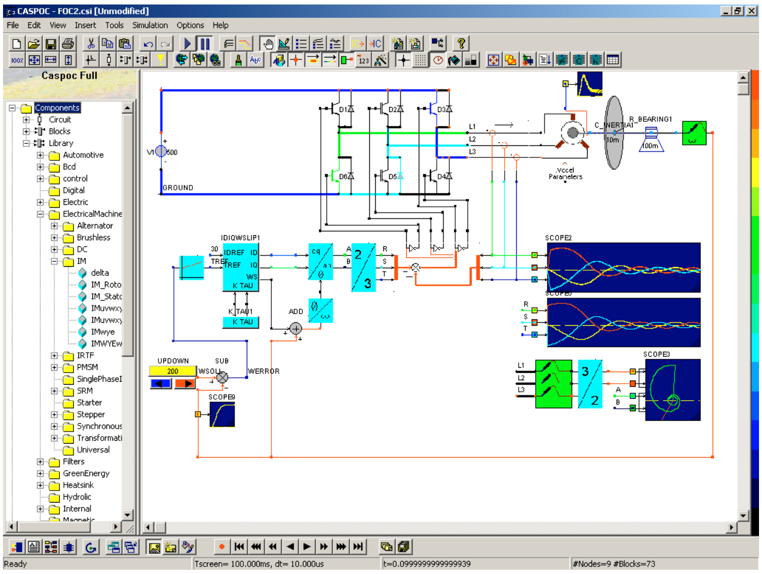
Caspoc

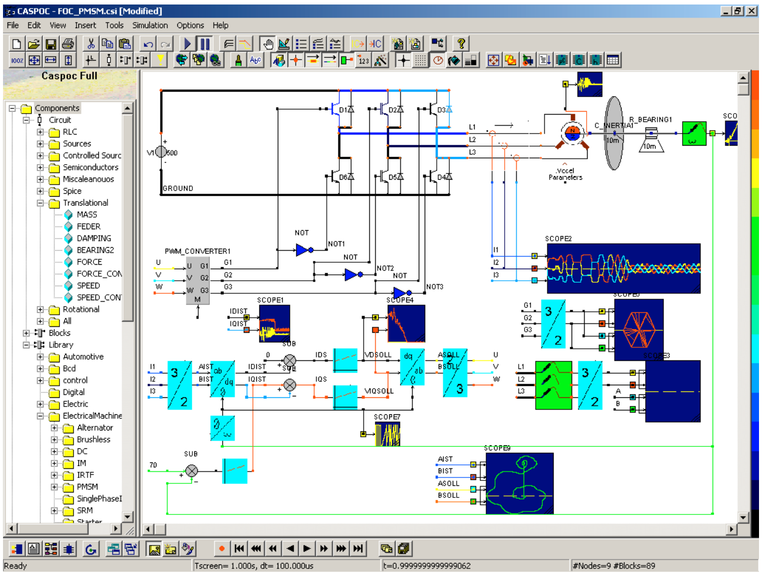
Fast and Easy Power Electronics and Electrical Drives Simulation

Motion Control and Variable Speed Drives

Analysis and design of a motor drive system becomes easy when using Caspoc. Modeling electrical machines and variable speed drives is included in the standard and professional version of Caspoc. It provides an easy and effective way of modeling and simulating motor drive systems.
Simply connecting the electrical machine to the power electronics and the mechanical shaft builds your drive system fast and efficient.



The power electronics, control loop, electrical machine and mechanical drive are modeled in one schematic. All basic types of machines and mechanical components are available.
Connected to the comprehensive control library components, such as PI-controllers, Field Oriented Control, etc., an electrical drive is build quick and convenient. Using modeling language such as C/C++, you can even create custom-built machine/load models.



Features:

- Applying ready to use components, such as abc-dq transformations, PI-controllers and digital / analog filters, any drive system is modeled very easy and the system layout is clearly visible.
- Many samples are available, for example, Field Oriented Control as shown here. The vector drive with induction machine (top) or Field Oriented PMSM drive are straightforward to implement.
- The Simulink coupling can be used to couple your Power Electronics and Electrical Drive to any Simulink control model if required.
- Co-Simulation and data exchange with famous FEM software gives you the power to any new type of electrical machine.

Electrical Machines:

- Permanent magnet synchronous machine
- Induction machine (squirrel cage, wound rotor and single-phase)
- Synchronous machines and generators, permanent magnet and externally excited
- Permanent magnet DC machines
- Brushless DC machines
- Series shunt and compound DC machines
- Switched reluctance machines
- Synchronous reluctance machines
- Stepper motors
- Automotive alternators (DC & 3 phase)

Mechanical components:

- Shafts, masses, spring, bearings, gearboxes, differential gear, planetary gear
- Constant torque, constant power and general type mechanical load
- Speed, torque and power sensors

Summarizing, any type of electrical machine can be modeled quick and easy.

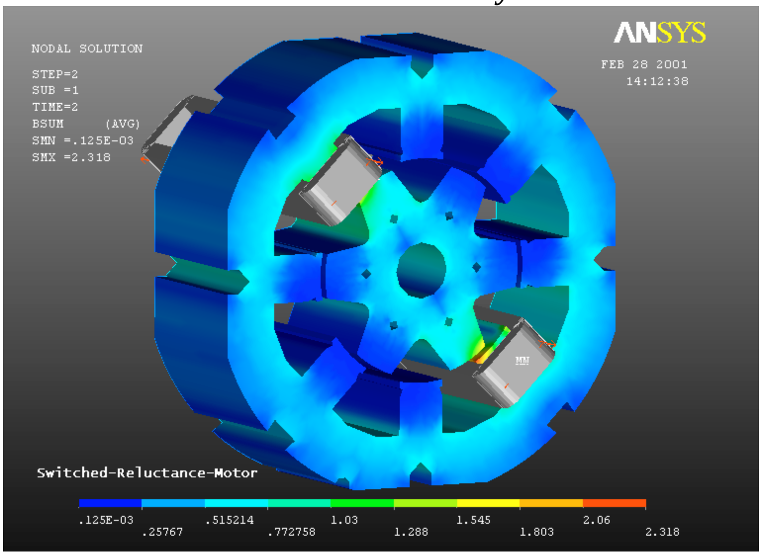
Caspoc

Fast and Easy Power Electronics and Electrical Drives Simulation

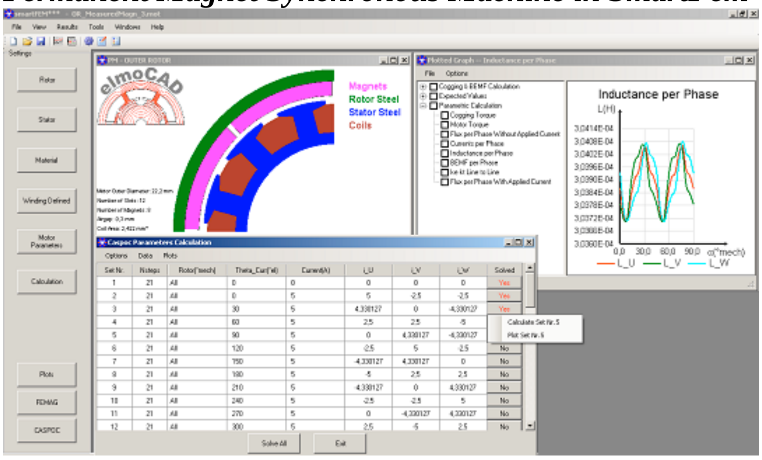
Data-Exchange and FEM Co-Simulation

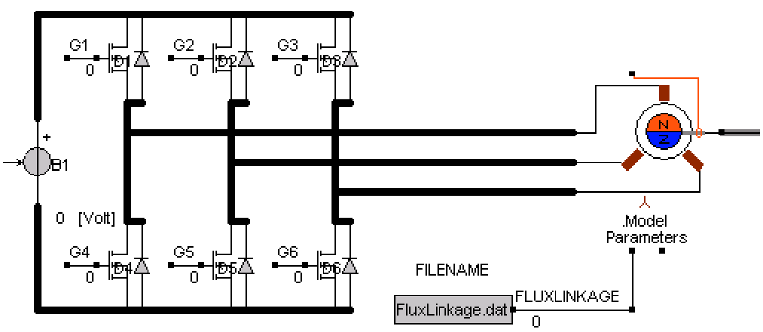
Get more from your electric drive simulations, by using detail models for your electric motors. Caspoc couples with various FEM packages.

Switched Reluctance Machine in Ansys



Permanent Magnet Synchronous Machine in SmartFem





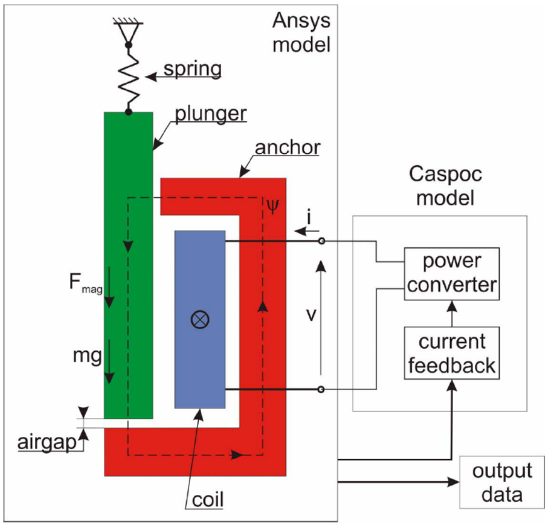
Coupling of the machine data to the machine model in the drive simulation in Caspoc.

Features:

- True Co-Simulation for complex electrical machines and linear actuators
- Included eddy currents and losses in the co-simulation
- Optimize your control with non-linear machine models parameterized from FEM models
- Static parameters, look-up tables and transient co-simulation
- Co-Simulation and data exchange with famous FEM software gives you the power to any new type of electrical machine.

Linear Actuator Co-Simulation

The linear actuator is modeled in Ansys and via a co-simulation controlled in Caspoc. The mechanical system can either be modeled in Ansys using a FEM and/or Multibody Kinetics model for the mechanical system, or a basic mechanical model is constructed in Caspoc



Summarizing,
get accurate results from Ansys and SmartFem for any type of electrical machine quick and easy.

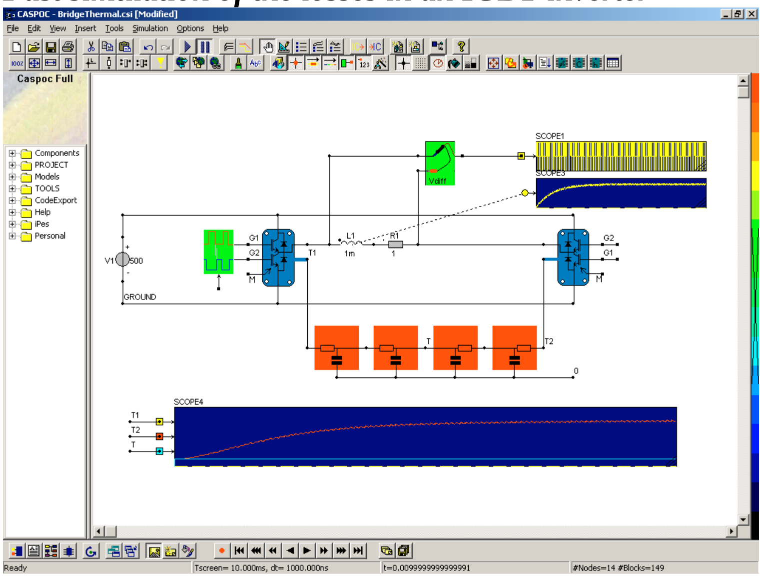
Caspoc

Fast and Easy Power Electronics and Electrical Drives Simulation

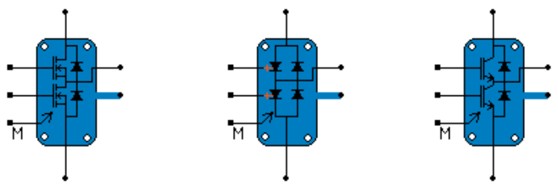
Semiconductors Detailed and Fast

Optimize your power electronic designs by using the "*fast power loss prediction models*" in Caspoc.

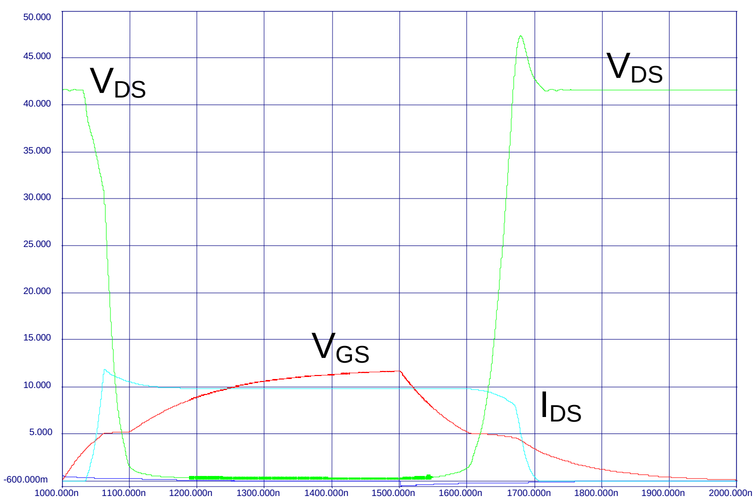
Fast simulation of the losses in an IGBT inverter



Fast Loss Predicting Semiconductor Models



Detailed Mosfet Modeling



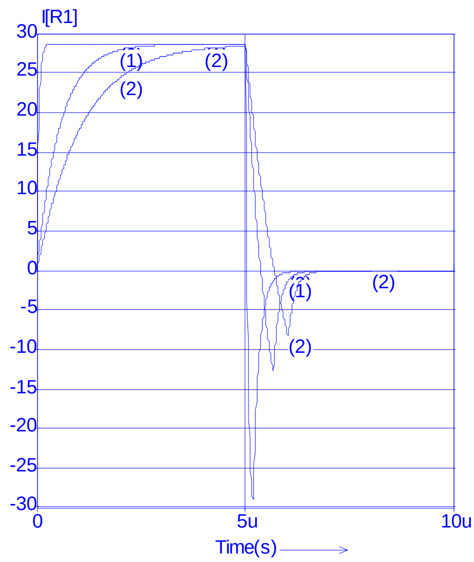
Detailed modeling of a mosfet in Caspoc reveals the on and off switching waveforms.

Features:

- Detailed mosfet models with non-linear capacitance's
- IGBT models with tail current
- Diode models with reverse recovery
- Fast loss-prediction models for fast simulation
- Coupling to Thermal models
- Include parasitic wire inductance and bus-bar capacitance in the circuit

Diode Reverse Recovery

The reverse recovery in a diode is dependent on the maximum forward current and its slope during turn off.. Increasing the inductance in each successive simulation increases the slope of the turn-off current and thereby decreasing the reverse recovery current.



Summarizing,
use detailed semiconductor models or loss-prediction models quick and easy.

www.caspoc.com CASPOC:You can't beat our speed!

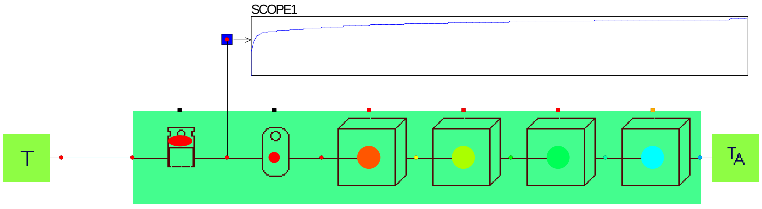
Caspoc

Fast and Easy Power Electronics and Electrical Drives Simulation

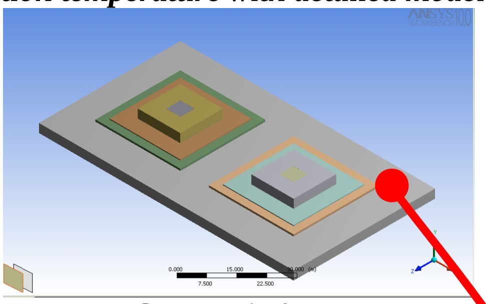
Heat Sink modeling

Estimate the efficiency and heating in your power electronics design with detailed heat sink models. Predict accurately the thermal behavior of your design with either basic heat sink models or with detailed thermal models from Ansys

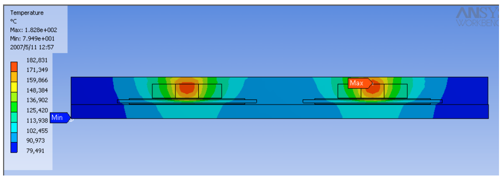
TO220 with heat sink and isolation layers



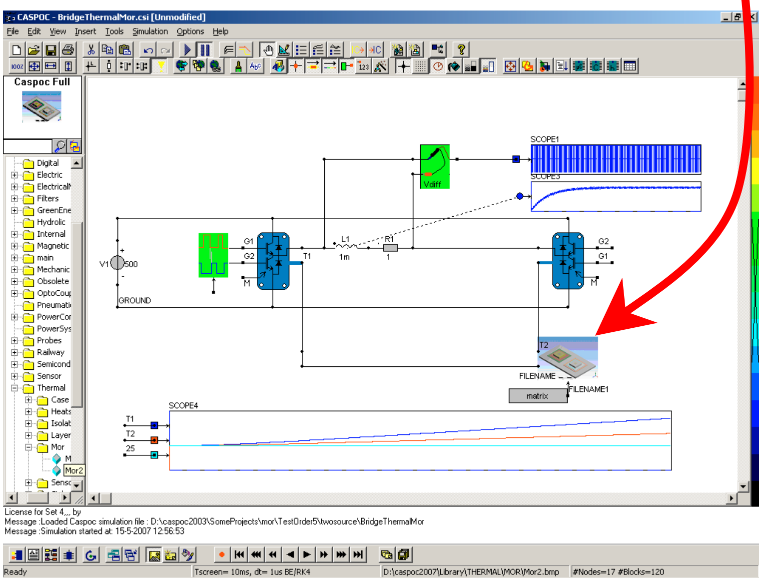
IGBT Junction temperature with detailed model



Geometry in Ansys



Static Temperature in Ansys and Model Identification



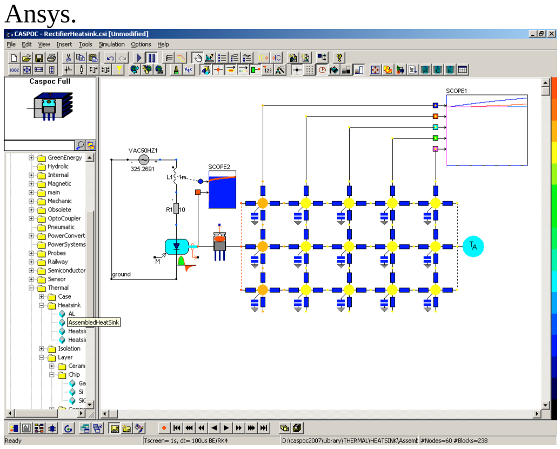
Single phase inverter with IGBT and thermal model from Ansys

Features:

- Heat Sink models directly coupled to semiconductor models
- Thermal material properties predefined
- Ready to use heat sink models
- Thermal models from Ansys directly imported into Caspoc

Thermal models

Thermal models are required to accurately predict the losses of semiconductors. The losses in the semiconductors are dependent on the junction temperature, which is in turn a function of the power losses from the semiconductor itself, and the surrounding semiconductors.
In Caspoc you can use the ready to use models for heat sinks or you can use the detailed models from Ansys.



Summarizing,
Thermal Models,
predefined or custom
quick and easy.

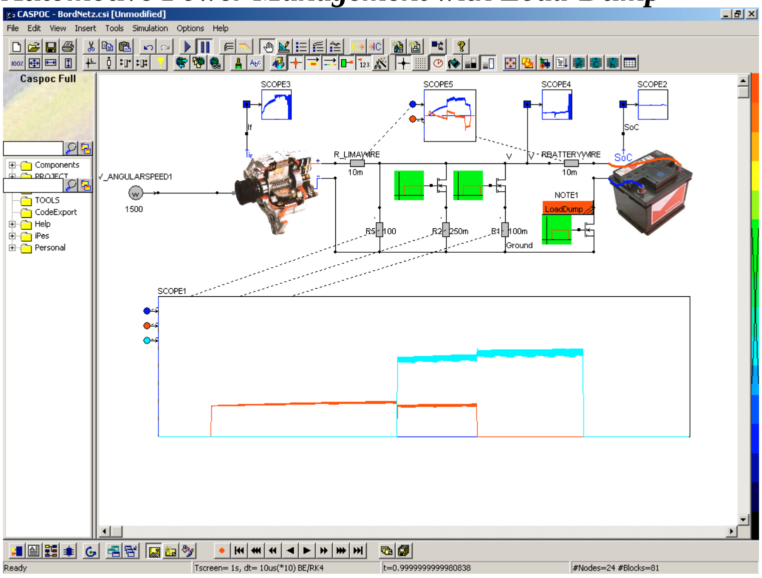
Caspoc

Fast and Easy Power Electronics and Electrical Drives Simulation

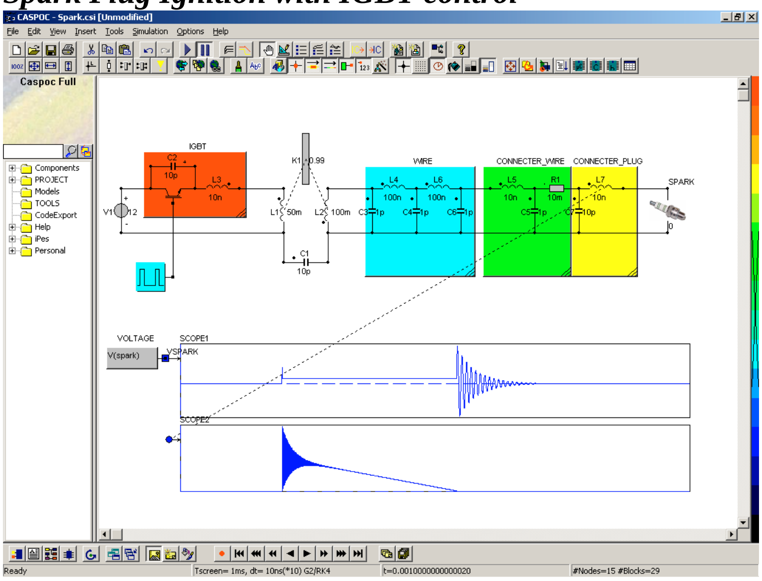
Automotive Power Management

Automotive Power Management optimized and tested for various load applications. Model the entire power grid with all users. Observe battery charging and discharging and harmonics caused by the alternator. Create a load-dump and simulate the stability of your power grid.

Automotive Power Management with Load-Dump



Spark Plug Ignition with IGBT control

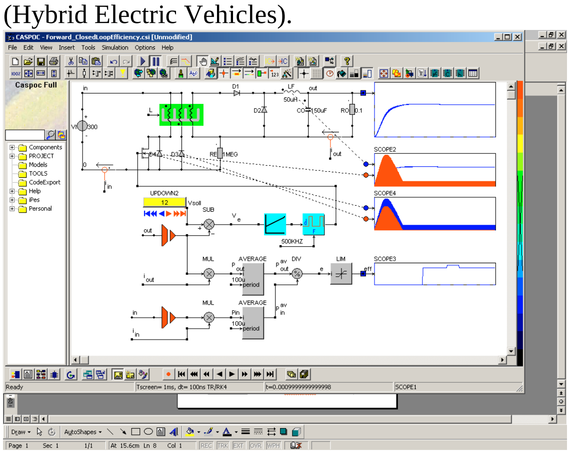


Features:

- Detailed Alternator model including 6 pulse rectifier and controller
- Battery model with SOC, and charge/discharge impedance.
- High-voltage spark plug model
- Bi-directional DC supplies with current limiting and efficiency modeled
- Drive cycles for Power Management

Bi-directional DC Converter

Power Electronics are emerging in automotive applications. They are not only controlling the engine, alternator and blinker, but nearly all devices like motors and other automotive actuators are controlled by power electronics. A Bi-directional converter is modeled in detail for the conversion between the battery voltage and the higher bus voltage in HEC (Hybrid Electric Vehicles).



Summarizing,
Automotive Power Management
Engine-Management
quick and easy.

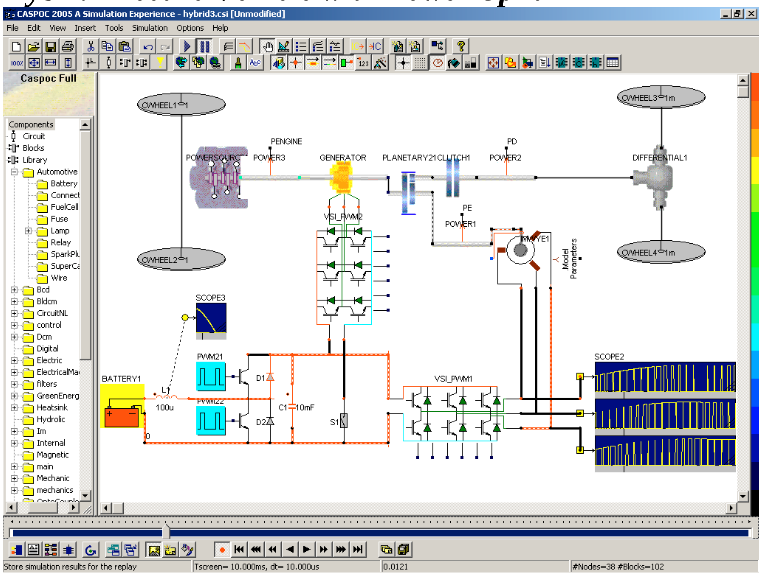
Caspoc

Fast and Easy Power Electronics and Electrical Drives Simulation

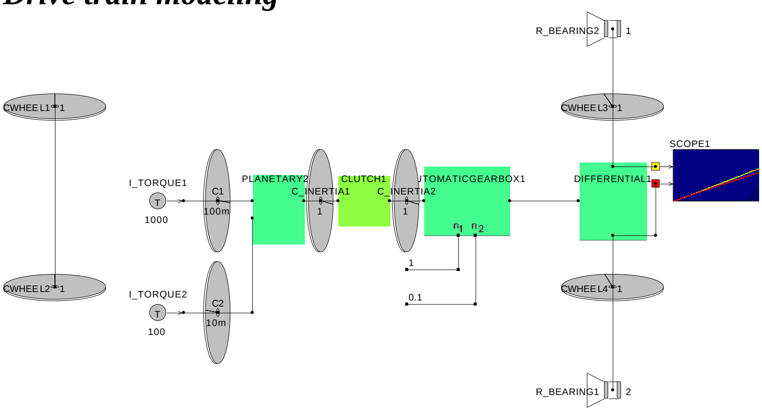
Hybrid Electric Vehicles

Complete drive train simulation for Hybrid Electric Vehicles. Include the combustion engine, wheels, clutch, differential, electric motor, generator, inverter, battery, bi-directional-converter in one model. Simulate entire drive cycles and observe the power management in the drive train.

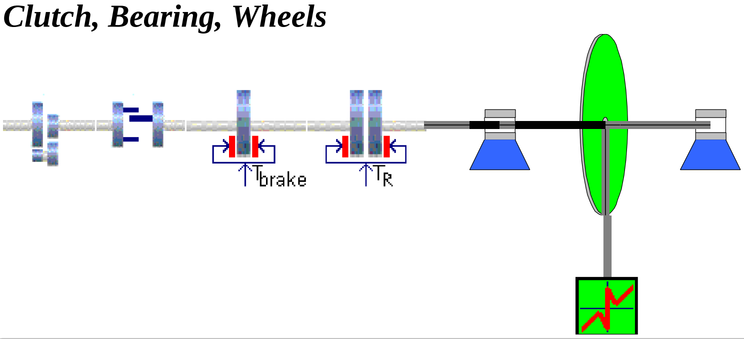
Hybrid Electric Vehicle with Power-Split



Drive train modeling



Drive train components like; GearBox, Back-Lash,Brake, Clutch, Bearing, Wheels

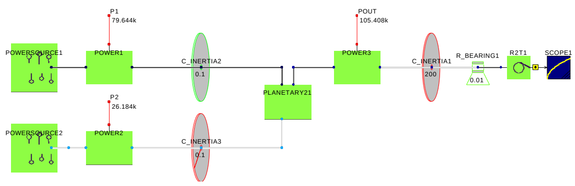


Features:

- Mechanical drive train
- Inverters with PWM and Field-Oriented Control
- Detailed non-linear machine models
- Alternator model including 6 pulse rectifier and controller
- Battery model with SOC, and charge/discharge impedance.
- High-voltage spark plug model
- Bi-directional DC supplies with current limiting and efficiency modeled
- Drive cycles for Power Management

Mechanical drive-train, electric machine and power electronics combined

The entire drive train is model in Caspoc. Not only the mechanical parts, but also the electric machine, inverter and control are modeled in detail. The mechanical components are modeled in detail like the clutch, brake, planetary gears and differential. Non-linear properties like spring characteristics and friction models can be imported from FEM.



Summarizing,
Drive train modeling with non-linear mechanical components
quick and easy.

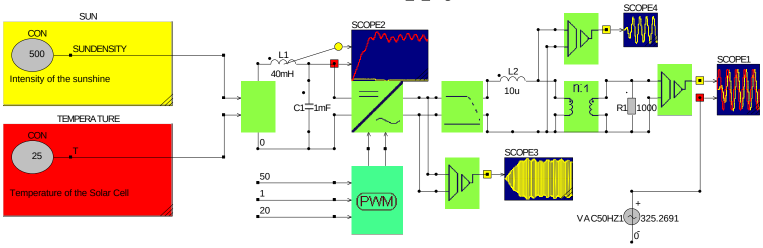
Caspoc

Fast and Easy Power Electronics and Electrical Drives Simulation

Green Renewable Energy

Renewable Green Energy is the future. Stay ahead and simulate Green Energy with Caspoc. Models are provided for Solar Cells, Wind Turbines and Fuel Cells.

Solar Cell with inverter and supply to the Grid



Wind Turbine models

The wind turbine model has variable pitch control and can be supplied with wind speed characteristics

Wind turbine with doubly fed induction generator

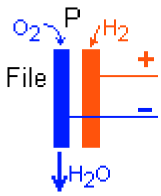
The Wind Turbine is connected via a stiff shaft and gearbox to a DFIG (Doubly Fed Induction Generator). The rotor of the generator is fed from an Inverter. Electric Power from the DFIG is fed into the main grid.

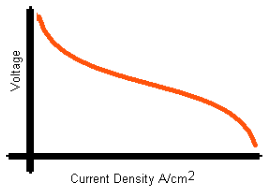
Features:

- Solar Cell model with load dependency
- Wind Turbine with variable pitch control and wind speed characteristics
- DFIG (Doubly Fed Induction Generator)
- PMSG (Permanent Magnet Synchronous Gen.)
- Planetary Gear, Stiff Shafts
- Wind Speed characteristics
- Fuel cell model with load dependency from CFD or detailed model

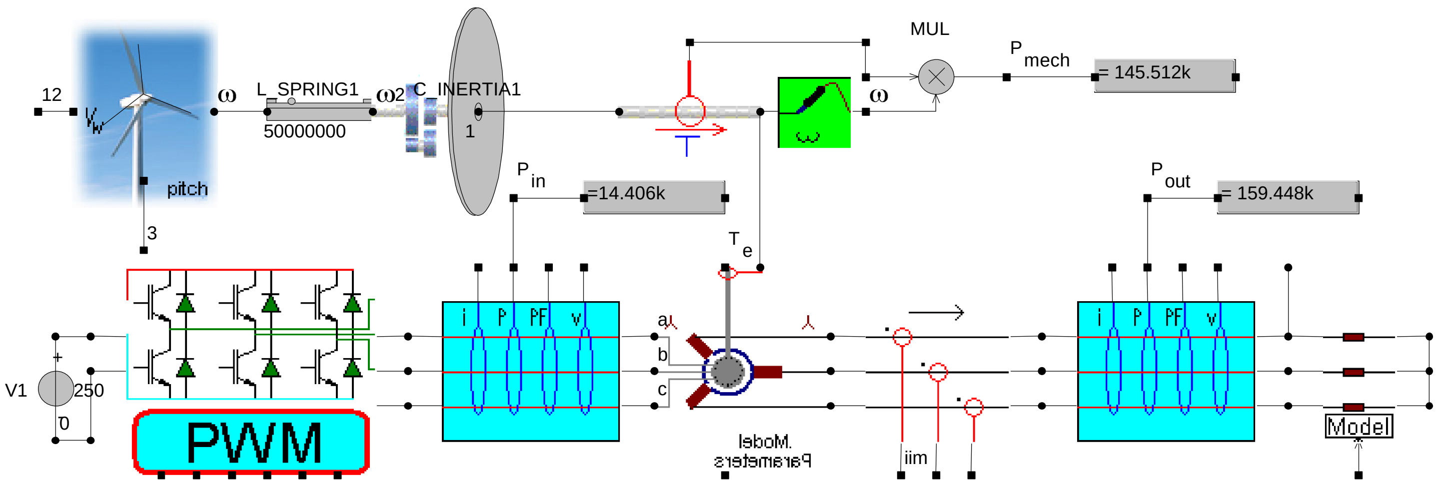
Fuel cell

The Fuel cell can be modeled either based on the voltage-current relations from a CFD package or the detailed model including hydrogen pressure and temperature.





Summarizing,
stay ahead in Green design
for a better future
quick and easy.



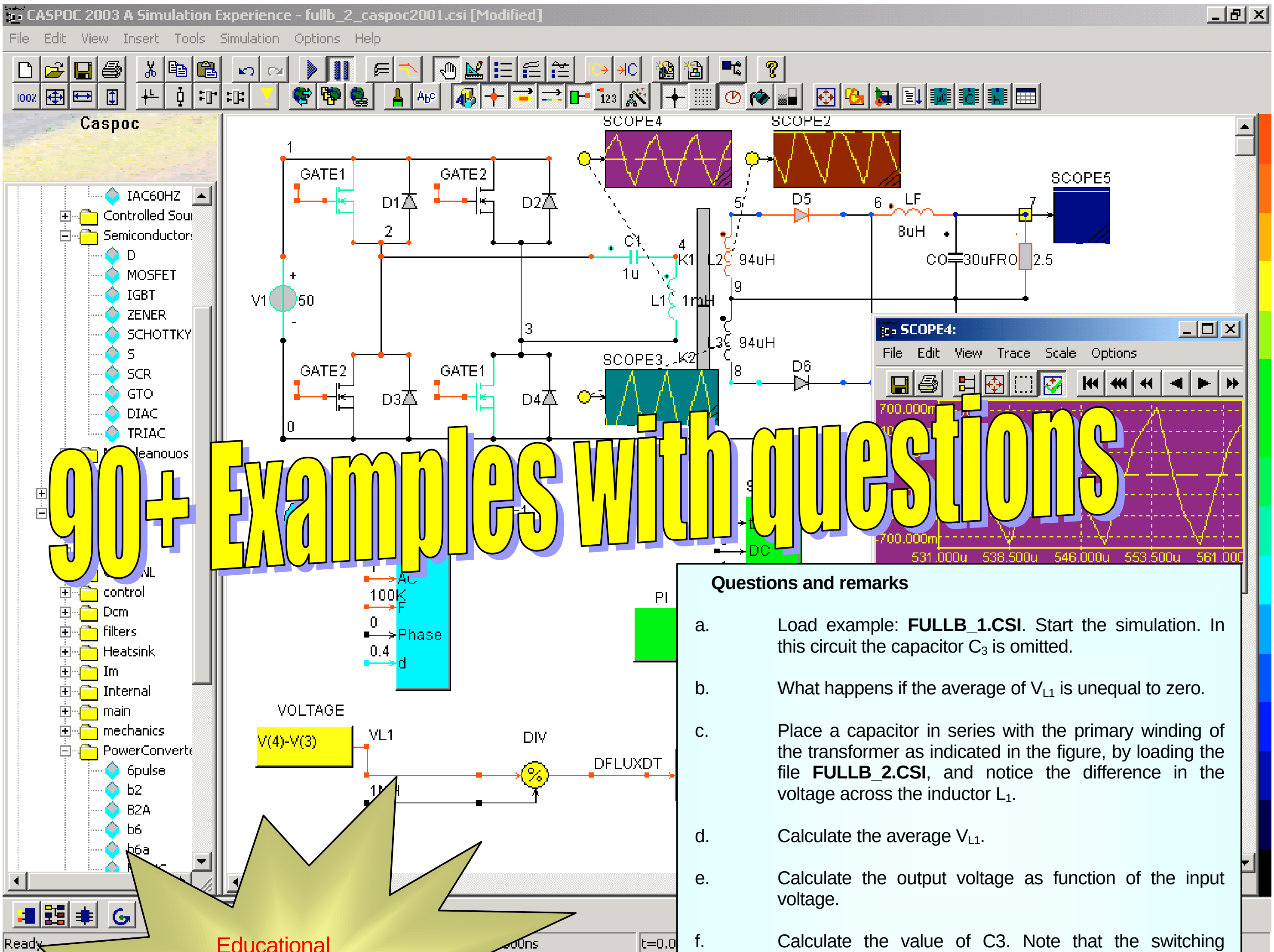
www.caspoc.com

CASPOC:You can't beat our speed!

CASPOC

A Simulation Experience

Power Electronics Example Package



90+ Examples with questions

Questions and remarks

a. Load example: **FULLB_1.CSI**. Start the simulation. In this circuit the capacitor C_3 is omitted.

b. What happens if the average of V_{L1} is unequal to zero.

c. Place a capacitor in series with the primary winding of the transformer as indicated in the figure, by loading the file **FULLB_2.CSI**, and notice the difference in the voltage across the inductor L_1.

d. Calculate the average V_{L1}.

e. Calculate the output voltage as function of the input voltage.

f. Calculate the value of C3. Note that the switching frequency must be higher the resonant frequency, $f_s > f_0$.

$$f_0 = \frac{1}{2\pi\sqrt{\left(\frac{N_p}{N_s}\right)^2 * L_f * C_3}} \Rightarrow C_3 = \frac{1}{4\pi^2 * f_0^2 * \left(\frac{n_p}{n_s}\right)^2 * L_f}$$

Educational
Power Electronics
Simulation & Animation
Examples

Fast & Easy!

WWW.CASPOC.COM

CASPOC: You can't beat our speed!

Power Electronics Example Package

Explore the world of Power Electronics and Electrical Drives using Caspoc. This Educational Example Package contains more than 90 preprogrammed examples of Power Electronics simulations for CASPOC. The examples include schematic, printed simulation results and educational questions and remarks on the example.

1-PHASE RECTIFIERS
1-phase diode rectifier
1-phase diode rectifier with inductive load
1-phase thyristor
1-phase diode bridge rectifier
1-phase half-controlled symmetrical bridge
1-phase half-controlled asymmetrical bridge
1-phase thyristor rectifier bridge
1-phase triac converter

3-PHASE RECTIFIERS
3-phase one sided thyristor bridge
3-phase half-controlled symmetrical bridge
3-phase thyristor bridge
3-phase diode bridge
3-phase triac converter

DC-DC CONVERTERS
boost converter
buck converter
buck-boost converter
2-quadrant converter
cuk converter
conventional chopper
bipolar switching dc-dc converter
unipolar switching dc-dc converter

RESONANT CONVERTERS
series resonant circuit
parallel resonant circuit
voltage-source series resonant converter
current-source parallel resonant converter
single-ended resonant dc/dc converter
resonant converter below the resonant frequency
resonant converter above the resonant frequency
series-loaded resonant converter
series-loaded resonant con. below resonant frequency
series-loaded resonant con. above resonant frequency
parallel-loaded resonant converter
parallel-loaded resonant con. below resonant freq.
parallel-loaded resonant con. above resonant freq.
zero-current-switching, quasi-res buck converter
zero-current-switching, quasi-res boost converter
zero-voltage-switching, quasi-res buck converter

SWITCH MODE DC POWER SUPPLIES WITH ISOLATION
forward dc/dc converter
flyback dc/dc converter
flyback parallel converter
forward 2 transistor dc/dc converter
flyback 2 output dc/dc converter
flyback 2 transistor dc/dc converter
current-source dc-dc converter
push-pull converter
full-bridge circuit
half-bridge circuit

DC TO AC INVERTERS
1-phase GTO DC-to-AC inverter
1-phase parallel inverter
1-phase current source inverter
mc Murray inverter
current-source inverter
voltage-source inverter

AC/AC CONVERTERS
dc-link converter with current storage
dc-link converter with voltage storage
dc-link converter with energy storage
6-pulse cycloconverter

TRANSFORMERS
1-phase transformer
triangle to star transformer
triangle to star transformer
star to triangle transformer
star to triangle transformer
triangle to triangle transformer

DRIVES
direct current machine
direct current machine with chopper drive
induction machine
current-source inverter with induction machine
voltage-source inverter with induction machine

CIRCUIT WITH CONTROLLER
switching of two capacitors
forward converter-feedback compensation
1-phase LC filter
3-phase LC filter
1-phase thyristor-controlled inductor for static var control
3-phase thyristor-controlled inductor for static var control
3-phase switch-mode static var controller
1-phase active filter
1-phase sinusoidal input current rectification
1-phase switch mode for a bidirectional powerflow
3-phase vector diagram
equivalent series resistance
second order system
diode snubber circuit
RMS and average calculation
flyback converter with voltage/current mode control

BUCK CONVERTER WITH CONTROLLER
buck current-mode control
buck current/voltage-mode control
buck P-I control
buck hysteresis control
buck converter with diode bridge and pwm controller
buck converter with diode bridge and amplitude mod.
buck converter with pwm controller

The Power Electronics Example package is included in the Educational Version in electronic form. A printed version can be ordered additionally.

More info:

Simulation Research
P.O. Box 397
NL 2400 AJ Alphen aan den Rijn
The Netherlands

Tel: +31 172 492 353

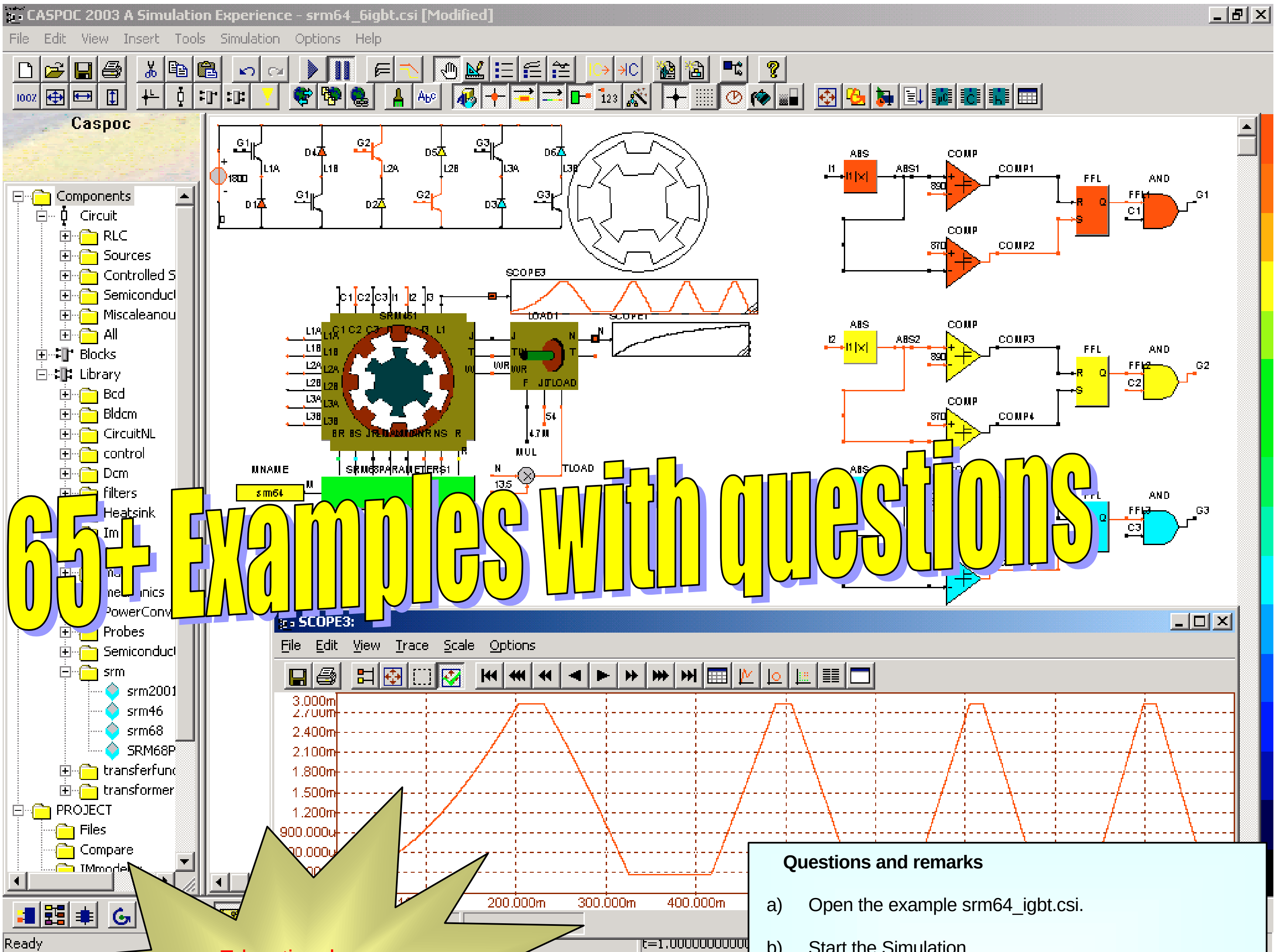
Email: sales@caspoc.com
Internet: www.caspoc.com

www.Simulation-Research.com

CASPOC

A Simulation Experience

Electrical Drives Example Package



65+ Examples with questions

Questions and remarks

a) Open the example srm64_igbt.csi.

b) Start the Simulation.

c) Calculate the maximum current through L1.

d) Explain the dependence on the rotor angle of the current through L1. Observe the rotor position in the animation.

Educational
Electrical Drives
Simulation & Animation
Examples

Fast & Easy!

WWW.CASPOC.COM

CASPOC: You can't beat our speed!

Electrical Drives Example Package

Explore the world of Electrical Drives using Caspoc. This Educational Example Package contains over 65 preprogrammed examples of Electrical Drives simulations for CASPOC. The examples include schematic, printed simulation results and educational questions and remarks on the example.

LINEAIR AND ROTATING SYSTEMS
Mass and damper
Mass, damper and spring
Axis inertia
Rotating axis
Sticktion

LOADS
Non linear loads
Inertia determining
Gearbox
Gearbox with margin
Lead-screw driven load
Lead-screw X- Y-axis driven load
Conveyor-belt
Conveyor-belt with variable load
Elevator
Moving car
Walking crane
Paper windup device with one roll
Paper windup device with two rolls

DCM MACHINES
Shunt-machine without induction
Shunt-machine with induction
Series-machine without induction
Series-machine with induction
Series-machine with induction and variable friction
DCM with permanent magnet
DCM temperature dependent

TRANSFORMATIONS
Transfer Ur, Us,Ut to Alpha and Beta vector
Transfer Alpha and Beta to D and Q vector
Transfer D and Q to Alpha and Beta vector
Transfer Alpha and Beta to Ur, Us and Ut
Transfer Ur, Us, Ut to Uu, Uv and Uw

MODULATION PRINCIPLES
Six pulse
Pulse wide modulation
Pulse amplitude modulation
Pulse frequency modulation
Vector pause modulation
Notch

ENCODERS
Analog to discreet encoder
Analog to amplitude modulation encoder
Analog to pulse freq. modulation encoder
Analog to three phase sinus encoder
Analog to trapezium encoder

INDUCTION MACHINES
Induction machine with formula of Kloss
Induction machine based on the T-model
Induction machine T-model with powers
Startup induction machine T-model
No load test with T-model
Induction machine slip=1
Direct current test induction machine
Startup induction machine 3-phase model
3-phase model with constant slip
3-phase mutual induction saturation
Vector diagram induction machine
Comparison T-model and 3-phase model

DRIVES INDUCTION MACHINES
Voltage source inverter
Adjustable speed drive
Induction machine in delta
Induction machine in star
Induction machine from star to delta
Soft-starter with constant fire angle
Soft-starter with decreasing fire angle
Six-step control

FIELD ORIENTED CONTROL
Vector-drive 1
Vector-drive 2
Vector-drive 3
Vector-drive 4
Vector-drive 5

DRIVES DCM
SCR-bridge with DCM
DCM, four quadrants and converter
Chopper controlled shunt DCM
Chopper controlled shunt DCM with brake
Controlled DCM with 3-phase SCR drive

STEP MACHINES
Step machine bipolar full-step
Step machine bipolar half-step
Step machine unipolar full-step
Step machine unipolar half-step

SWITCHED RELUCTANCE MACINES
Switched Reluctance Machine 4/6
Switched Reluctance Machine 6/8
Switched Reluctance Machine 4/6 with current control

The Electrical Drives Example package is included in the Educational Version in electronic form. A printed version can be ordered additionally.

More info:

Simulation Research
P.O. Box 397
NL 2400 AJ Alphen aan den Rijn
The Netherlands

Tel: +31 172 492 353

Email: sales@caspoc.com
Internet: www.caspoc.com

www.Simulation-Research.com