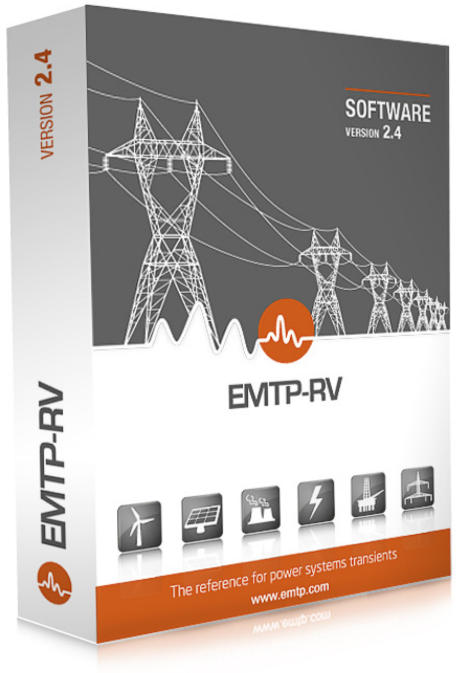


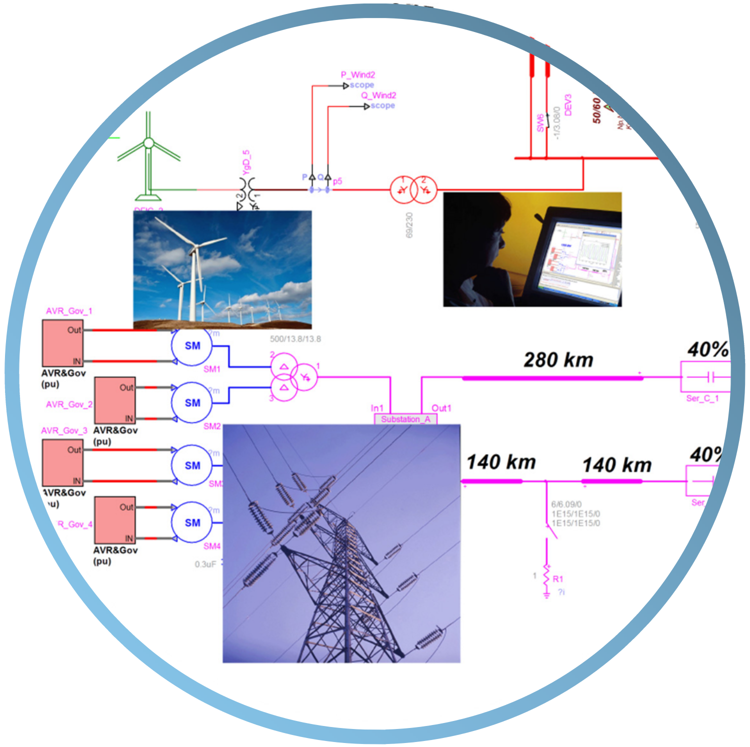
An introduction to EMTP-RV

The reference for power systems transients

powersys solutions
SOFTWARE & SERVICES

August 2012

EMTP-RV



The simulation of power systems has never been **so easy!**

EMTP-RV

Power system simulation tools

Short circuit calculation :
CYME 5.0 (CYMFAULT), ETAP

Calculations based on sequence data
Suitable for high scale networks
Frequency range : 50/60 Hz

Load-flow calculation :
CYME 5.0 (CYMFLOW), ETAP, PSLF, …

Calculation on 3-phase networks
Mainly on balanced networks
Frequency range : 50/60 Hz

DC — 50/60 Hz — kHz, MHz

Transient Stability programs :
Eurostag, PSS/E, DigSilent

Suitable for high scale networks
Simplified modeling of HVDC and FACTS components
Frequency range : 0.1Hz – 1kHz

EMTP type programs :
EMTP-RV, ATP, PSCAD, SimPowerSystems

Not suitable for high scale networks
Detailed modeling of equipments
Frequency range : 0.1 Hz – MHz

All software can handle transient study related to electromechanical time constants but **EMTP-RV can handle electromagnetics time constant which are significantly smaller (faster transients).**

EMTP-RV

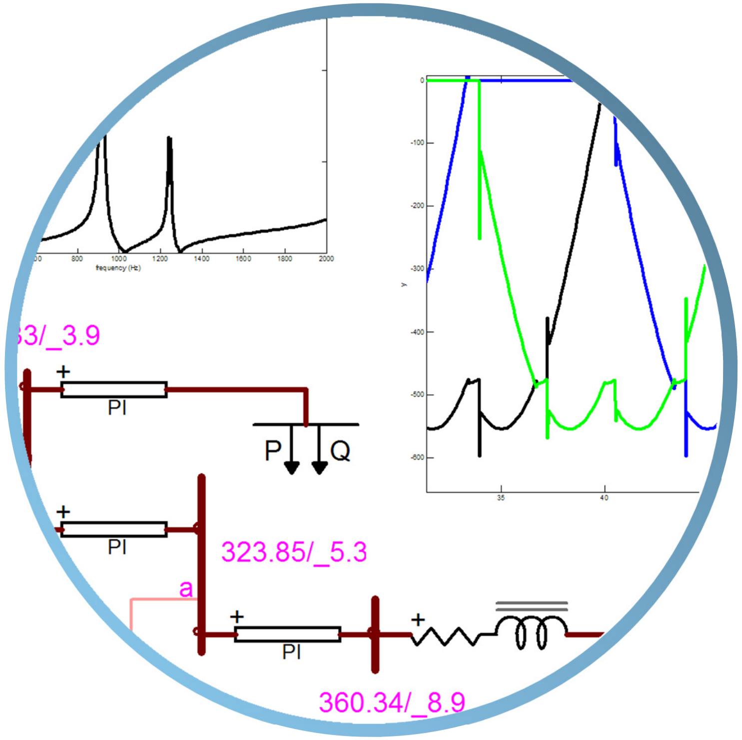
EMTP-RV, the Restructured Version

- Written from scratch using mostly Fortran-95 in Microsoft Visual Studio environment.
- Include all the EMTP96 functionalities and much more:
  - 3-phase unbalanced load-flow
  - Scriptable user interface
  - New models : machines, nonlinear elements…
  - No topological restrictions

- New numerical analysis methods :
  - Newton-raphson solution method for nonlinear models
  - New three-phase load-flow
  - Simultaneous switching options for power electronics applications
  - Open architecture coding that allows users customization (ex : connection with user defined DLL)

EMTP-RV

EMTP-RV benefits:



- Robust simulation engine
- Easy-to-use, drag and drop interface
- Unmatched ease of use
- Superior modeling flexibility
- Customizable to your needs
- Competitive pricing

EMTP-RV

Customizable to your needs

- Superior modeling flexibility

  – Can’t find exactly what you’re looking for in the device library? Simply add your own user-defined device.

  – Scripting techniques provide the ability to externally program device data forms and generate the required Netlists. A symbol editor is used to modify and customize device drawings. Scripting techniques are also used for parametric studies.

  – EMTPWorks also lets the user define any number of subcircuits to create hierarchical designs.a

The software package

EMTP-RV Package includes:

- EMTP-RV : computational engine

- With EMTP-RV, complex problems become simple to work out.

A powerful and super-fast computational engine that provides significantly improved solution methods for nonlinear models, control systems, and user-defined models. The engine features a plug-in model interface, allowing users to add their own models.

- EMTPWorks : Graphical User Interface

EMTPWorks, the user-friendly and intuitive Graphical User Interface, provides top-level access to EMTP-RV simulation methods and models.

EMTPWorks sends design data into EMTP-RV, starts EMTP-RV and retrieves simulation results.
An advanced, yet easy-to-use graphical user interface that maximizes the capabilities of the underlying EMTP-RV engine. EMTPWorks offers drag-and-drop convenience that lets users quickly design, modify and simulate electric power systems. A drawing canvas and the ability to externally program device data allows users to fully customize simulations to their needs. EMTPWorks can be used for small systems or very large-scale systems.

- ScopeView: the Output Processor for Data display and analysis

ScopeView displays simulation waveforms in a variety of formats.
With EMTPWorks, users can dramatically reduce the time required to setup a study in EMTP-RV.

Key features

- EMTP-RV Key features

- **The reference in transients simulation**

- **Solution for large networks**

- Provide **detailed modeling of the network component** including control, linear and non-linear elements

- **Open architecture** coding that allows users customization and implementation of sophisticated mode

- New **steady-state solution with harmonics**

- New three-phase **load-flow**

- **Automatic initialization** from steady-state solution

- New capability for **solving detailed semiconductor models**

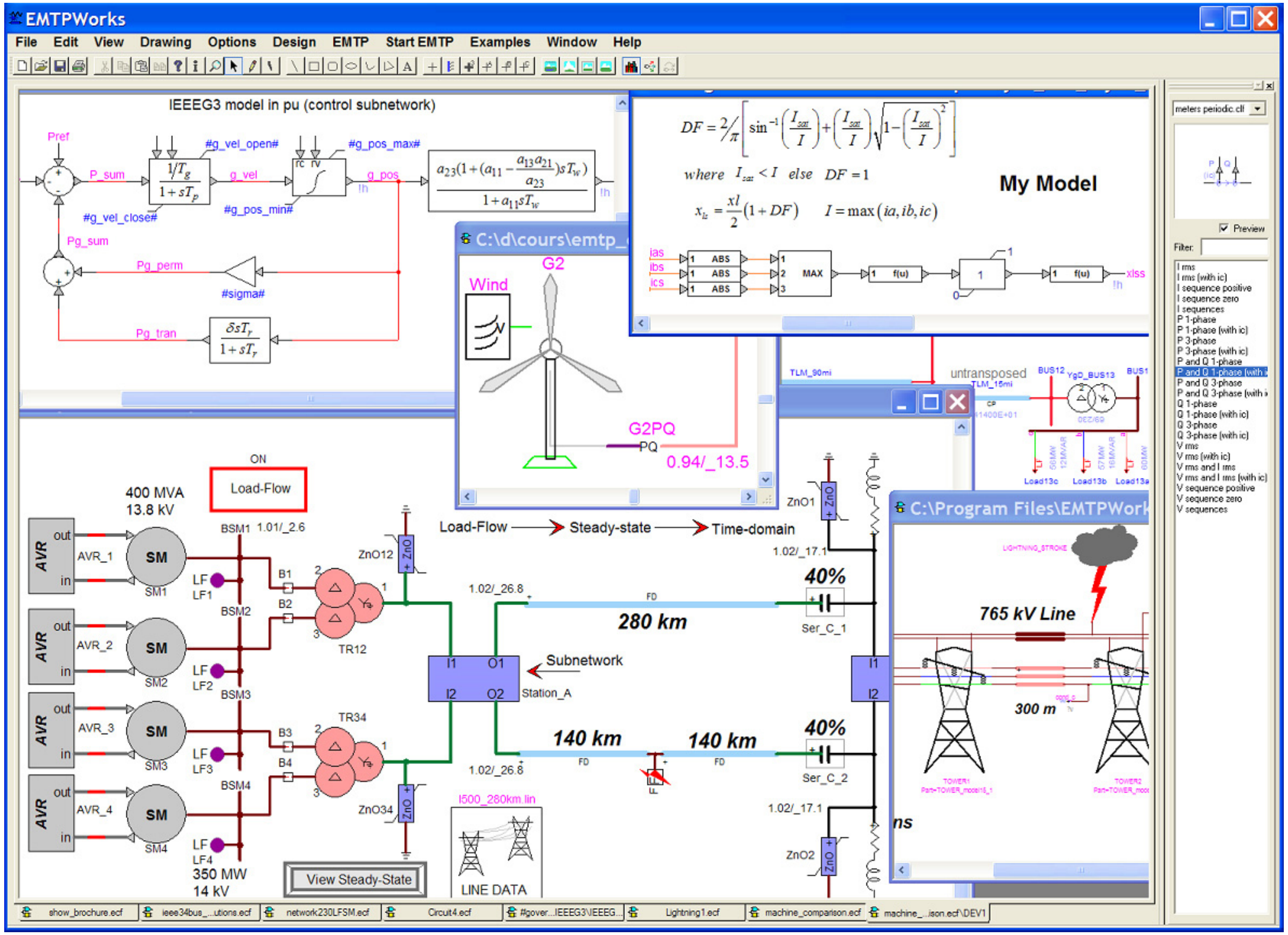
- Simultaneous switching options for power electronics applications

The GUI key features

EMTPWorks Key features

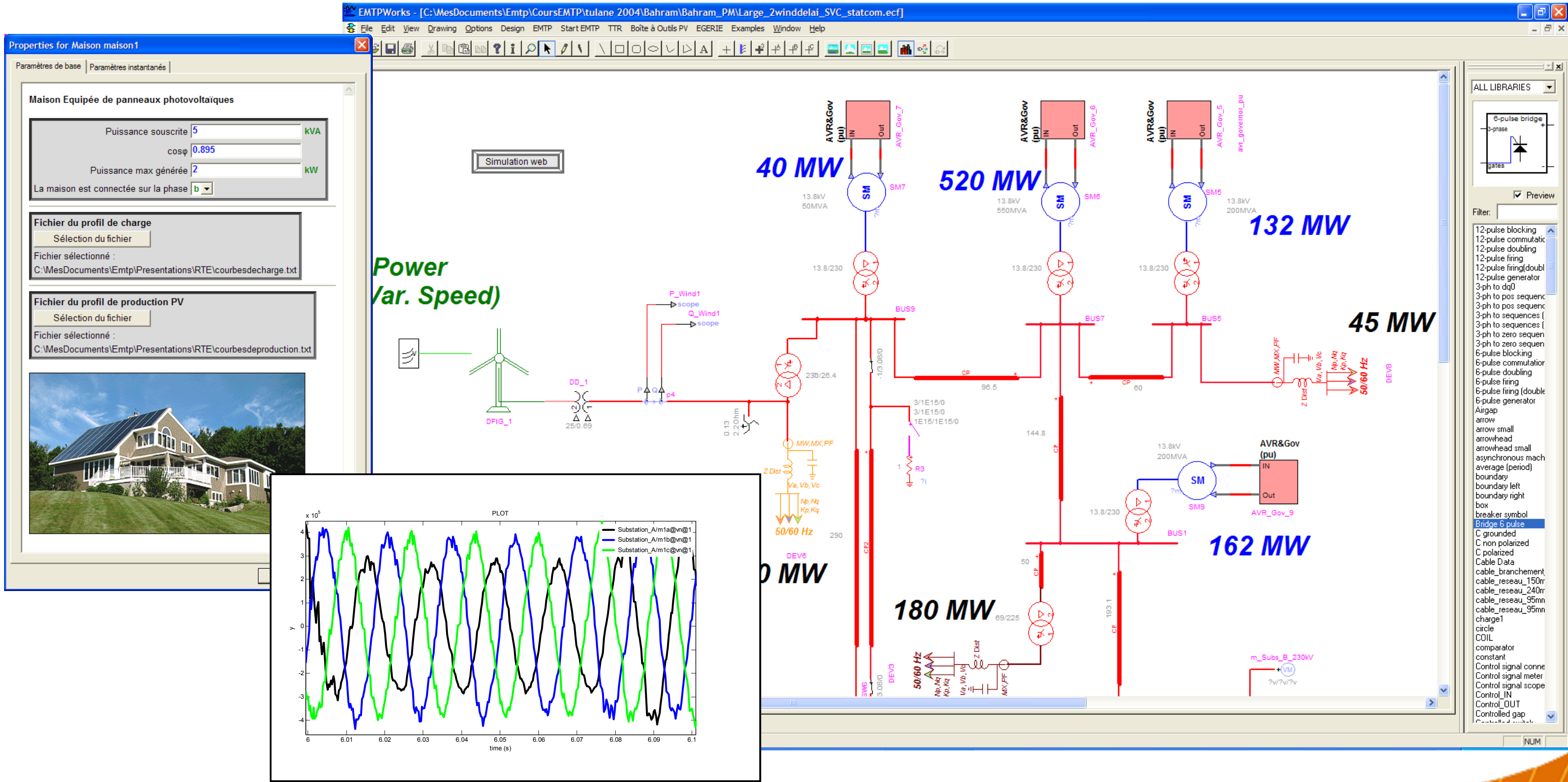
- Object-oriented design fully compatible with Microsoft Windows
- Powerful and intuitive interface for creating sophisticated Electrical networks
- Drag and drop device selection approach with simple connectivity methods
- Both devices and signals are objects with attributes. A drawing canvas is given the ability to create objects and customized attributes
- Single-phase/three-phase or mixed diagrams are supported
- Advanced features for creating and maintaining very large to extremely large networks
- Large number of subnetwork creation options including automatic subnetwork creation and pin positioning. Unlimited subnetwork nesting level
- Options for creating advanced subnetwork masks
- Multipage design methods
- Library maintenance and device updating methods

EMTPWorks: EMTP-RV user interface



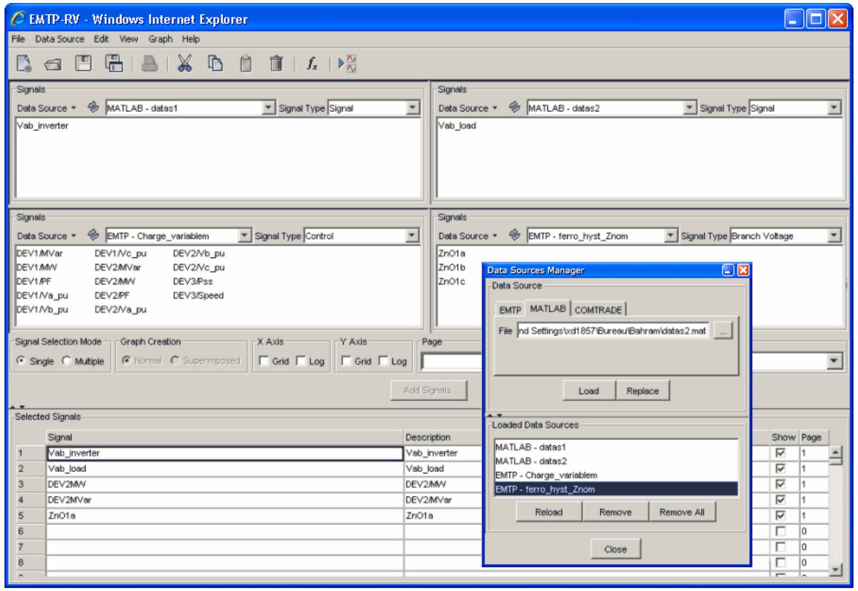
EMTPWorks: EMTP-RV user interface

- Object-oriented design fully compatible with Microsoft Windows
- Single-phase/three-phase or mixed diagrams are supported
- Large collection of scripts for modifying and/or updating almost anything appearing on the GUI

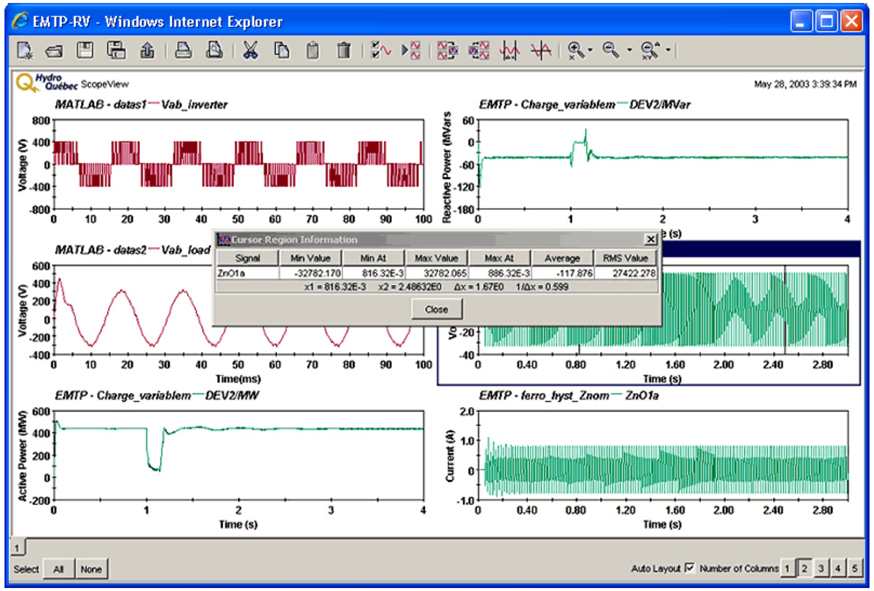


ScopeView

ScopeView is a data acquisition and signal processing software adapted very well for visualisation and analysis of EMTP-RV results.
It may be used to simultaneously load, view and process data from applications such as EMTP-RV, MATLAB and Comtrade format files.



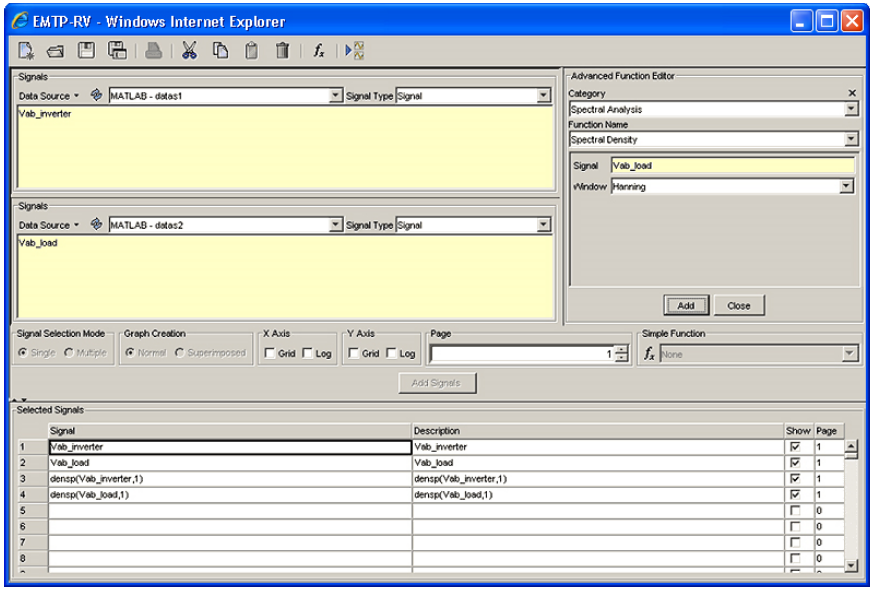
Multi-source data importation



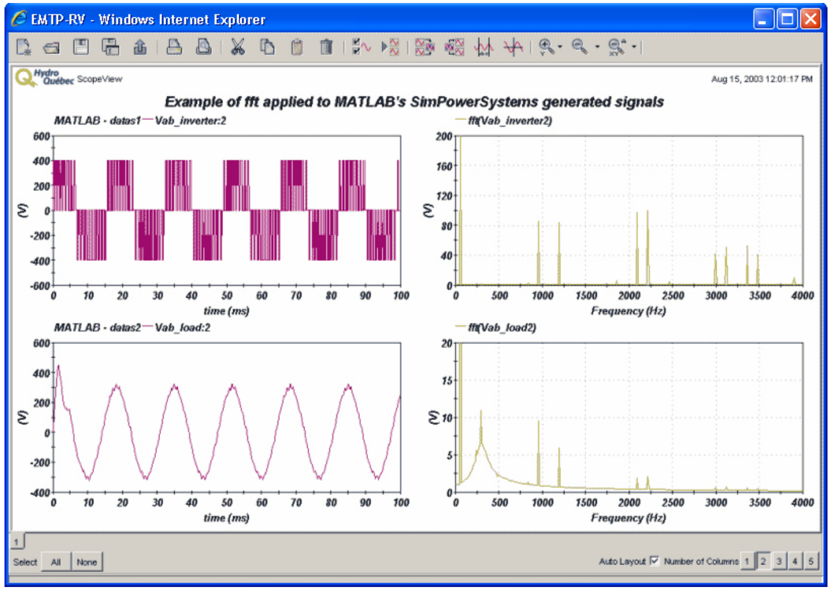
Cursor region information

EMTP-RV

ScopeView



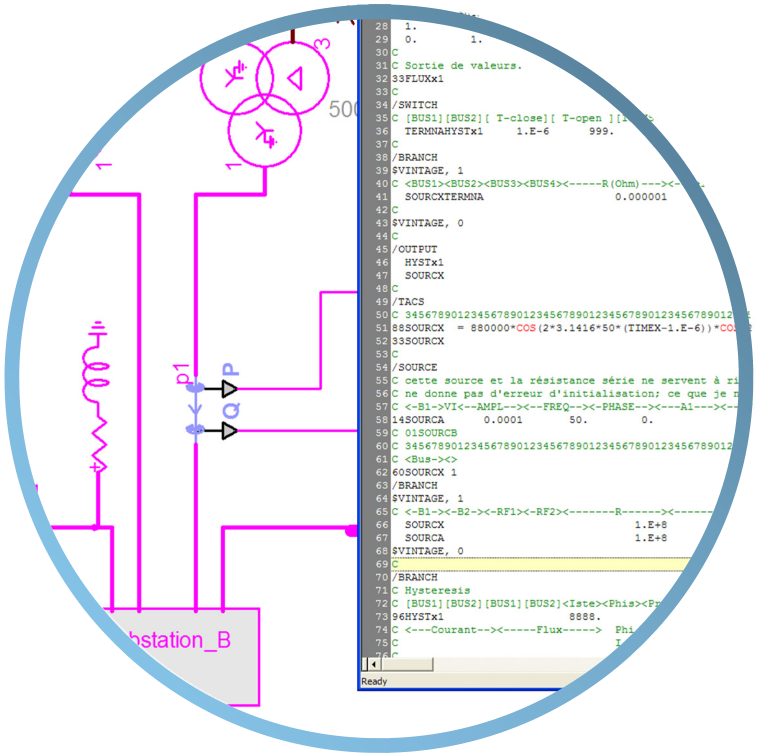
Function editor of ScopeView



Typical mathematical post-processing

A versatile program

EMTP-RV is suited to a wide variety of power system studies, whether they relate to project design and engineering, or to solving problems and unexplained failures.



EMTP-RV offers a wide variety of modeling capabilities encompassing electromagnetic and electromechanical oscillations ranging in duration from microseconds to seconds.

A powerful power system simulation software

EMTP-RV's benefits are:

Unmatched ease of use

Superior modeling flexibility

Customizable to your needs

Dynamic development road-map

Prompt and effective technical support

Reactive sales teams

EMTP-RV

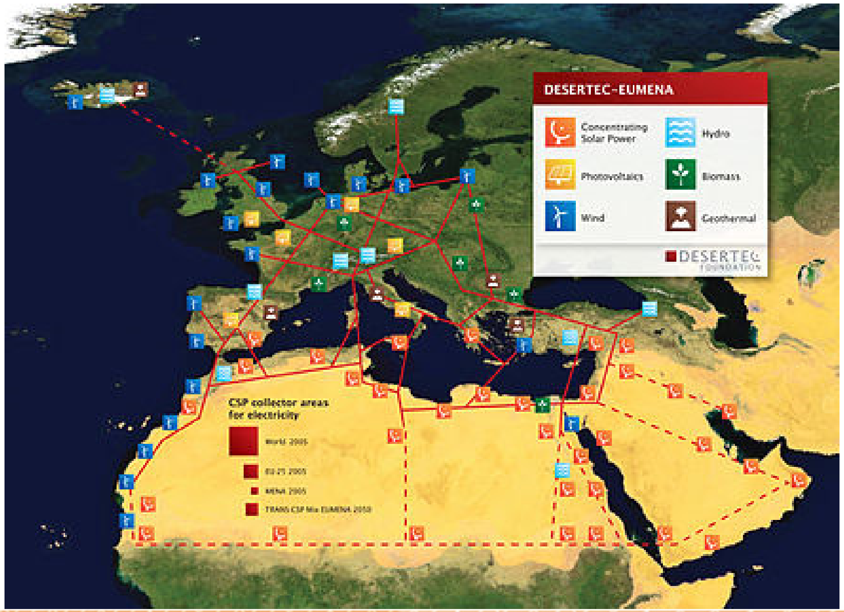
A powerful power system simulation software

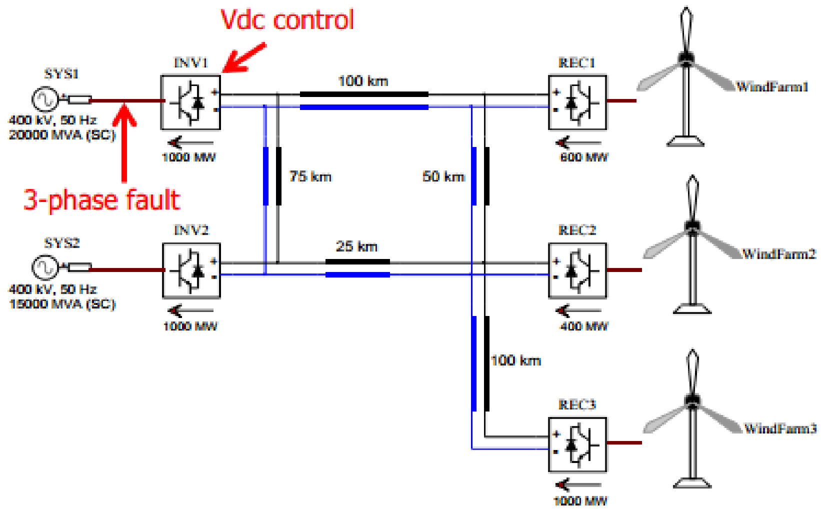
EMTP-RV's strengths:

- Used worldwide as a reference tool by the main actors of the power system industry since many years (EDF, Hydro-Québec, RTE and many other utilities, manufacturers, consultants…),
- Large field of power systems applications,
- Numerical robustness and stability,
- Comprehensive built-in libraries including detailed models of electrical machines, transformers, lines, cables, ...
- Automatically initializes time-domain simulations from steady-state,
- Capability to simulate very large power systems and power electronics systems without compromising precision,
- The most advanced user-defined modeling capabilities using DLLs and devices in the GUI,
- The same design can be used for load-flow, steady-state, time-domain and frequency scan simulation,
- Scriptable and customizable easy-to-use GUI,
- Many application examples are provided with EMTP-RV,
- Reactive and efficient technical support,
- Competitive pricing.

EMTP-RV version 2.4 new features:

- New and advanced **HVDC models**, including MMC-HVDC
- New **wind generator models**, including average-value model
- New **control system diagram DLL capability**
- New Simulink/Real-time Workshop interface DLL





EMTP-RV version 2.4 improvements:

Workshop interface DLL

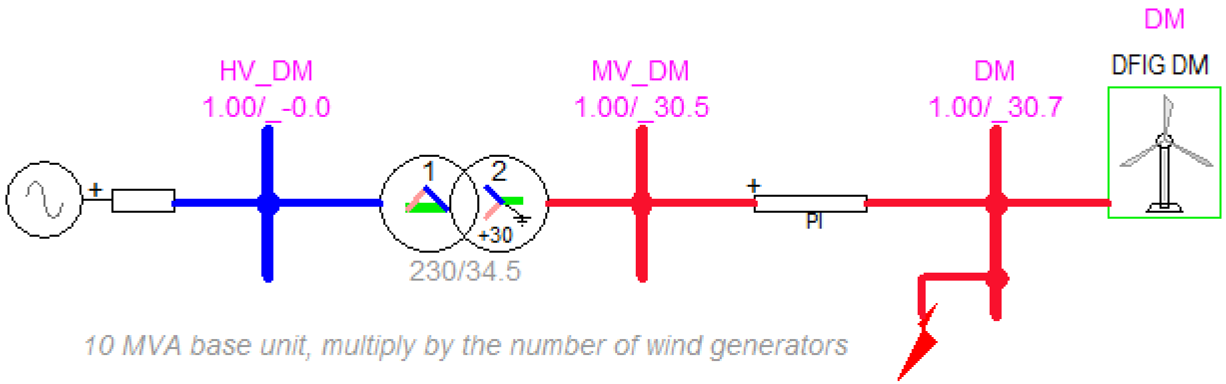
Improvements in synchronous machine model including a new black start option

Improvements in the asynchronous machine model

Capability to solve multiple frequency load-flow

Improved documentation and various other improvements

New application examples



Power system studies

EMTP-RV is suited to a wide variety of power system studies including and not limited to:

- Power system design
- Power system stability & load modeling
- Control system design
- Motor starting
- Power electronics and FACTS
- HVDC networks
- Lighting surges
- Switching surges
- Temporary overvoltages
- Insulation coordination
- Complete network analysis
- Ferroresonance
- Steady-sate analysis of unbalanced system
- Distribution networks and distributed generation
- Power system dynamic and load modeling
- Subsynchronous resonance and shaft stresses
- Power system protection issues
- General control system design
- Power quality issues
- Capacitor bank switching
- And much more!

A versatile program

Complete system studies:

- Load-flow solution and initialization of synchronous machines
- Temporary overvoltages to network islanding
- Ferroresonance and harmonic resonance
- Selection and usage of arresters
- Fault transients
- Statistical analysis of overvoltages
- Electromechanical transients

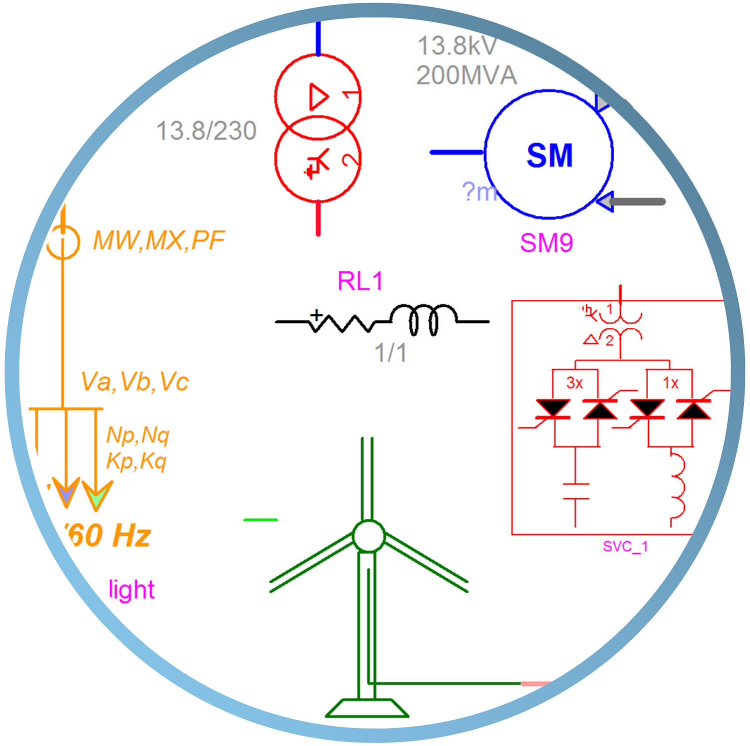
EMTP-RV

Applications

- **Power system design**
- Power systems protection issues
- **Network analysis**: network separation, power quality, geomagnetic storms, interaction between compensation and control components, wind generation
- Detailed simulation and analysis of **large scale** (unlimited size) **electrical systems**
- Simulation and analysis of **power system transients:** lightning, switching, temporary conditions
- General purpose **circuit analysis**: wideband, from load-flow to steady-state to time-domain (Steady-state analysis of unbalanced systems)
- **Synchronous machines**: SSR, auto-excitation, control
- **Transmission line systems**: insulation coordination, switching, design, wideband line and cable models

Applications

- **Power Electronics and FACTS** (HVDC, SVC, VSC, TCSC, etc.)
- Multiterminal **HVDC systems**
- **Series compensation**: MOV energy absorption, short-circuit conditions, network interaction
- **Transmission line systems**: **insulation coordination**, switching, design, wideband line and cable models
- **Switchgear**: TRV, shunt compensation, current chopping, delayed-current zero conditions, arc interaction
- **Protection**: power oscillations, saturation problems, surge arrester influences
- **Temporary overvoltages**
- **Capacitor bank switching**
- **Series and shunt resonances**
- **Detailed transient stability analysis**
- **Unbalanced distribution networks**



Simulation options

Load-flow

Steady-state

Time-domain

Frequency scan

Simulation options

- **Load-Flow solution**
  - The electrical network equations are solved using complex phasors.
  - The active (source) devices are only the Load-Flow devices (LF-devices). A load device is used to enter PQ load constraint equations.
  - Only single (fundamental) frequency solutions are achievable in this version. The solution frequency is specified by 'Default Power Frequency' and used in passive network lumped model calculations.
  - The same network used for transient simulations can be used in load-flow analysis. The EMTP Load-Flow solution can work with multiphase and unbalanced networks.
  - The control system devices are disconnected and not solved.
  - This simulation option stops and creates a solution file (Load-Flow solution data file). The solution file can be loaded for automatically initializing anyone of the following solution methods.

Simulation options

- Steady-state solution

  - The electrical network equations are solved using complex numbers. This option can be used in the stand-alone mode or for initializing the time-domain solution.
  - A harmonic steady-state solution can be achieved.
  - The control system devices are disconnected and not solved.
  - Some nonlinear devices are linearized or disconnected. All devices have a specific steady-state model.
  - The steady-state solution is performed if at least one power source device has a start time (activation time) lower than 0.

Simulation options

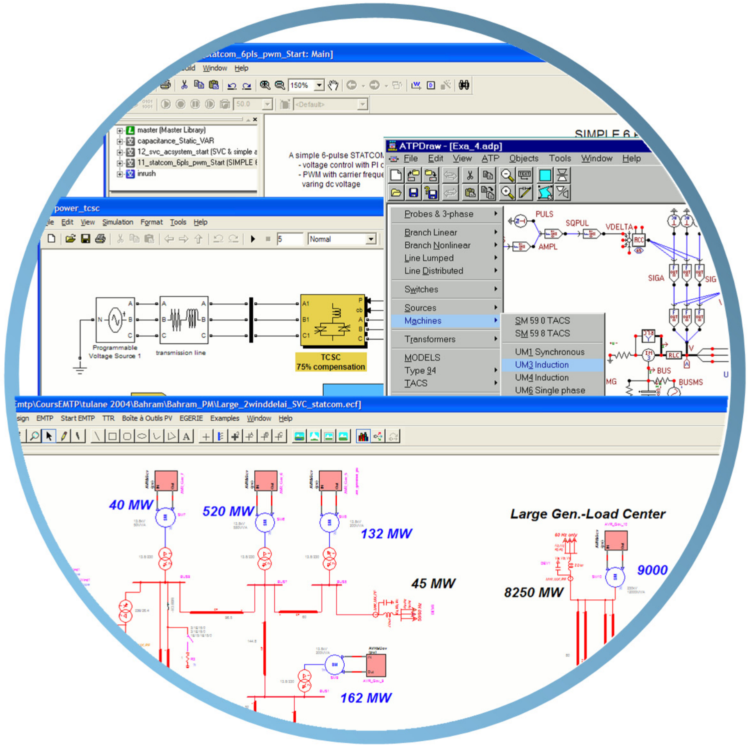
- Time-domain solution

  - The electrical network and control system equations are solved using a numerical integration technique.
  - All nonlinear devices are solved simultaneously with network equations. A Newton method is used when nonlinear devices exist.
  - The solution can optionally start from the steady-state solution for initializing the network variables and achieving quick steady-state conditions in time-domain waveforms.
  - The steady-state conditions provide the solution for the time-point t=0. The user can also optionally manually initialize state-variables.

Simulation options

- Frequency scan solution

  – This option is separate from the two previous options. All source frequencies are varied using the given frequency range and the network steady-state solution is found at each frequency.



Build-in libraries and Standard models available in EMTP-RV

Built-in librairies

EQUIPMENT	FEATURES
advanced.clf	Provides a set of advanced power electronic devices
Pseudo Devices.clf	Provides special devices, such as page connectors. The port devices are normally created using the menu "Option>Subcircuit>New Port Connector", they are available in this library for advanced users.
RLC branches.clf	Provides a set of RLC type power devices. .
Work.clf	This is an empty library accessible to users
control.clf	The list of primitive control devices.
control devices of TACS.clf	This control library is provided for transition from EMTP-V3. It imitates EMTP-V3 TACS functions.
control functions.clf	Various control system functions.
control of machies.clf	Exciter devices for power system machines.
flip flops.clf	A set of flip-flop functions for control systems.
hvdc.clf	Collection of dc bridge control functions. Documentation is available in the subcircuit.
lines.clf	Transmission lines and cables.
machines.clf	Rotating machines.
meters.clf	Various measurement functions, including sensors for interfacing control device signals with power device signals.
meters periodic.clf	Meters for periodic functions.
nonlinear.clf	Various nonlinear electrical devices.
options.clf	EMTP Simulation options, plot functions and other data management functions.
phasors.clf	Control functions for manipulating phasors.
sources.clf	Power sources.
switches.clf	Switching devices.
symbols.clf	These are only useful drawing symbols, no pins.
transformations.clf	Mathematical transformations used in control systems.
transformers.clf	Power system transformers.

EMTP-RV

Standard models

Library	Models
RLC branches	R, L, C branches PI circuits Loads State space block
Control	Gain, constant Integral, derivative Limiter, Sum Selector Delay State-space block PLL…
Control of Machines	IEEE excitation systems Governor / turbine
Flip flops	Flip-flop D, J-K, S-R,T
Lines	CP (distributed parameters) FD (=CP + frequency dependence) FDQ (=FD for cables) WB (phase domain) Corona

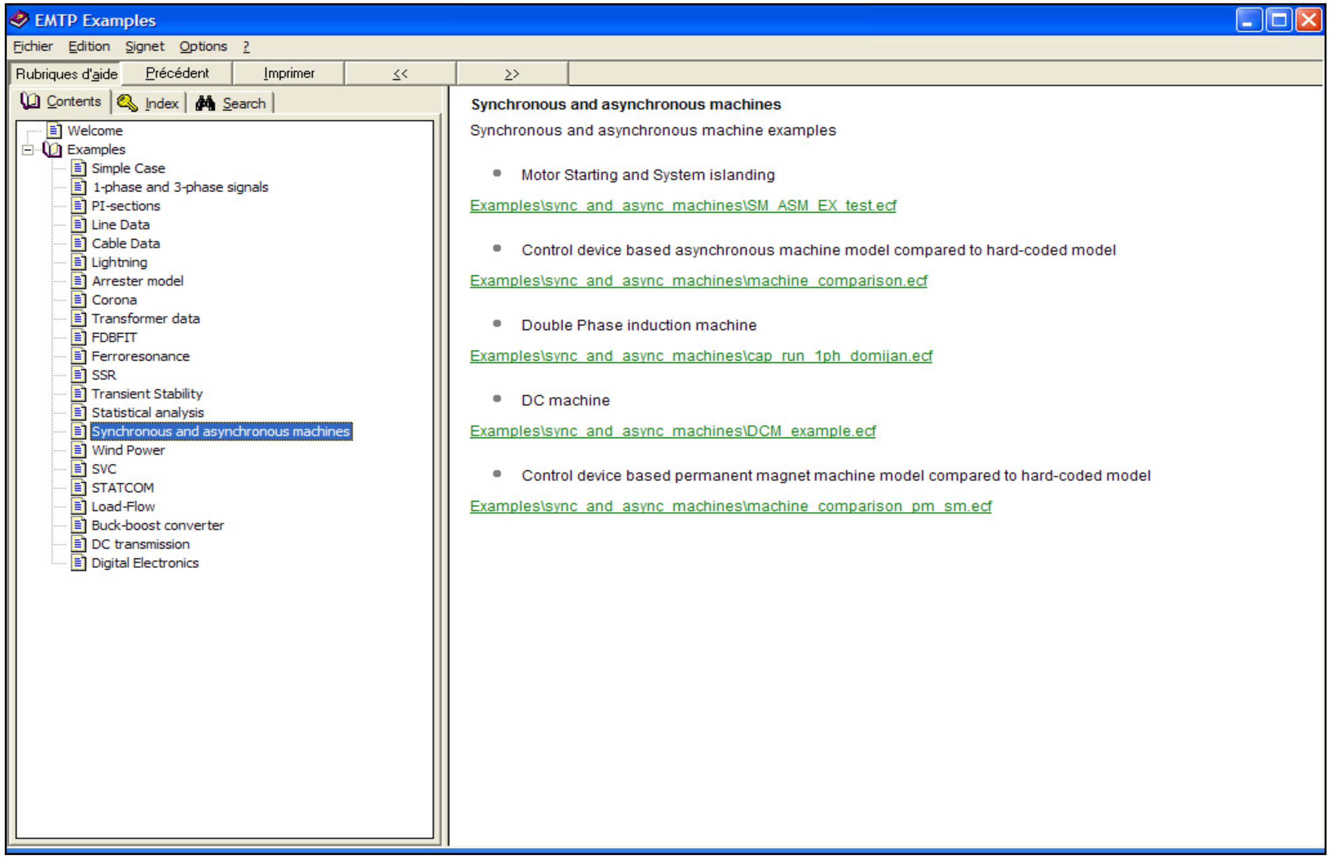
Standard models

Library	Models
Machines	Induction Machine (single cage, double cage, wound rotor) Synchronous Machine Permanent Magnet Synchronous Machine DC machine 2-phase machine
Meters	Current, voltage, power meters
Meters periodic	RMS meters and sequence meters
Nonlinear	Non linear resistance Non linear inductance Hysteresis reactor ZnO arrester SiC arrester
Sources	AC, DC voltage sources AC, DC current sources Lightning inpulse current source Current and voltage controlled sources Load-flow bus

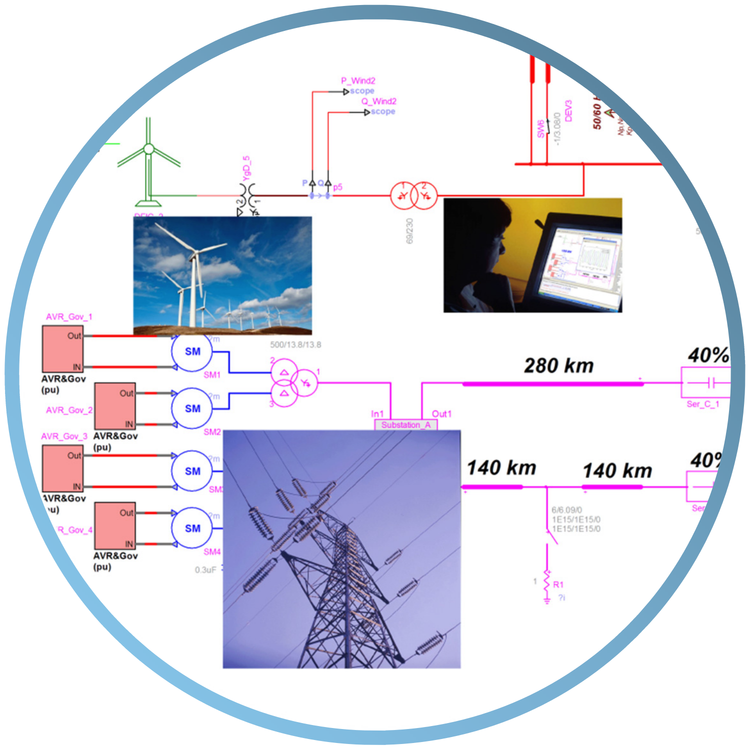
Standard models

Library	Models
Switches	Ideal switch Diode Thyristor Air gap
Transformations	3-phase <-> sequence 3-phase <-> dq0
Transformateurs	Based on single phase units : DD, YY, DY, YD, YYD… Topological models : TOPMAG Impedance based : BCTRAN, TRELEG Frequency dependent admittance matrix : FDBFIT
Advanced	Variable load SVC STATCOM

Built-in library of examples



Easily find what you're looking for by browsing or using a simple index.

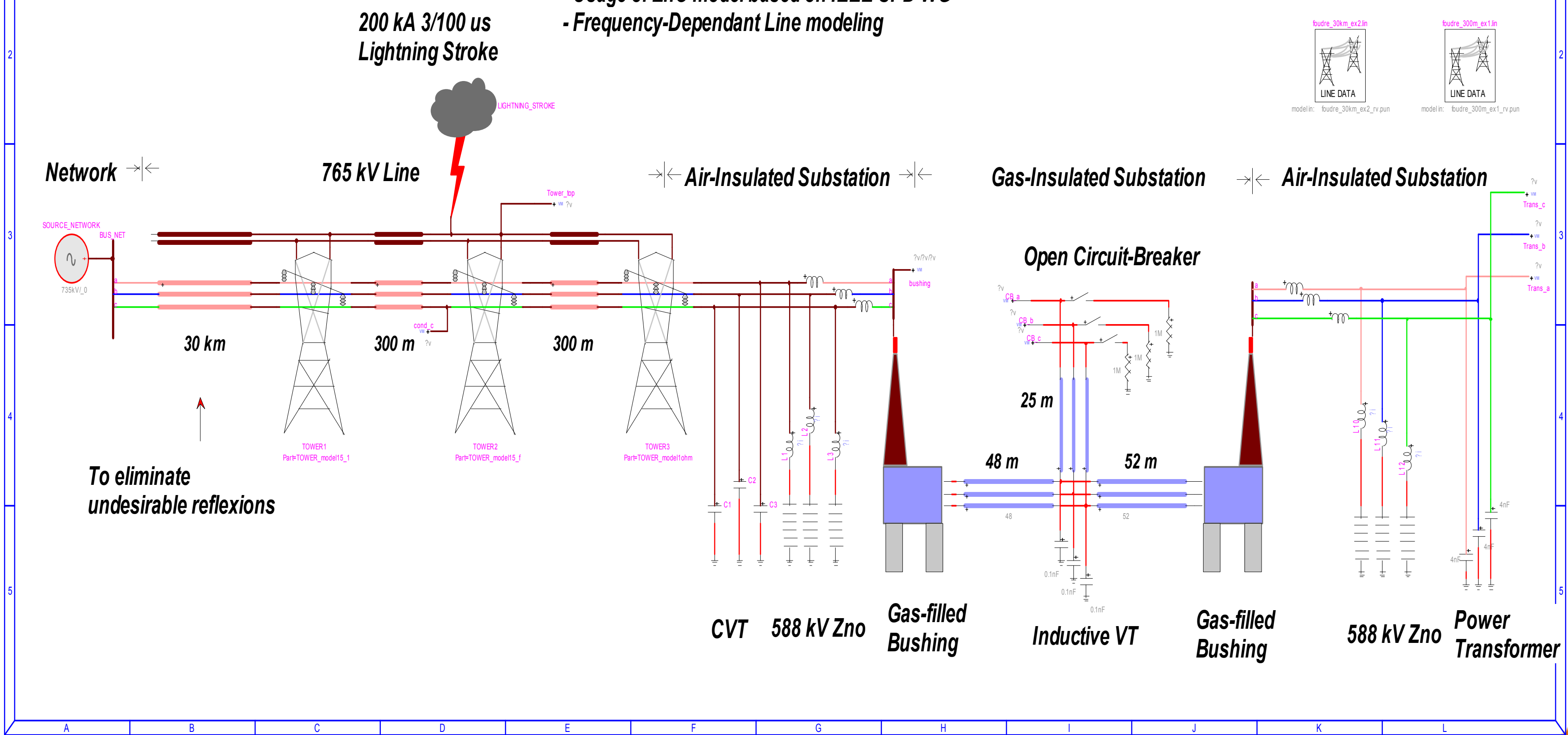


Typical designs

Modeling Electrical Systems with EMTP-RV

Insulation Coordination of a 765 kV GIS

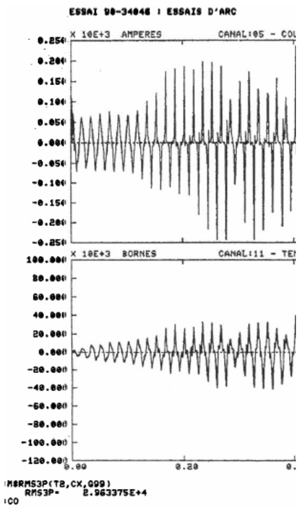
- Backflashover Case
- Impulse Footing Resistance of the stricken Tower may be represented by Ri = f(I)
- Usage of ZnO model based on IEEE SPD WG
- Frequency-Dependant Line modeling



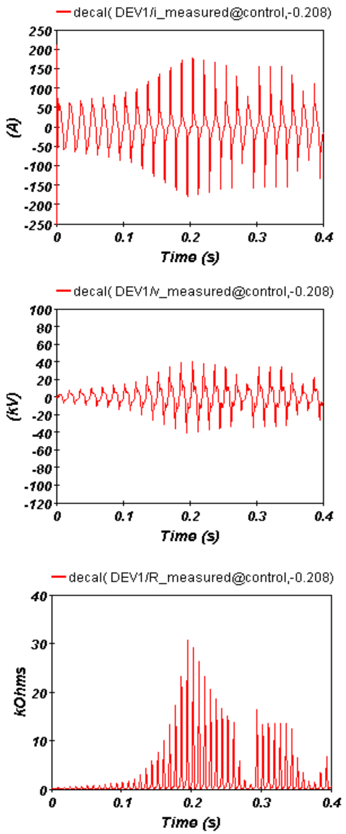
EMTP-RV

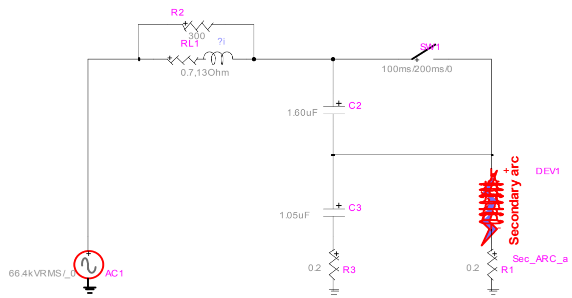
Validation of the Secondary Arc Model with IREQ Laboratory Tests

Field Recording
(10-08-1986)



EMTP-RV Simulation
(05-22-2005)





Primary Arc: 5 kA eff
Secondary Arc: 40 A
Wind Speed: 9.7 km/h
Secondary Arc Duration: 1.04 sec.
315 kV insulator string, l=2.3 m

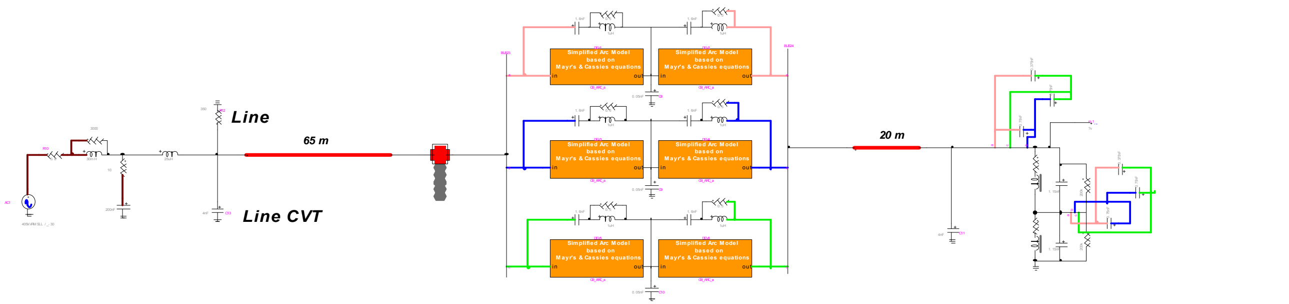
I/O FILES

EMTP-RV

Switching of A 420 kV Three-Phase Shunt-Reactor

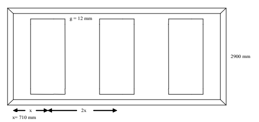
State of the art simulation introducing:

- ***A realistic model of a three-phase shunt reactor taking into account the asymetrical couplings of the magnetic circuit;***
- ***A realistic circuit-breaker model based on the well-known Cassie - Mayr modified arc equations.***



Three-Phase 420 kV 100 MVARS Shunt Reactor

F= 0.548 Wb, N=1409 turns, L1=5.617 H

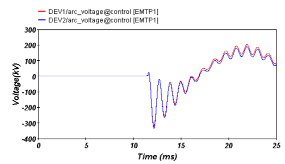


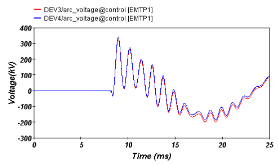
For mu (50 Hz) = 0.06 H/m:

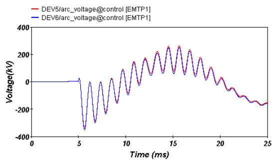
Xac=Xca= 9 Ohms
Xba=Xbc=7 Ohms
Xab=14 Ohms
Xaa= 1741 Ohms
Xbb= 1750 Ohms
Xcc=1741 Ohms

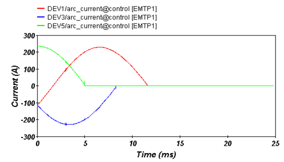
For mu (700 Hz) = 0.01 H/m:

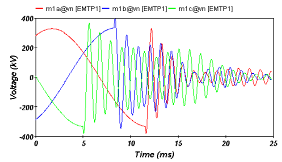
Xac=Xca= 54 Ohms
Xba=Xbc=42 Ohms
Xab=84 Ohms
Xaa= 1741 Ohms
Xbb= 1750 Ohms
Xcc=1741 Ohms



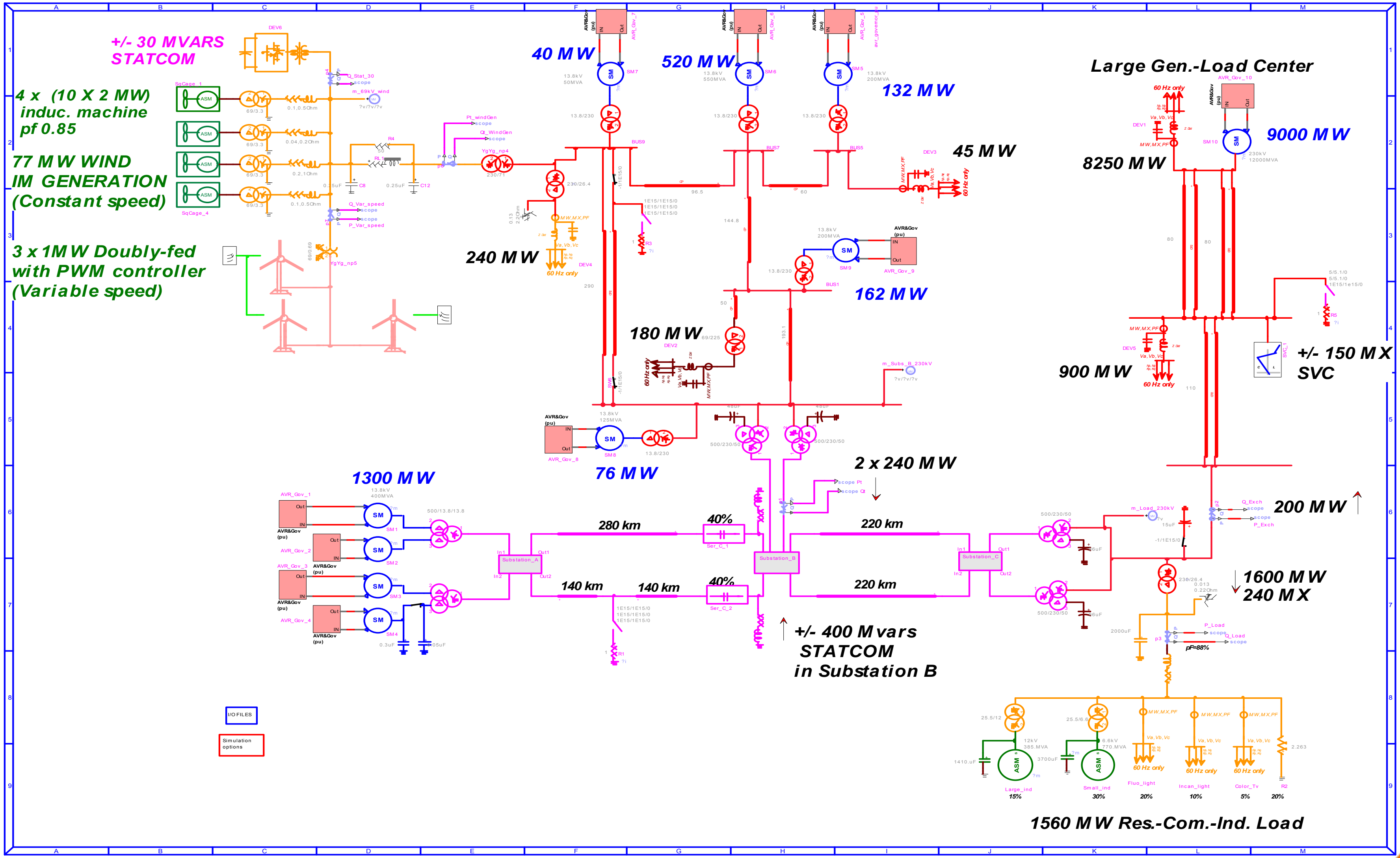








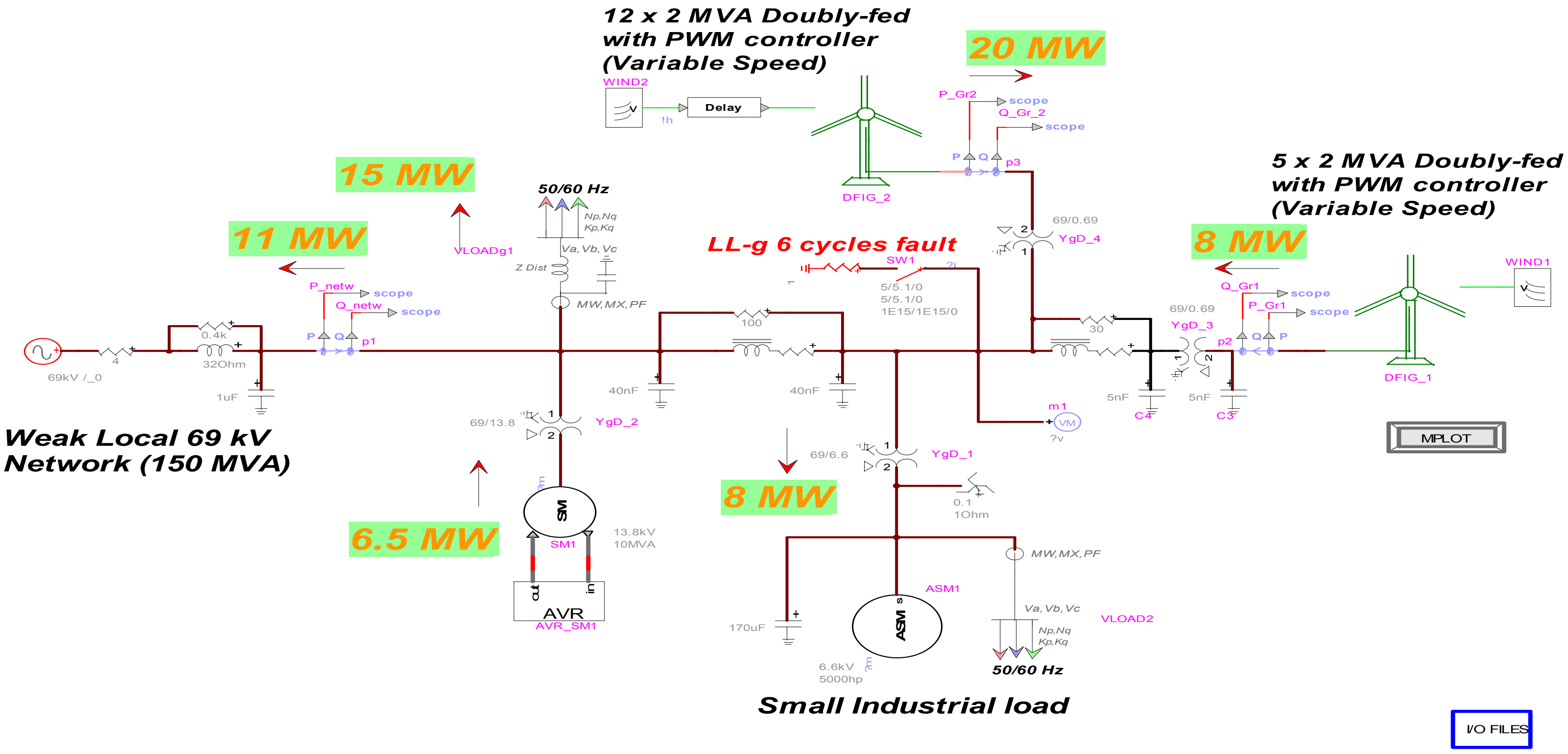
EMTP-RV


+/- 30 MVARS
STATCOM
4 x (10 X 2 MW)
induc. machine
pf 0.85
77 MW WIND
IM GENERATION
(Constant speed)
3 x 1MW Doubly-fed
with PWM controller
(Variable speed)
40 MW
520 MW
132 MW
45 MW
240 MW
162 MW
180 MW
76 MW
Large Gen.-Load Center
9000 MW
8250 MW
900 MW
+/- 150 MX
SVC
2 x 240 MW
1300 MW
280 km
40%
220 km
140 km
140 km
40%
220 km
200 MW
1600 MW
240 MX
+/- 400 Mvars
STATCOM
in Substation B
1560 MW Res.-Com.-Ind. Load

EMTP-RV

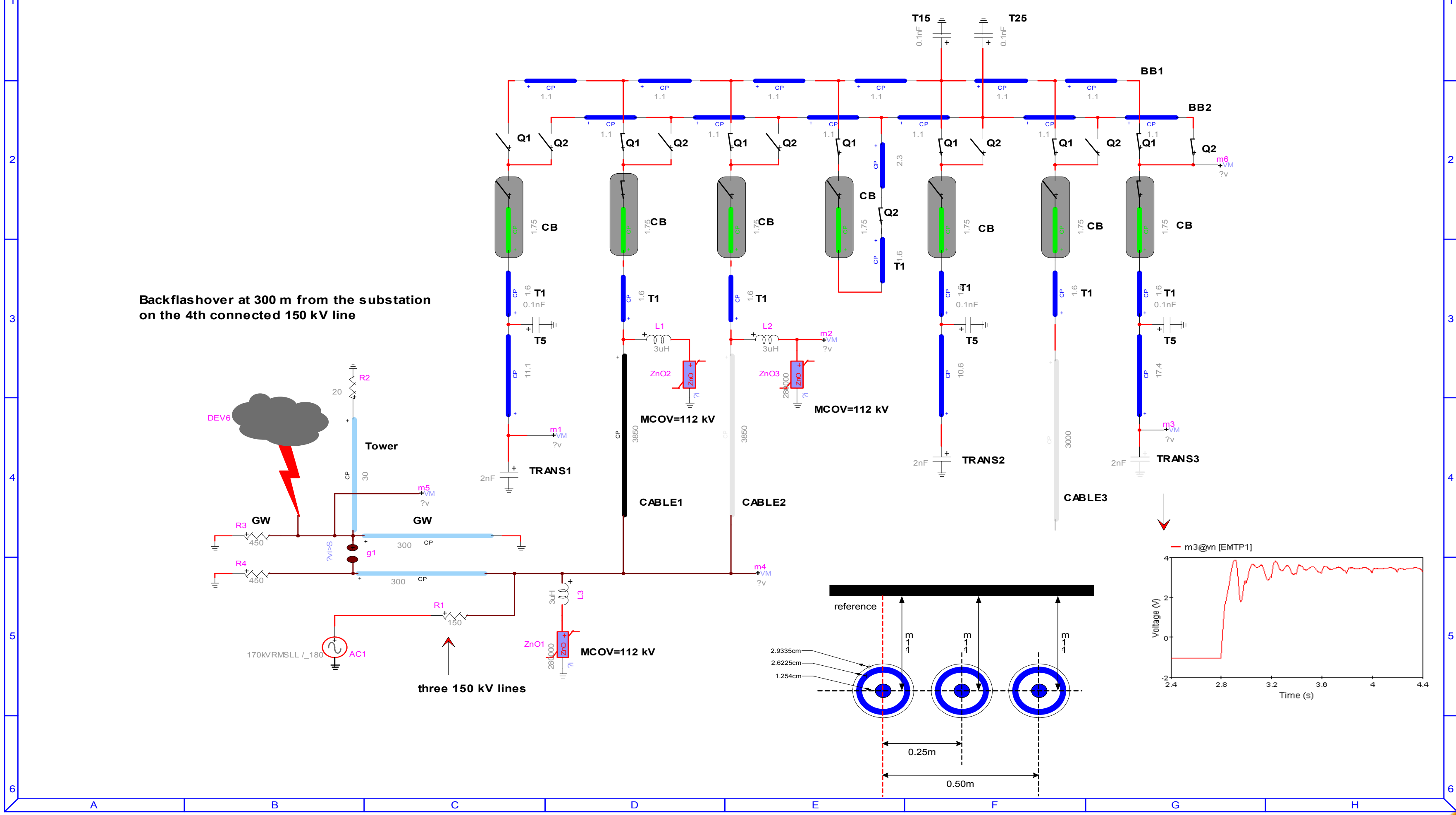
Windmill Power Generation In a weak Power System

- Realistic Wind Data;
- Realistic DFIG Modeling;
- Realistic Network & Load Models
- Realistic Harmonic Distorsions & Dynamic Performances



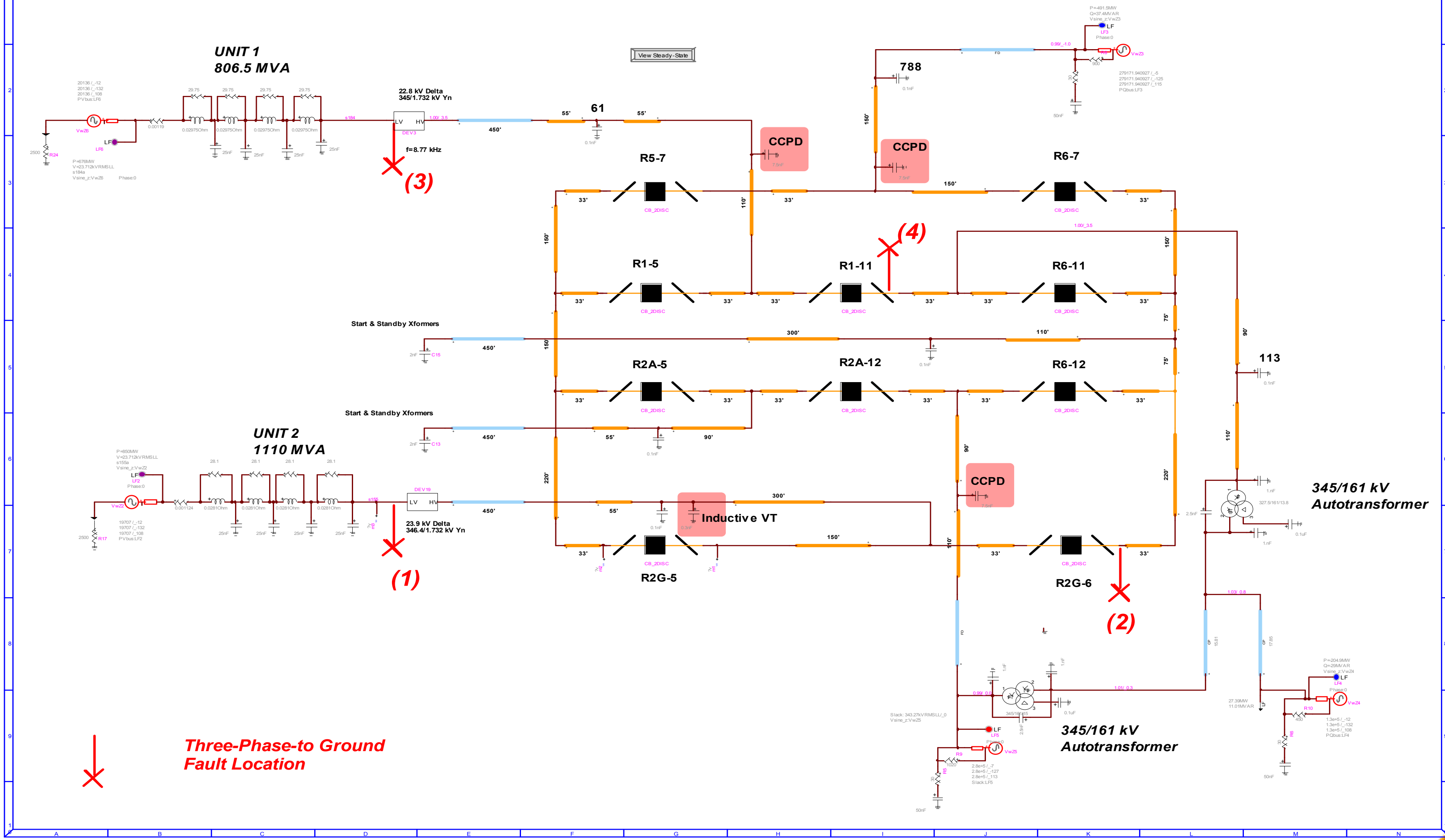
EMTP-RV

Insulation Coordination of a 150 kV GIS



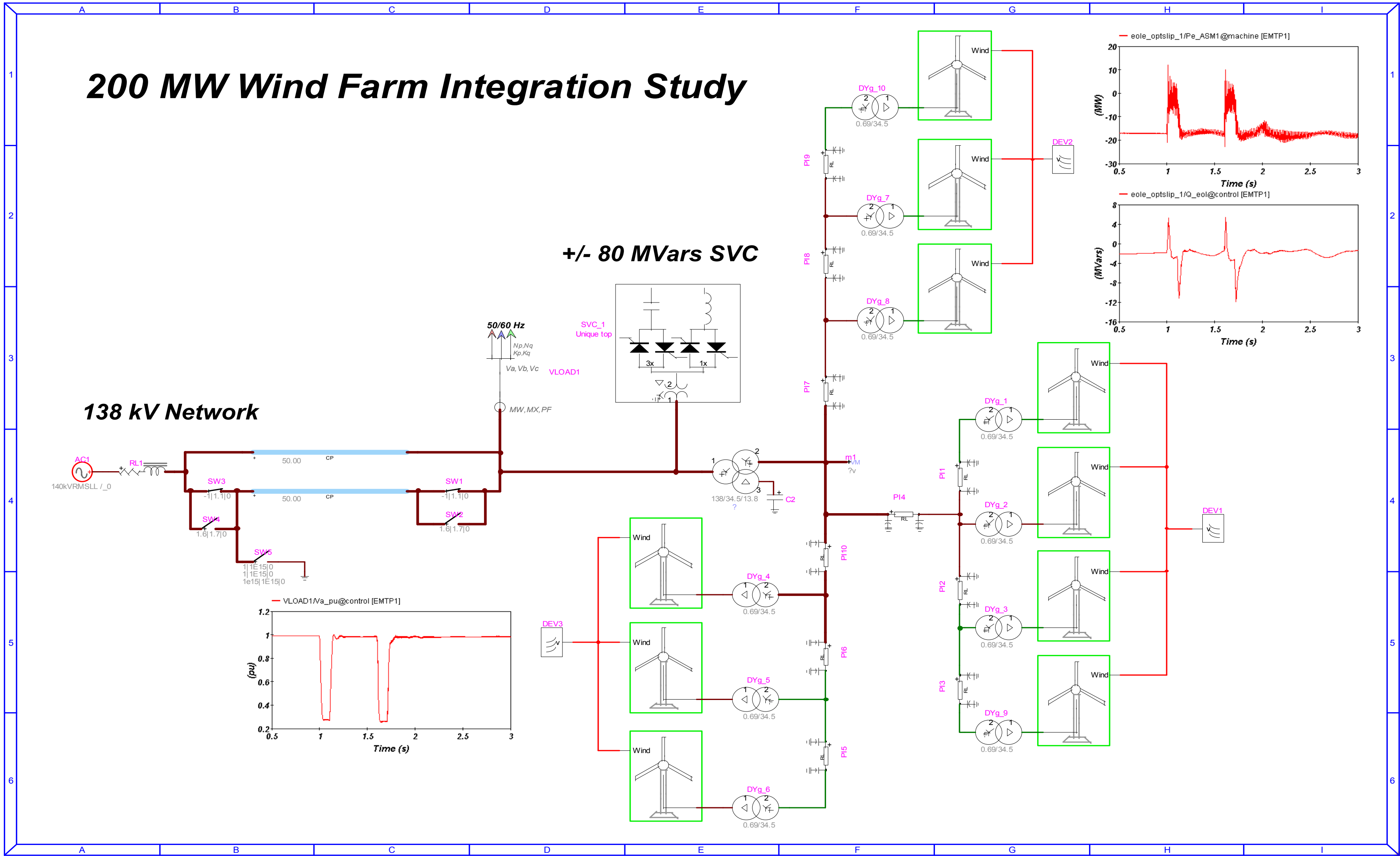
EMTP-RV

TRV STUDY AT A 345 kV SUBSTATION



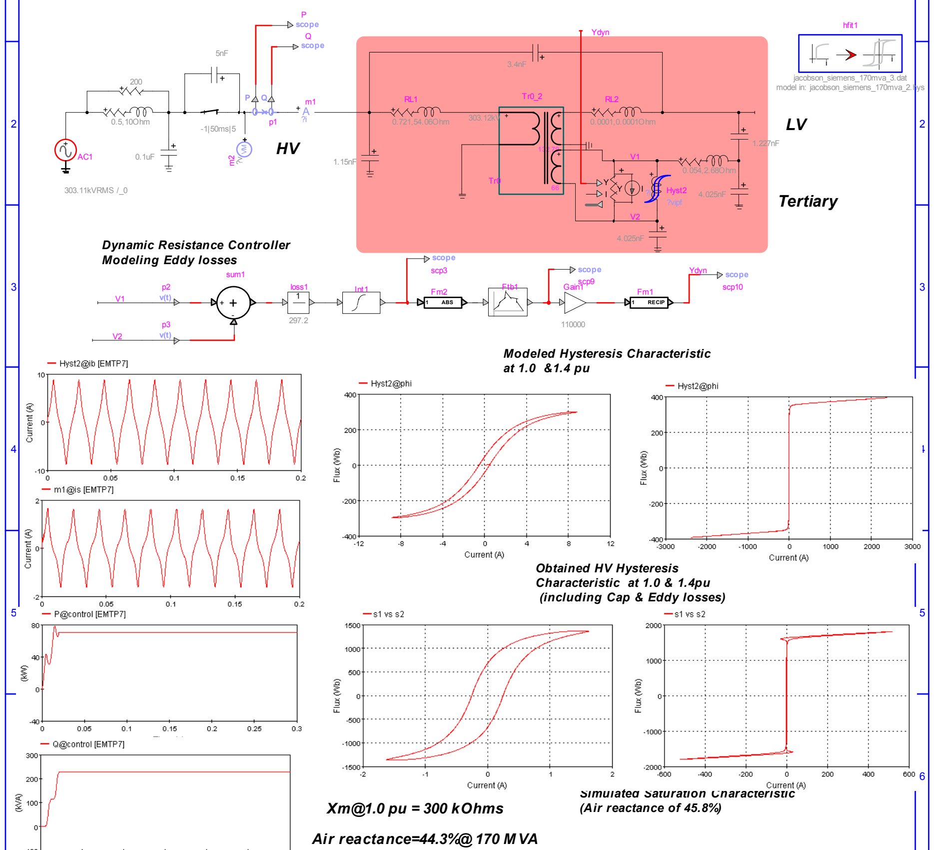
EMTP-RV

200 MW Wind Farm Integration Study



EMTP-RV

Ferroresonance Study



Vm2 rms in pu of 303.11 kV	Im1 (rms) in pu of 170 MVA
1.2	0.021
1.3	0.180
1.4	0.406

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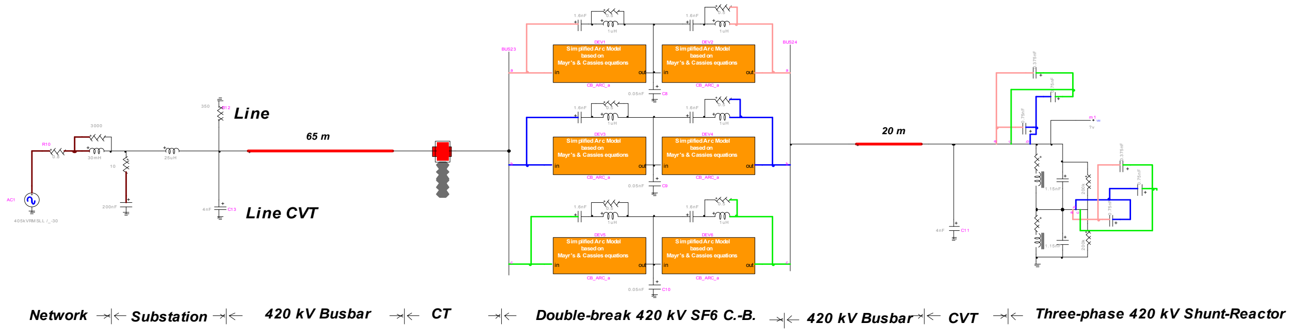
Switching of A 420 kV Three-Phase Shunt-Reactor

I/O FILES

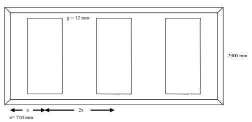
State of the art simulation introducing:

- ***A realistic model of a three-phase shunt reactor taking into account the asymetrical couplings of the magnetic circuit;***
- ***A realistic circuit-breaker model based on the well-known Cassie - Mayr modified arc equations;***



Three-Phase 420 kV 100 MVARS Shunt Reactor

F= 0.548 Wb, N=1409 turns, L1=5.617 H

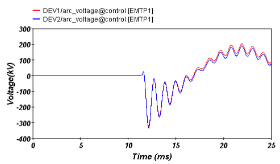


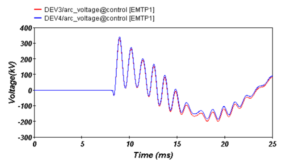
For mu (50 Hz) = 0.06 H/m:

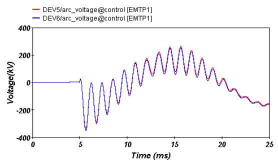
Xac=Xca= 9 Ohms
Xba=Xbc=7 Ohms
Xab=14 Ohms
Xaa= 1741 Ohms
Xbb= 1750 Ohms
Xcc=1741 Ohms

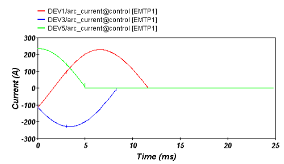
For mu (700 Hz) = 0.01 H/m:

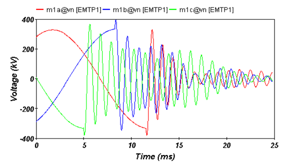
Xac=Xca= 54 Ohms
Xba=Xbc=42 Ohms
Xab=84 Ohms
Xaa= 1741 Ohms
Xbb= 1750 Ohms
Xcc=1741 Ohms











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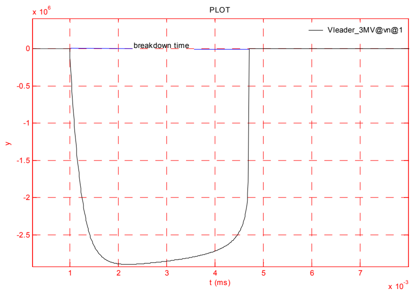
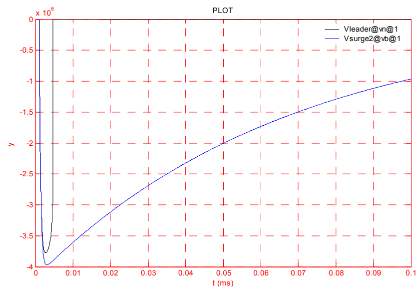
Validation of the Air gap leader Model with CIGRE equation



breakdown time definition



A typical leader breakdown voltage compared to the applied surge voltage

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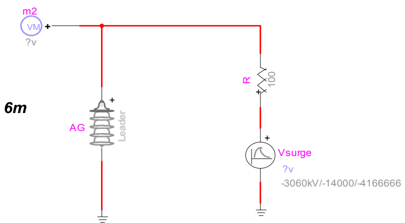
The applied surge varies between -3 and -5M V

The leader length varies between 3 and 6m



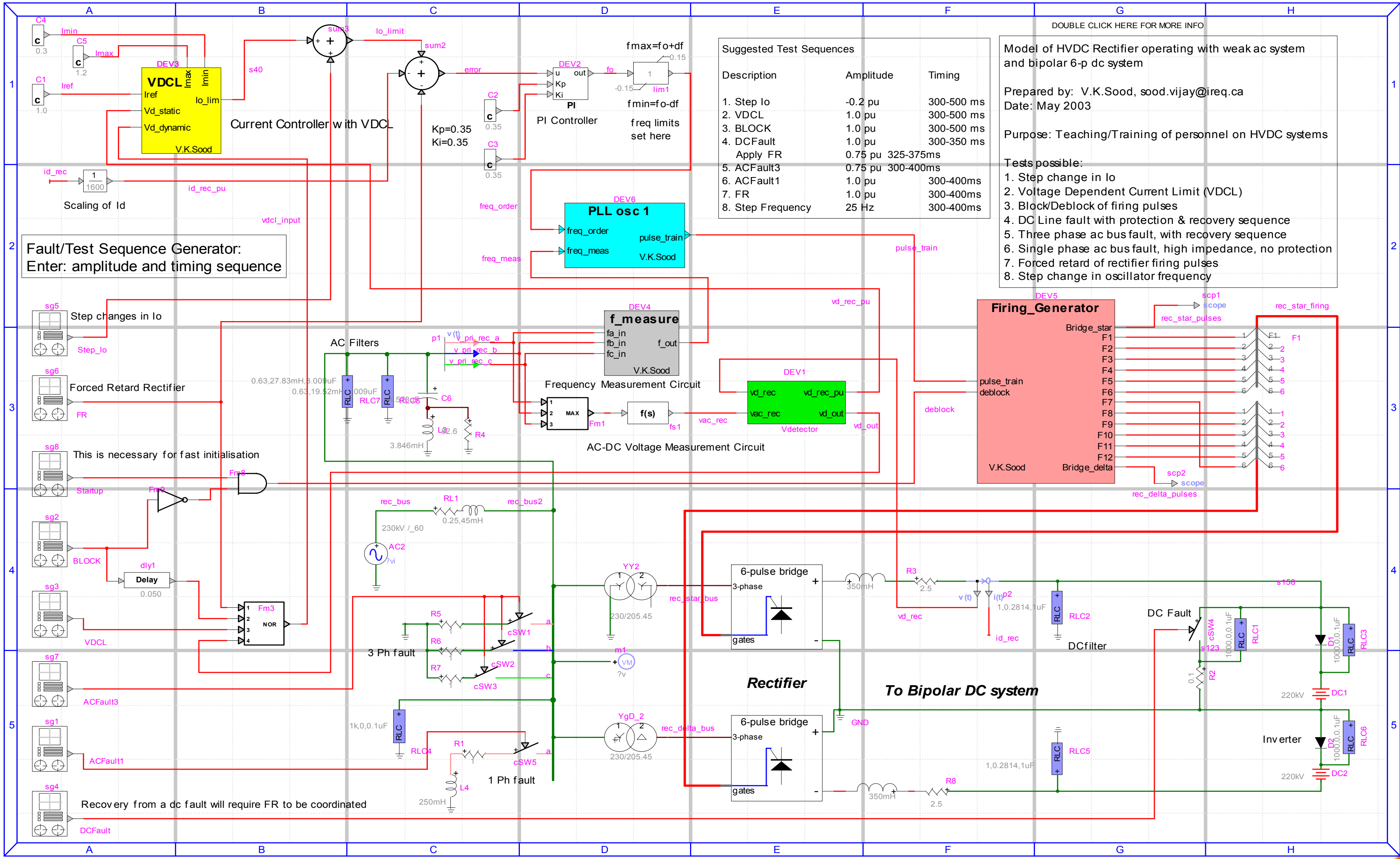
Voltage(MV)	Length (m)							
	3		4		5		6	
	Equation	Model	Equation	Model	Equation	Model	Equation	Model
3	1.2516	1.69	2.568	2.9	5.4155	4.8		
4	0.6944	0.95	1.2516	1.58	2.1491	2.15	3.6902	3.1
5	0.4622	0.69	0.7867	1.1	1.2516	1.3	1.9316	1.8

breakdown time comparison in us

Ref:

1- Shindo, Takatoshi; Suzuki, Toshio (CRIEPI) " New Calculation Method of Breakdown Voltage-Time Characteristics of Long Air Gaps", IEEE Transactions on Power Apparatus and Systems, Vol. PAS-104, No. 6, June 1985, pp 1556-1563.

2- DARVENIZA(M.); POPOLANSKY (F.); WHITEHEAD (E.R.) "Lightning protection of UHV transmission lines", CIGRE report 1975-41.



Description	Amplitude	Timing
1. Step Io	-0.2 pu	300-500 ms
2. VDCL	1.0 pu	300-500 ms
3. BLOCK	1.0 pu	300-500 ms
4. DCFault	1.0 pu	300-350 ms
Apply FR	0.75 pu	325-375ms
5. ACFault3	0.75 pu	300-400ms
6. ACFault1	1.0 pu	300-400ms
7. FR	1.0 pu	300-400ms
8. Step Frequency	25 Hz	300-400ms

Suggested Test Sequences

Model of HVDC Rectifier operating with weak ac system and bipolar 6-p dc system

Prepared by: V.K.Sood, sood.vijay@ireq.ca
Date: May 2003

Purpose: Teaching/Training of personnel on HVDC systems

Tests possible:
1. Step change in Io
2. Voltage Dependent Current Limit (VDCL)
3. Block/Deblock of firing pulses
4. DC Line fault with protection & recovery sequence
5. Three phase ac bus fault, with recovery sequence
6. Single phase ac bus fault, high impedance, no protection
7. Forced retard of rectifier firing pulses
8. Step change in oscillator frequency

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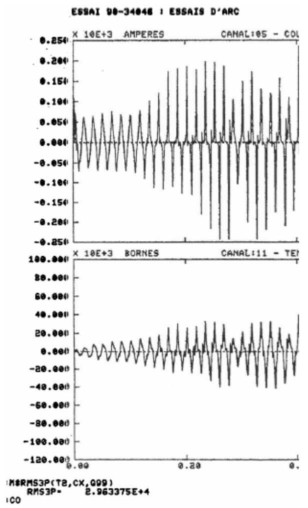
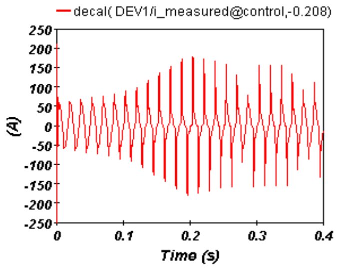
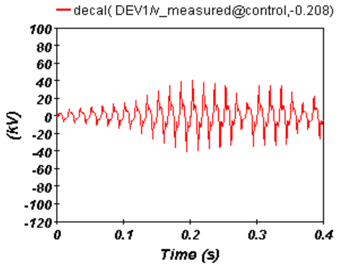
Validation of the Secondary Arc Model with IREQ Laboratory Tests

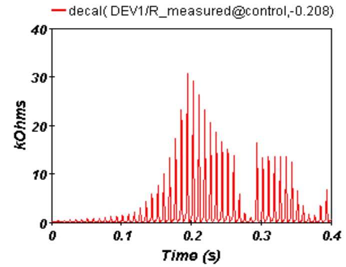
Field Recording (10-08-1986)



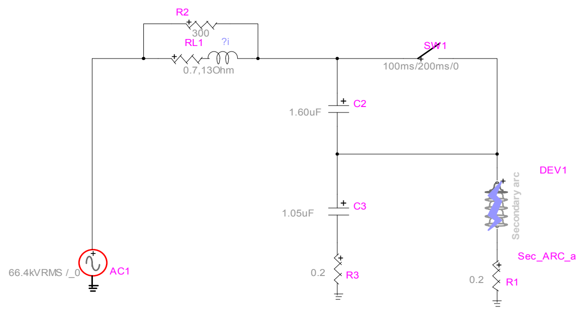
EMTP-RV Simulation (05-22-2005)







I/O FILES



Primary Arc: 5 kA eff
Secondary Arc: 40 A
Wind Speed: 9.7 km/h
Secondary Arc Duration: 1.04 sec.
315 kV insulator string, l=2.3 m

Ref.: Kizilcay M., Bán G., Prikler L., Handl P.: "Interaction of the Secondary Arc with the Transmission System during Single-Phase Autoreclosure" IEEE Bologna PowerTech Conference, June 23-26, 2003 Bologna, Italy, Paper 471

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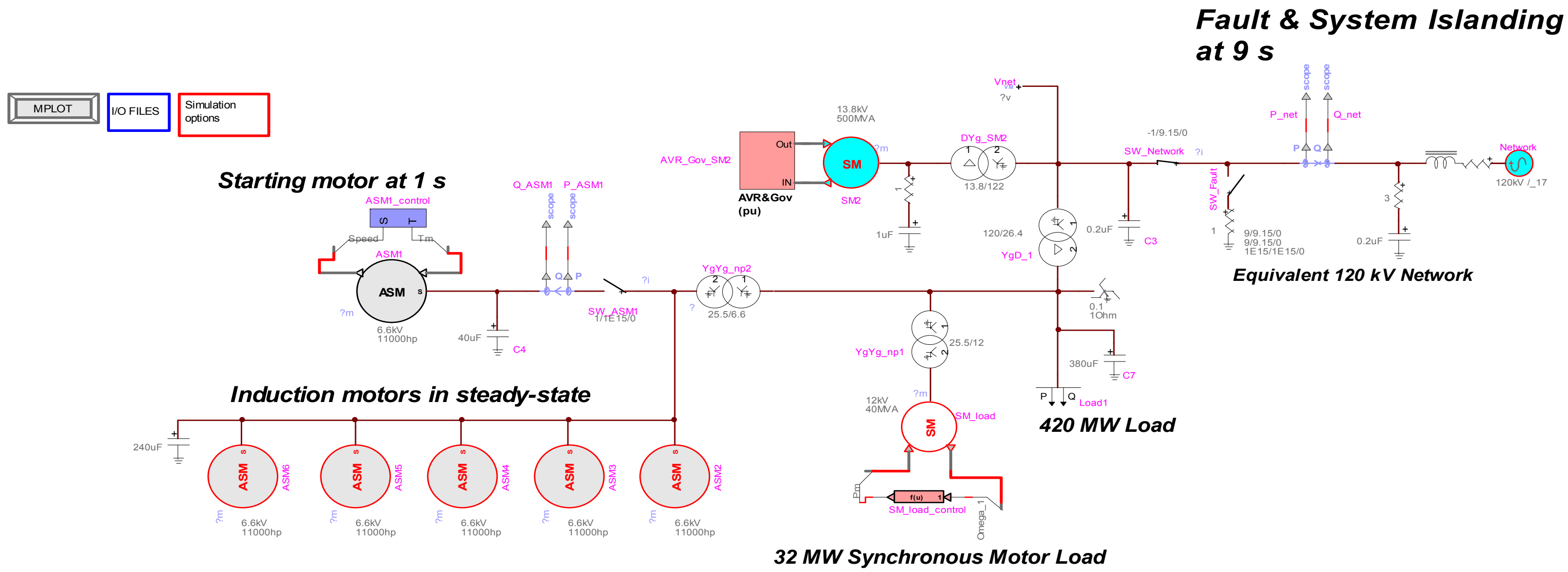
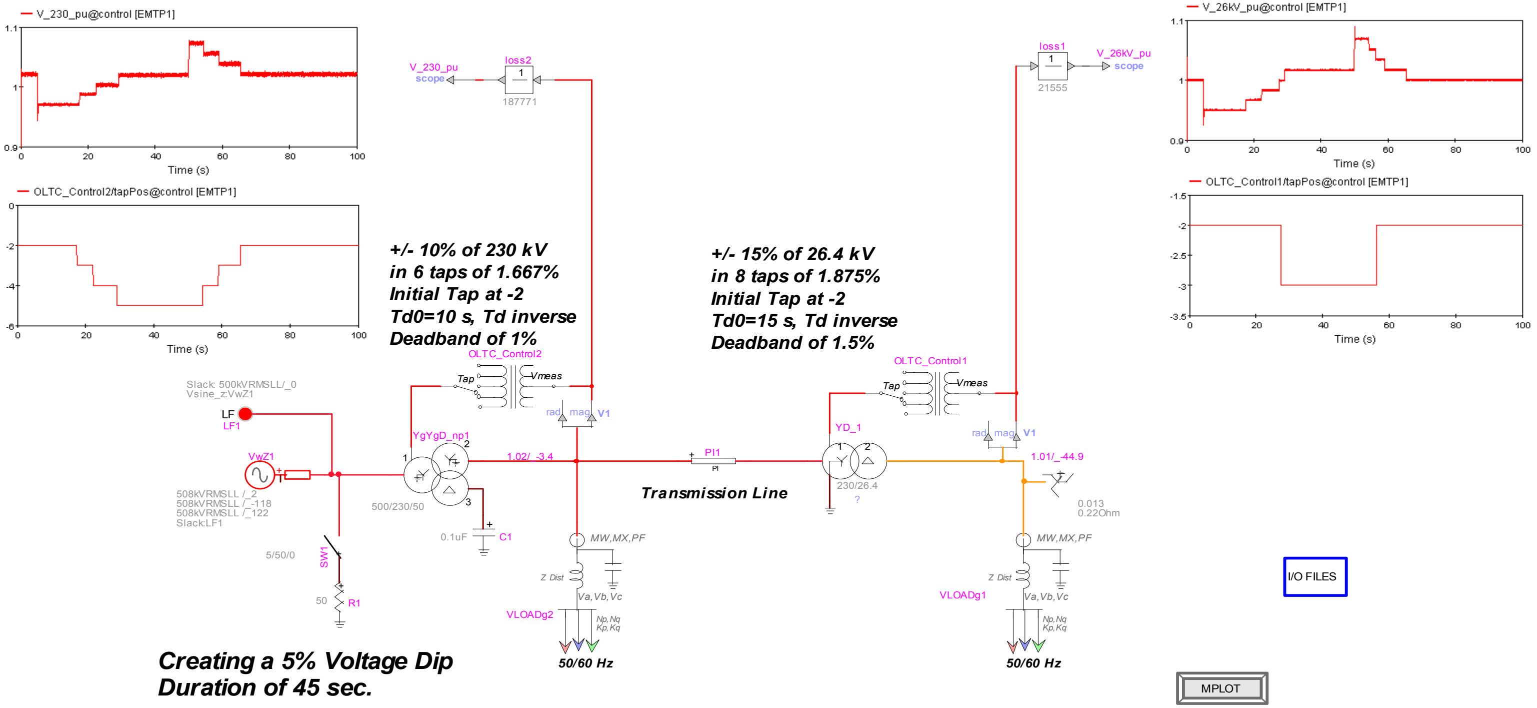
Example of Synchronous/Asynchronous Machine Modeling

- Starting an 11000 hp motor at 1s with 5 induction machines already in steady-state
- LL-g fault on the 120 kV bus with system islanding at 9 s
- System recovery by the governor system of the large SM until 30 s
- Case showing the good numerical stability of large number of machines in EMTP-RV
- Ref. (Motor): G. J. Rogers, IEEE Trans. on Energy Conversion, Vol. EC2, No 4 Dec. 1987, pp. 622-628.
- Using variable output rate after 15 s of simulation.



Operation of Tap Changers During a Voltage Dip



ZnO Arrester model based on IEEE Surge Protective Device Working Group

Simulation options

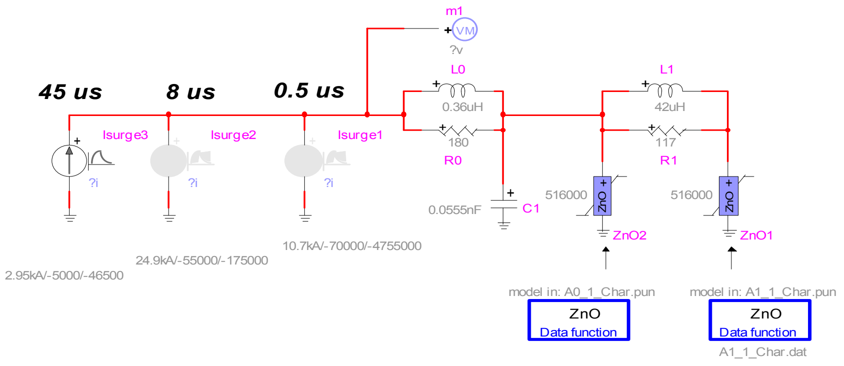
I/O FILES

- L1 (uH) = 15 d/n; R1 (Ohm) = 65 d/n
- L0 (uH) = 0.2 d/n; R0 (Ohm) = 100 d/n
- C0 (pF) = 100 n/d

d is the Height of the arrester and n is the number of parallel columns

Example of Modeling of an Ohio-Brass Zno Arrester for a 330 kV Network
MCOV= 209 kV
d=1.8 m, n=1

A0 & A1 Characteristics adjusted to get 516 kV for a 2 kA 45 us Switching Surge
then L1 adjusted to get 604 kV for a 10 kA 8/20 us Lightning surge
then checking for 10 kA 0.5 us front of wave 664.5 kV vs 665 kV from Ohio-Brass
FANTASTIC!!



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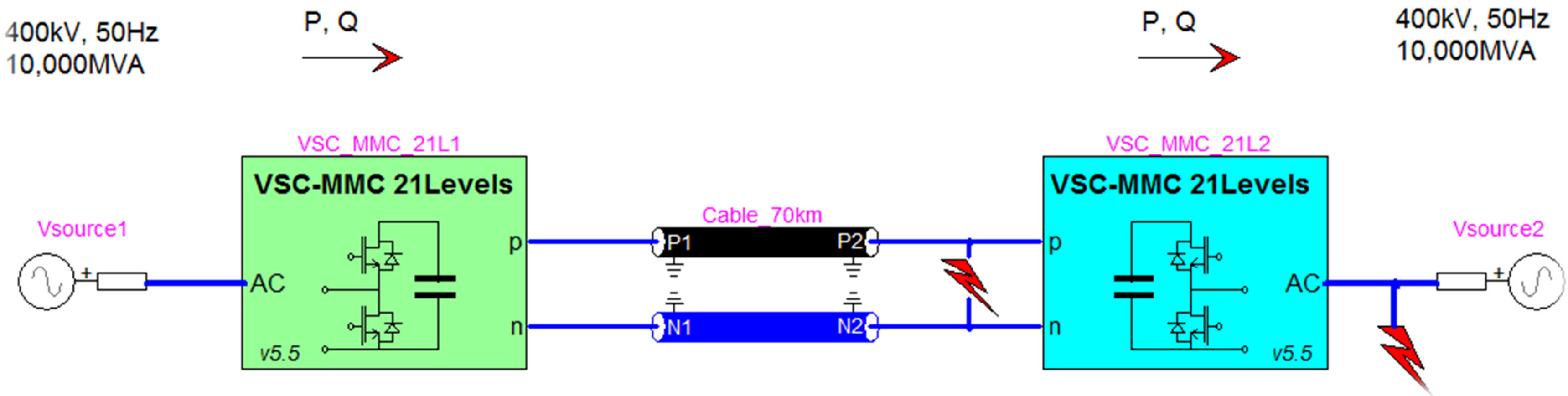
New example

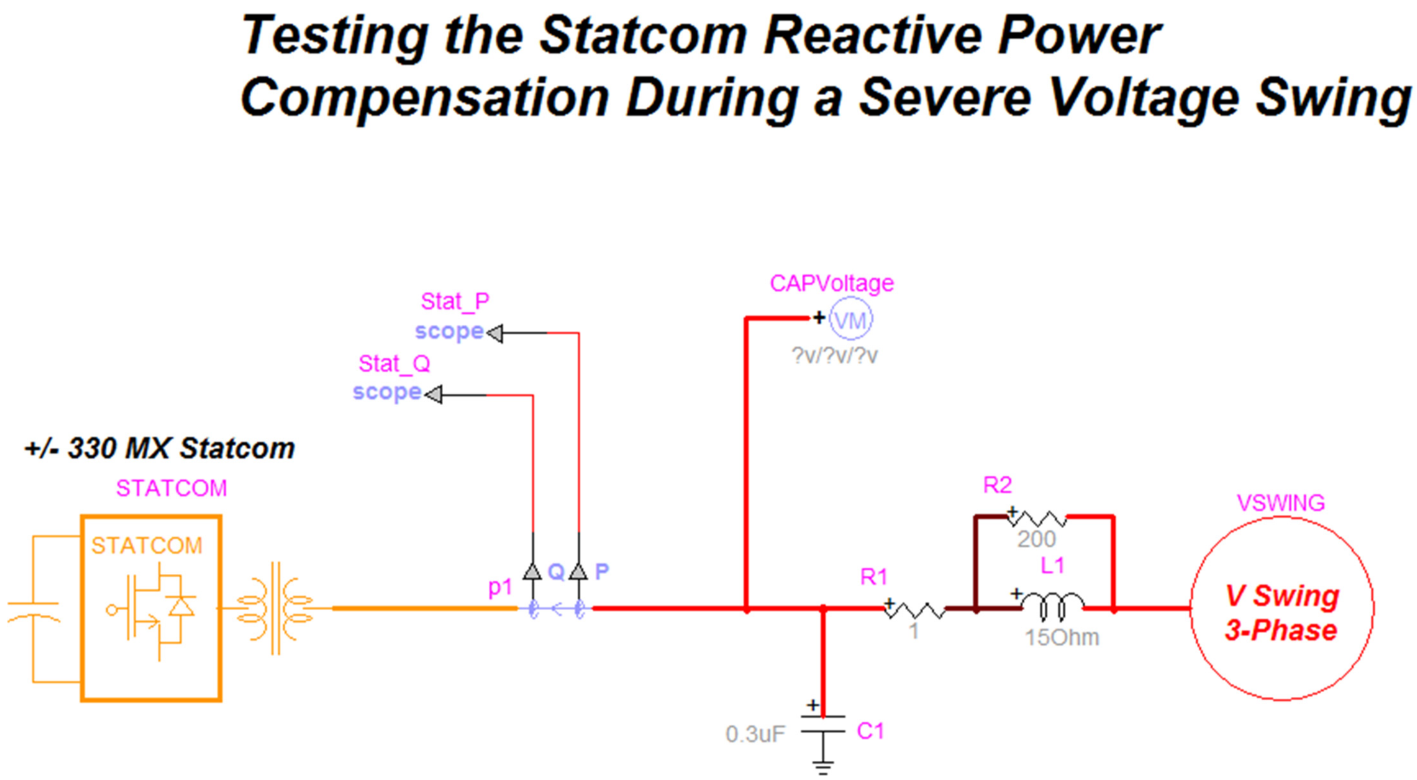
HVDC VSC-MMC transmission system
1,000 MVA (+/- 320kV DC)

Double Click here to access the User Guide of VSC-MMC model

Double Clcik here to access the Description of HVDC MMC model



New example



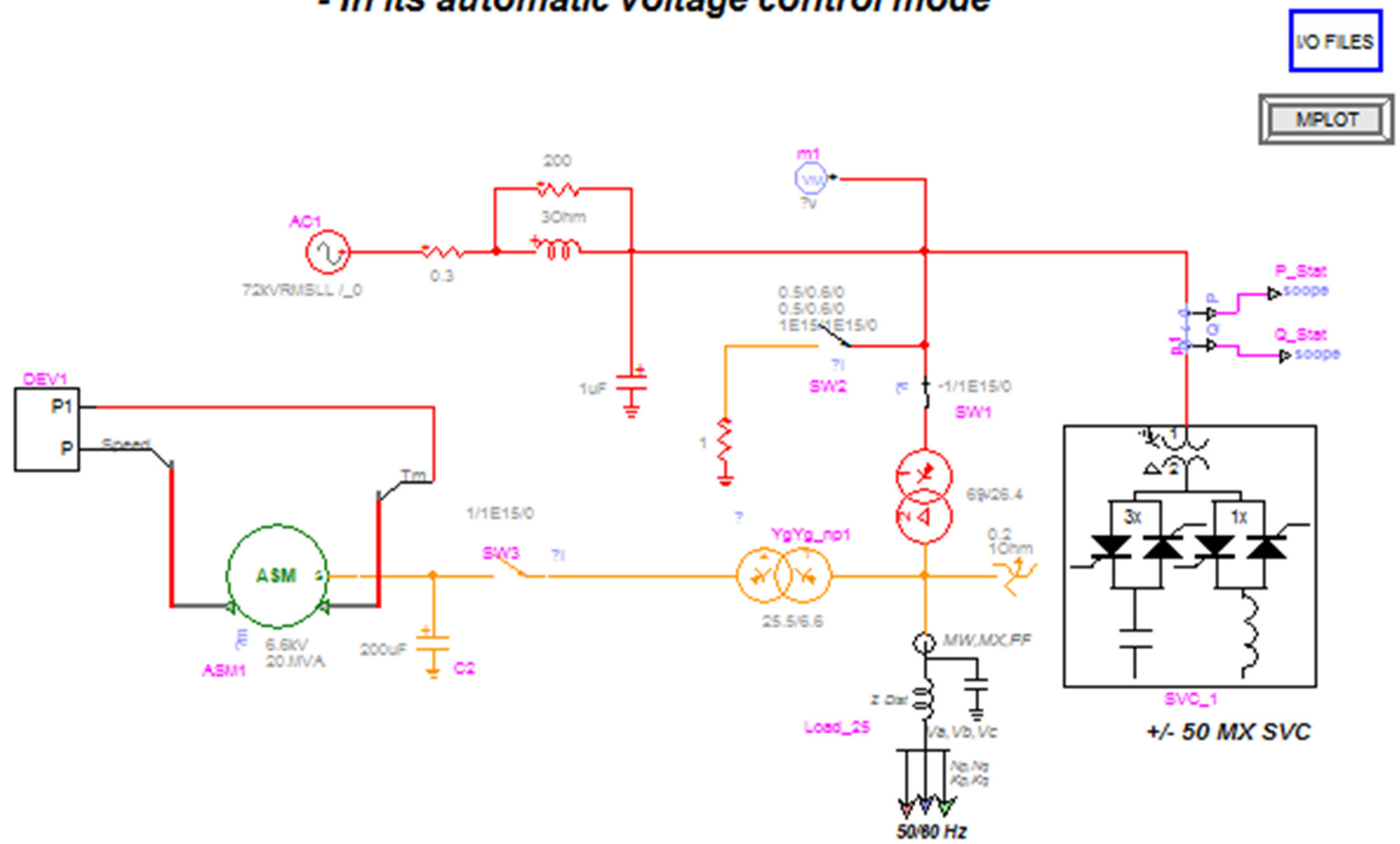
Testing the Statcom Reactive Power
Compensation During a Severe Voltage Swing
Stat_P
scope
Stat_Q
scope
CAPVoltage
VM
?v/?v/?v
+/- 330 MX Statcom
STATCOM
STATCOM
p1
Q
P
R2
200
L1
R1
1
15Ohm
VSWING
V Swing
3-Phase
0.3uF
C1

New example

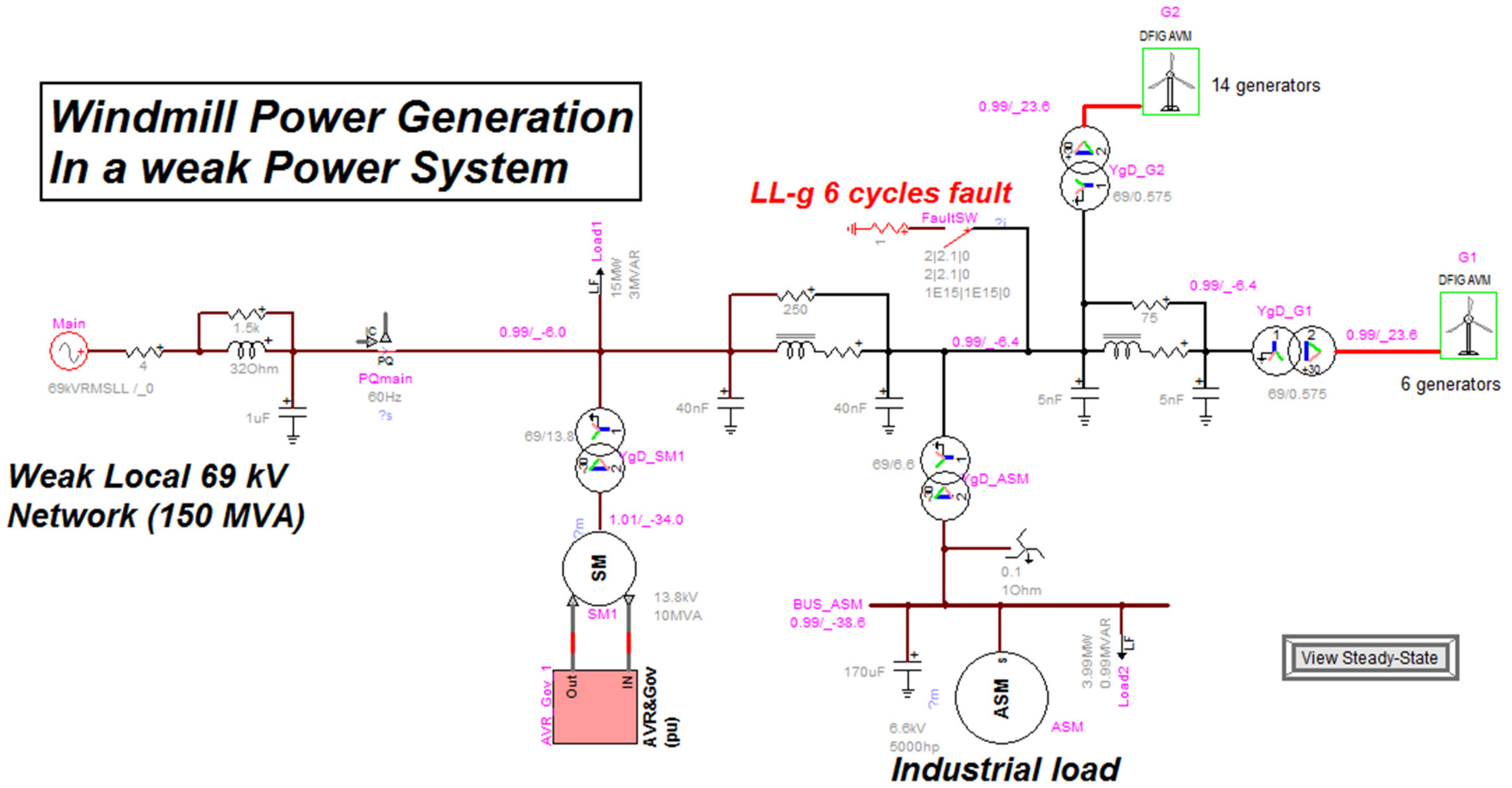
Static Var Compensator Model

Testing the SVC behavior:

- ***During faults and harmonic distorsions due to transformer saturation***
- ***In its automatic voltage control mode***



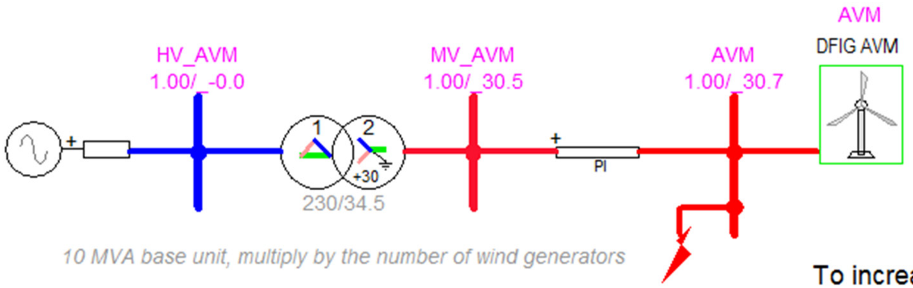
New example



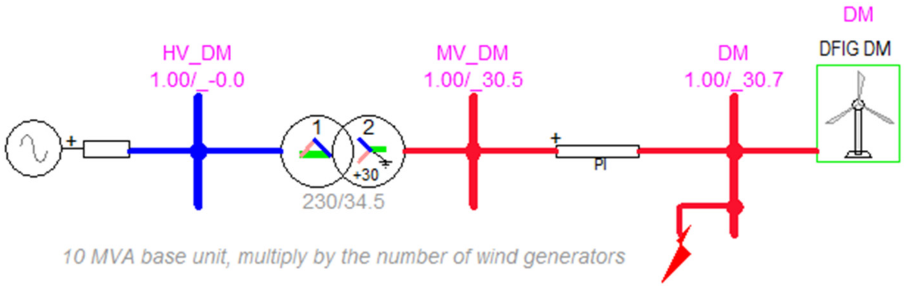
Windmill Power Generation
In a weak Power System
LL-g 6 cycles fault
Weak Local 69 kV
Network (150 MVA)
Industrial load
14 generators
6 generators
G2
DFIG AVM
G1
DFIG AVM
YgD_G2
69/0.575
YgD_G1
69/0.575
FaultSW
2|2.1|0
2|2.1|0
1E15|1E15|0
Main
69kVRMSLL /_0
1.5k
32Ohm
1uF
PQmain
60Hz
Load1
15MW
3MVAR
0.99/_-6.0
250
40nF
40nF
0.99/_-6.4
75
5nF
5nF
0.99/_23.6
YgD_SM1
69/13.8
1.01/_-34.0
SM
SM1
13.8kV
10MVA
AVR_Gov_1
AVR&Gov
(pu)
YgD_ASM
69/6.6
0.1
1Ohm
BUS_ASM
0.99/_-38.6
170uF
ASM
6.6kV
5000hp
3.99MW
0.99MVAR
Load2
View Steady-State

New example

Comparison of Detailed model (DM) and Average value model (AVM), DFIG-type wind generator.
The numerical integration time-step can be increased if the AVM is used alone in a network simulation.



To increase the number of wind generators for aggregation,
see documentation in the mask script of the wind generator device.



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The reference for power systems transients

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