

PowerFactory and DSL models

Presentation at DTU

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Torsten Lund



Three main simulation types

1. Electro Magnetic Transients (EMT)
 1. All state variables of the system are modeled
 2. Both AC and DC transients are considered
 3. Suitable for simulation of fast transients
2. Root Mean Square (RMS) (Fundamental frequency)
 1. Only the fundamental frequency part is considered.
 2. The differential equations of the network are reduced to algebraic equations by elimination of the corresponding state variables.
 3. Machine fluxes, Machine rotor speeds and controllers are modeled as state variables
3. Load Flow
 1. An equilibrium where the derivatives of all state variables are zero is found.



Different Power System Simulation Tools

	EMT	RMS	LoadFlow
PSCAD®	Yes	(Yes)	No
SIMPOW®	Yes	Yes	Yes
PowerFactory®	Yes	Yes	Yes
PSS/E®	No	Yes	Yes



PowerFactory

- Power Factory is an integrated power system analysis tool from the German company DIgSILENT (DIgital SImuLator for Electrical NeTwork)
- The development of DIgSILENT software began in 1976.
- DIgSILENT Version 7 was the world's first power system analysis software with an integrated graphical one-line interface.
- One of the other strengths of the program was the object oriented database structure.

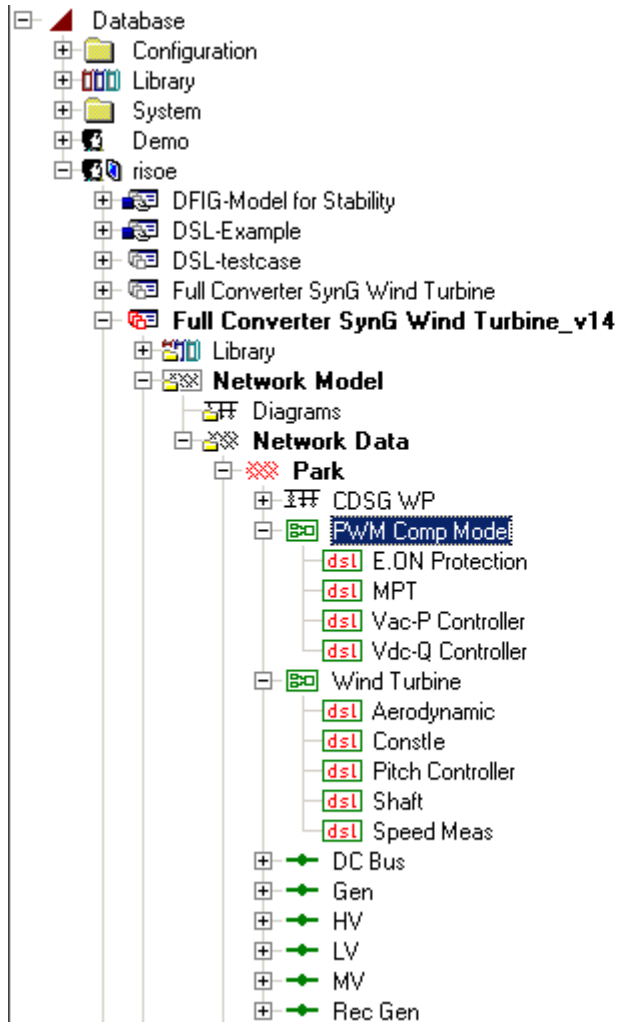


Features (from their web site)

- Load Flow and Fault Analysis of complete AC/DC network representation, and allows meshed and mixed 1-, 2-, and 3-phase AC and/or DC networks to be modeled.
- Dynamic Simulation
- EMT Simulation
- Voltage Stability Analysis
- Eigenvalue Analysis
- System Identification
- Protection Analysis:
- Harmonic Analysis
- Reliability Analysis
- Production Planning
- Contingency Analysis
- Power Electronic Device Modeling
- Grounding
- A/D Interfacing
- Interface for SCADA/GIS/NIS
- Compatibility with other software systems such as PSS/E & PSS/U
- Multi-User Database and User Accounting
- Low Voltage Network Analysis
- Distribution Network Optimization
- IEC Cable Sizing
- Advanced Tools: Optimal Power Flow and Production Planning



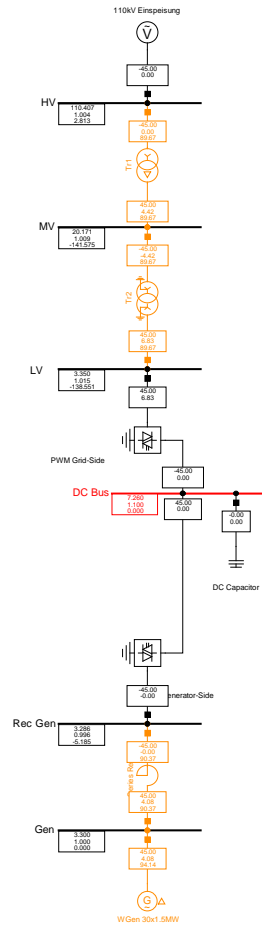
Data base structure



	Name
	E.ON Protection
	MPT
	Vac-P Controller
	Vdc-Q Controller
	PLL_I
	PLL_R
	PQ Meas Gen
	PQ Meas Grid
	AC Gen Voltage
	AC Grid Voltage
	DC Bus Voltage



Single line graphic



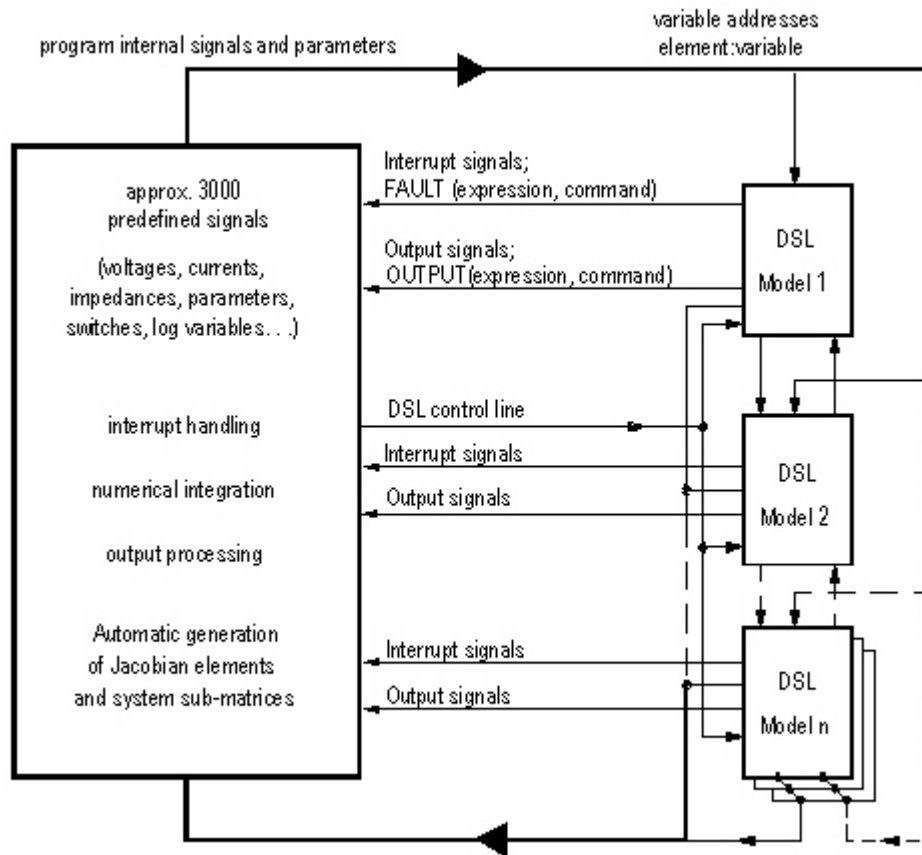
DigSILENT

DigSILENT GmbH PowerFactory 14.1.2	Bechmarking	Project: DENA
	CDSG WKA, 30*1.5MW	Graphic: CDSG WP
		Date: 12/14/2011
		Annex:

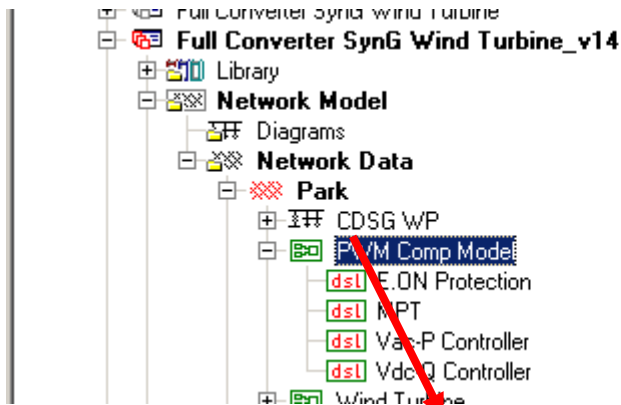


DSL-models

DIgSLENT Simulation language



Structure



Block Definition - Library\Block Definitions\Full Converter\Vac-P Control.BlkDef

Name: Vac-P Control

Title: [Empty]

Caution: Changing level of already used models requires adaptation of all dependent models

Level: Level 3. Level 2 + lim()-function precise in time

Automatic Calculation of Initial Conditions

Classification:

- Linear
- Macro
- Matlab

Upper Limitation:

Limiting Parameter: L_Max/Max

Limiting Input Signals: [Empty]

Lower Limitation:

Limiting Parameter: L_Min

Limiting Input Signals: [Empty]

Variables:

Output Signals: id_ref, iq_ref

Input Signals: sw_P_ref, P_id_ext, Vdc_ref, Vdc, Vac, Vac_ref

State Variables: iP_F, iVac_F, iWdc_F, iFP, iVac, iWdc

Parameter: TIP, TVac, TVdc, KP, TP, KVac, TVac, KVdc, TVdc, deltaVdc

Internal Variables: iMax1, Min1, P_Fil, Vac_Fil, Vdc_F, dP, dVdc, deltaV, idref1, iqref2, iqrref

Composite Model - Park\PWM Comp Model.ElmComp

Name: PWM Comp Model

Frame: Library\Frames\PWM Frame

Out of Service

Slot Definition:

	Slots BlkSlot	Net Elements Elm*,Sta*,IniRef
1	Inverter	✓ PWM Grid-Side
2	Rectifier	✓ PWM Generator-Side
3	PLL_I	✓ PLL_I
4	DC Voltage	✓ DC Bus Voltage
5	Power Meas_Gen	✓ PQ Meas Gen
6	Power Meas_Grid	✓ PQ Meas Grid
7	Vac-P Controller	✓ Vac-P Controller
8	Vdc-Q Controller	✓ Vdc-Q Controller
9	MPT	✓ MPT

Buttons: Slot Update, Step Response Test

Common Model - Park\PWM Comp Model\Vac-P Controller.ElmDsl

Name: Vac-P Controller

Model Definition: ...ions\Full Converter\Vac-P Control

Out of Service A-stable integration algorithm

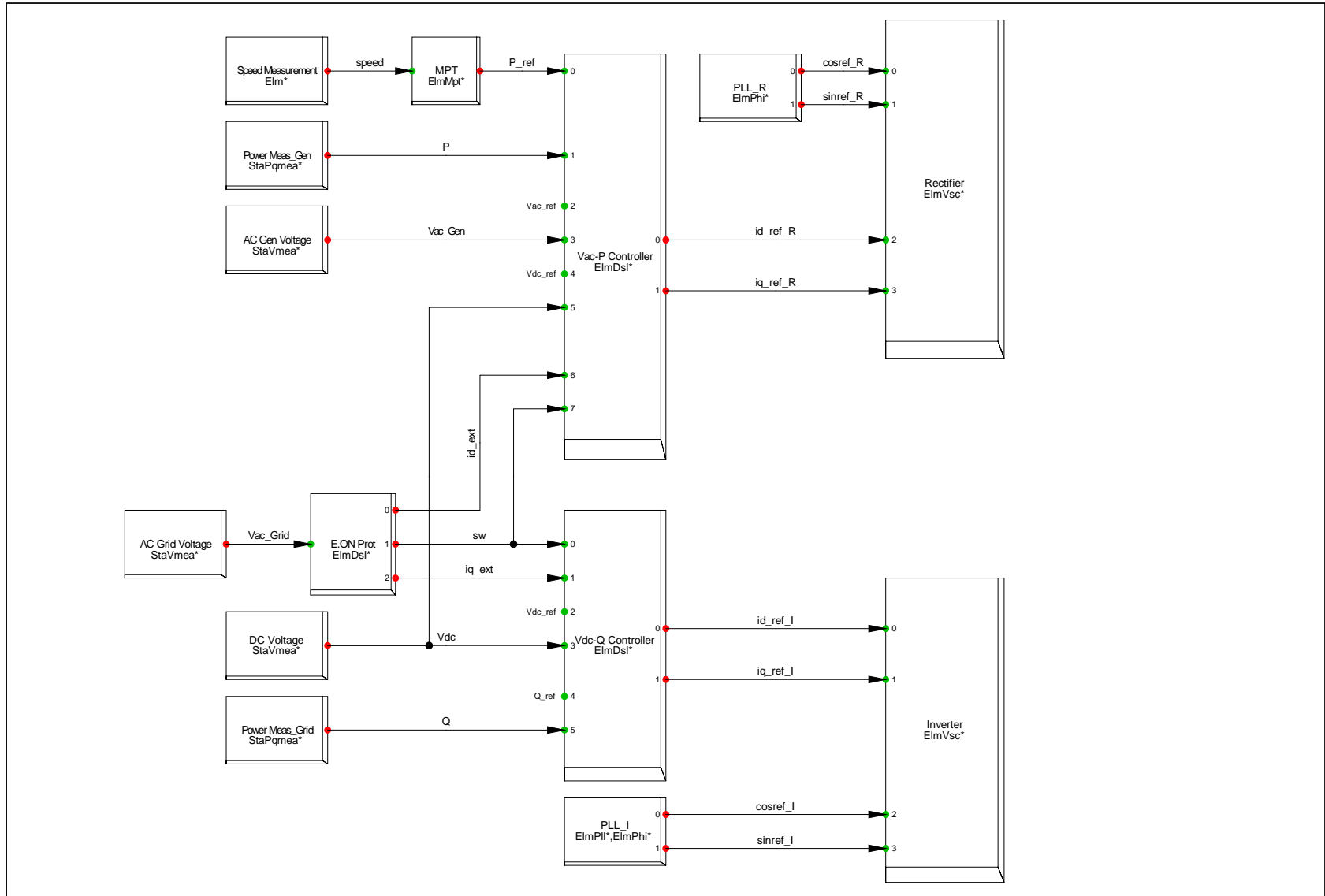
	Parameter
▶ TIP Meas. Delay Active Power [s]	0.01
TVac Meas. Delay AC Voltage [s]	0.01
TVdc Meas. Delay DC Voltage [s]	0.01
KP Active Power Control Gain [p.u.]	0.5
TP Active Power Control Time Constant [s]	0.005
KVac AC Voltage Control Gain [p.u.]	5.
TVac AC Voltage Control Time Constant [s]	0.01
TVdc DC Voltage Control Gain [p.u.]	0.
TVdc DC Voltage Control Time Constant [s]	0.05
deltaVdc	0.05
i_Min	-1.
L_Max	1.
iMax	1.1

Buttons: OK, Cancel, Contents, Events, Export to Clipboard



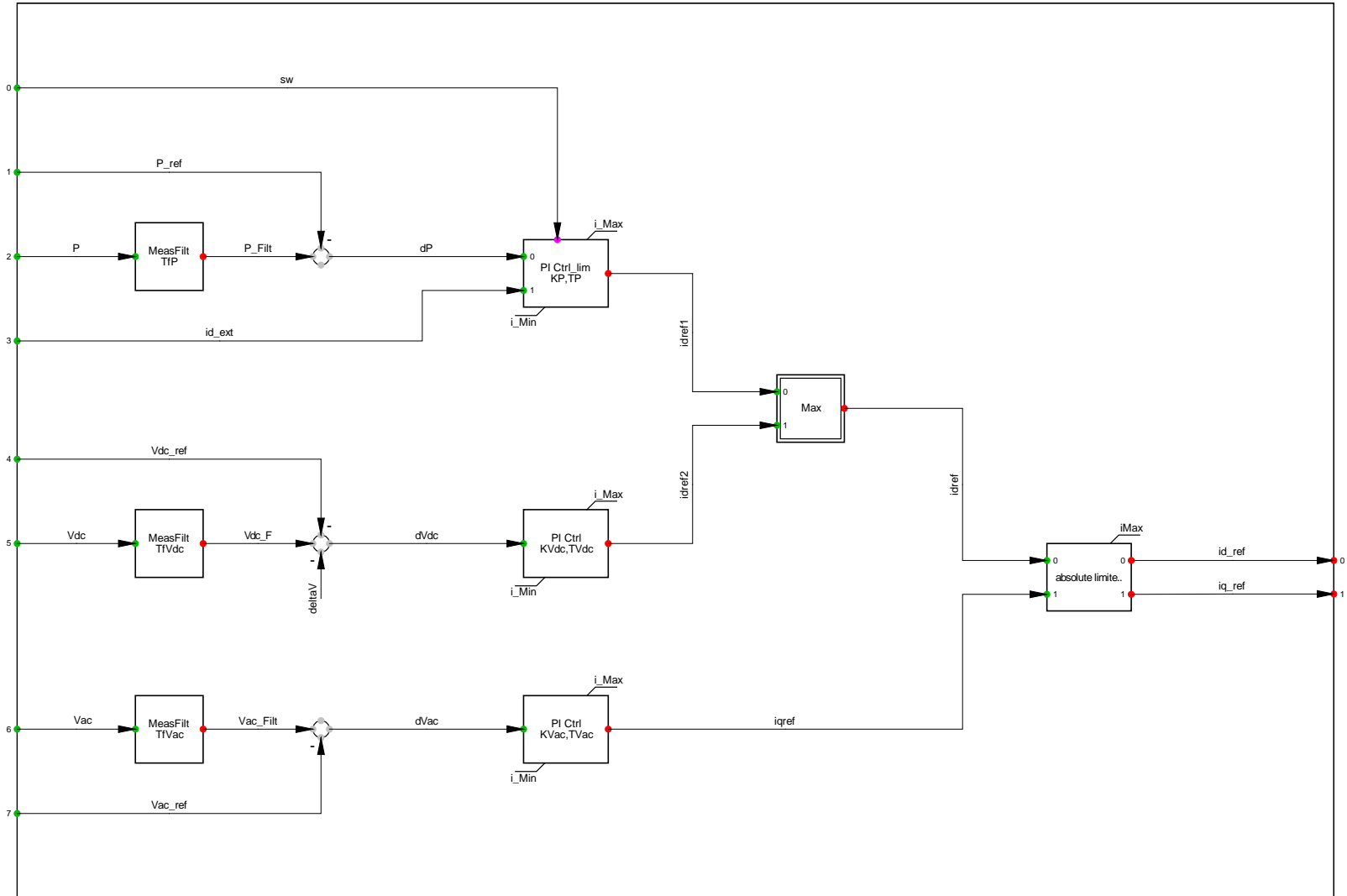
Composite frames

PWM Frame:

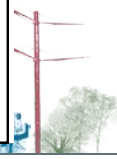


Composite model

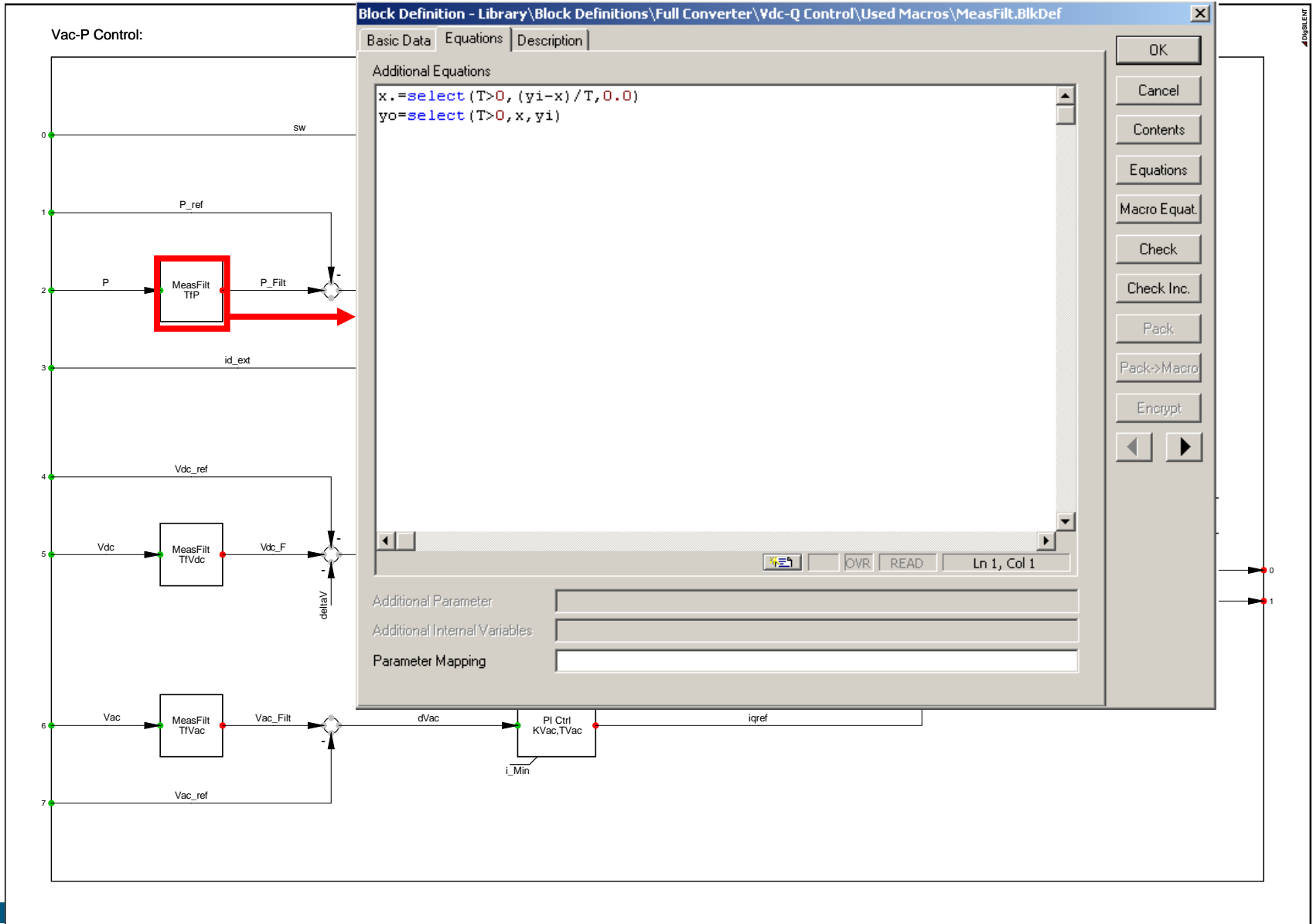
Vac-P Control:



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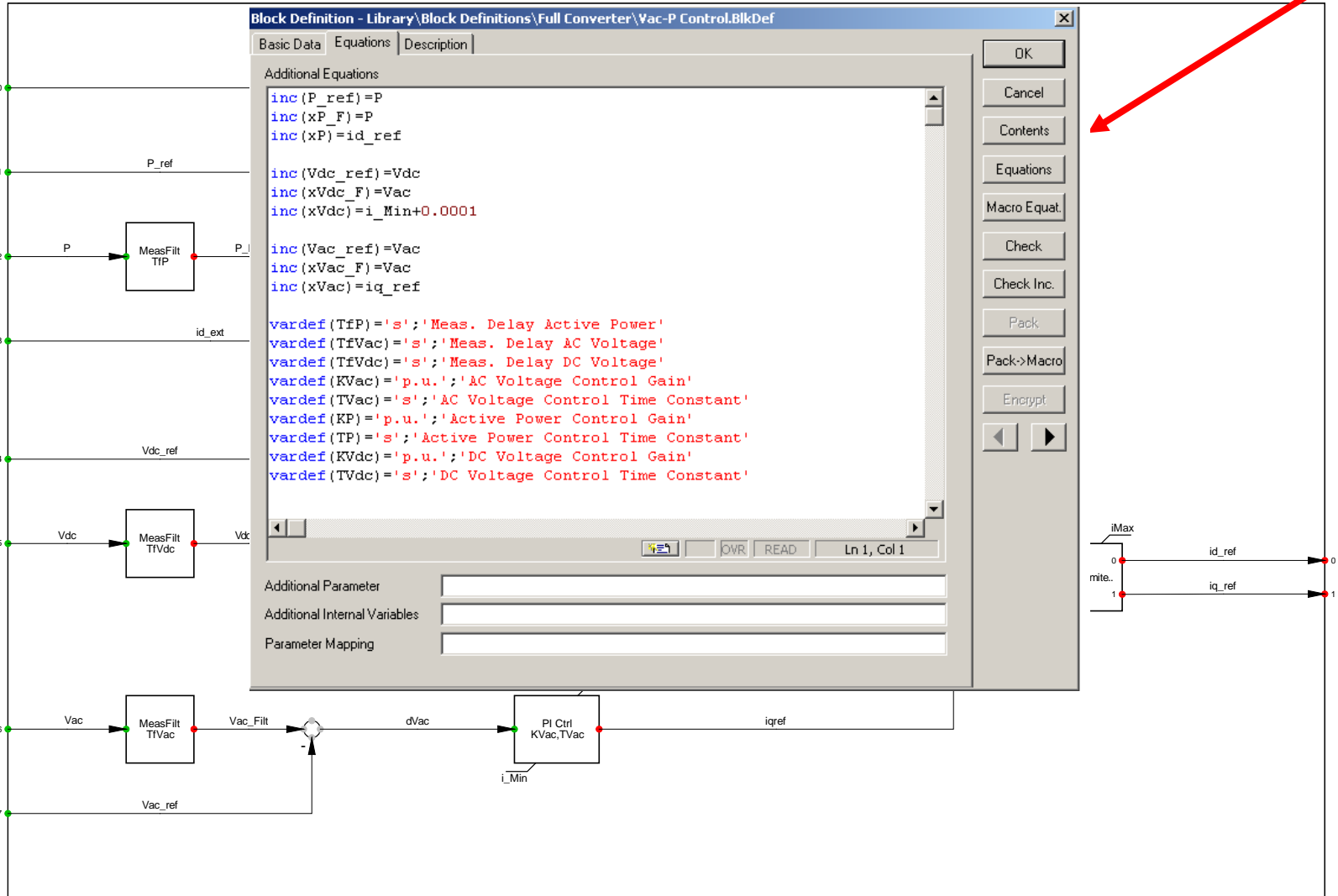


First order filter



Initialization

Vac-P Control:



Defining events

DigSILENT PowerFactory 14.1 - [Graphic : Park\CDSG WP.IntGrfnet]

File Edit Calculation Data Output Tools Window Help

Study Case

110 kV ABC

Simulation Events/Fault - Study Cases\Study Case\Simulationereignisse :

Name	Time	Object	Out of Service	Object mo
DC Current	0.	StaBar*_ElmTerm*....	<input checked="" type="checkbox"/>	14-12-201
DC Voltage	0.		<input checked="" type="checkbox"/>	14-12-201
Set Par Vac-P	0.	Vac-P Controller	<input checked="" type="checkbox"/>	14-12-201
Set Par Vdc-Q	0.	Vdc-Q Controller	<input checked="" type="checkbox"/>	14-12-201
SC 110kV on	0.	HV	<input type="checkbox"/>	14-12-201
SC 110kV off	0.15	HV	<input type="checkbox"/>	14-12-201

Ln 5 6 object(s) of 6 1 object(s) selected

Short-Circuit Event - ... Case\Simulationereignisse\SC 110kV on.EvtShc

Out of Service

Execution Time

Absolute

hours: 0 h

minutes: 0 m

seconds: 0 s

Object: Park\HV

Fault Type: 3-Phase Short-Circuit

Fault Resistance: 0 Ohm

Fault Reactance: 50 Ohm

OK Cancel

Defining results to record

DigSILENT PowerFactory 14.1 - [Graphic : Park\CDSG WP.IntGrfnet]

File Edit Calculation Data Output Tools Window Help

Study Case

110 kV ABC

110kV Einspeisung

HV

Results - Study Cases\Study Case\Ergebnisse :

Name	Object	Object modified	Object modified by
110kV Einspeisung	110kV Einspeisur	14-12-2011 17:37:13	risoe
DC Bus	DC Bus	14-12-2011 17:37:13	risoe
HV	HV	14-12-2011 17:37:13	risoe
MV	MV	14-12-2011 17:37:13	risoe
PQ-PCC	PQ-PCC	14-12-2011 17:37:13	
WGen 30x1.5MW	WGen 30x1.5MW	14-12-2011 17:37:13	
Vac-P Controller	Vac-P Controller	14-12-2011 17:37:13	
Vdc-Q Controller	Vdc-Q Controller	14-12-2011 17:37:13	

Ln 7 8 object(s) of 8 1 object(s) selected

DC Capacitor

Rec Gen

Gen

WGen 30x1.5MW

Variable Set - Study Cases\Study Case\Ergebnisse\Vac-P Controller.IntMon

EMT-Simulation | Harmonics | Optimization | State Estimator | Reliability | Generation Adequacy | Tie Open Point Opt. | Description

Basic Data | Load Flow | VDE/IEC Short-Circuit | Complete Short-Circuit | ANSI Short-Circuit | IEC 61363 | RMS-Simulation

Object: ... Comp Model\Vac-P Controller

Class Name:

Display Values during Simulation in Output Window (see Simulation Command)

Filter for:

Variable Set: Calculation Parameter

Variable Name:

Bus Name:

Display All

Loc_name	Name
KP	p.u. Active Power Control Gain
KVac	p.u. AC Voltage Control Gain
KVdc	p.u. DC Voltage Control Gain
P_Filt	P_Filt
TP	s Active Power Control Time Constant
TVac	s AC Voltage Control Time Constant
TVdc	s DC Voltage Control Time Constant
TfP	s Meas. Delay Active Power
TVac	s Meas. Delay AC Voltage
TVdc	s Meas. Delay DC Voltage
Vac_Filt	Vac_Filt
Vdc_F	Vdc_F
dP	dP
dVac	dVac
dVdc	dVdc
deltaV	deltaV
deltaVdc	deltaVdc
iMax	iMax
iMax1	iMax1
iMin1	iMin1
iMax	iMax

Selected Variables

s:id_ref
s:iq_ref
c:idref1
c:idref2
c:idref
c:iqref

CDSG WP | VI PQ_Net | VI i_Net | VI u_SS | PWM Frame | Vac-P Control | Vdc-Q Control

Initializing the model



Calculation of Initial Conditions - ...rechnung der Anfangsbedingungen.ComInc

Advanced Options | Noise Generation | Real-Time
Basic Options | Step Sizes | Step Size Adaptation

Execute | Close | Cancel

inc/rms/rst/lt/show/loc/dfrotx/def/adapt/time/sin

Simulation Method

- RMS values (Electromechanical Transients)
- Instantaneous Values (Electromagnetic Transients)

Network Representation

- Balanced, Positive Sequence
- Unbalanced, 3-Phase (ABC)

Selection of Simulation Events

Events: ... Study Case\Simulationsereignisse

Show | From Library | Remove All

Result Variables: ... Study Cases\Study Case\Ergebnisse

Load Flow: ... es\Study Case\Lastflußberechnung

- Verify Initial Conditions
- Automatic Step Size Adaptation

Calculation of Initial Conditions - ...rechnung der Anfangsbedingungen.ComInc

Advanced Options | Noise Generation | Real-Time
Basic Options | Step Sizes | Step Size Adaptation

Execute | Close | Cancel

inc/rms/rst/lt/show/loc/dfrotx/def/adapt/time/sin

Integration Step Sizes

Electromechanical Transients (sym, asm, vco, pss) s

Maximum Step Size s

Output s

Start Time s



Starting the simulation

The screenshot displays the DigSILENT PowerFactory 14.1 interface. The main window shows a power system diagram with HV, MV, LV, and DC Bus sections. A red arrow points to the 'ABC' dropdown menu in the top toolbar. A 'Run Simulation' dialog box is open, showing the simulation name 'sim', a 'Stop Time' field set to '1' second, and options for displaying result variables and internal DSL-events. The 'Initial Conditions' section is set to '... errechnung der Anfangsbedingungen'. The bottom status bar shows the current project path: CDSG WP \ VI PQ_Net \ VI i_Net \ VI u_SS \ PWM Frame \ Vac-P Control \ Vdc-Q Control \ Generator PMG \ Protection \ MPT.



Plotting the results

DigSILENT PowerFactory 14.1 - [Graphic : Study Cases\Study Case\Grafiksammlung\VI u_SS]

File Edit Calculation Data Output Tools Window Help

Study Case

152%

Paper

SubPlot - Study Cases\Study Case\Grafiksammlung\VI u_SS\Subplot\Diagramm.VisPlot

y-Axis x-Axis Advanced

Name Subplot/Diagramm

Scale

Use local Axis

Limits

Maximum 1.017775

Minimum 0.7777618

Log

Linear Log

Auto Scale

Off On Online

Adapt Scale

On Off

Offset 0

Show Deviation from Offset

Automatic

Colour Line Style Line Width

Shown Results

Curves:

	Result File	Element	Variable	Colour	Style	Width	Variable D...	No
▶ 1		HV	mu1	Variable				

Variable

mu1 u1 Magnitude in p.u.

0.778 [s] 0.997

0.778 [s] 0.997

0.778 [s] 0.997

DigSILENT

CDSG WKA, 30*1.5MW

VI u_SS Date: 12/14/2011

Annex: 1 / 3

CDSG WP / VI PQ_Net / VI i_Net / VI u_SS / PWM Frame / Vac-P Control / Vdc-Q Control / Generator PMG / Protection / MPT

