



DIGSILENT GridCode:

LVRT in South Africa with DIGSILENT GridCode

DIGSILENT Ibérica
Madrid, 30 August 2011



South African Study Case

New document in South Africa: "GRID CODE COMPLIANCE TEST FOR WIND ENERGY FACILITY CONNECTED TO TRANSMISSION OR DISTRIBUTION GRIDS IN SOUTH AFRICA"

The wind farm must be tested:

- FIELD TESTING:
 - ACTIVE POWER MANAGEMENT TEST
 - SYSTEM VOLTAGE REQUIREMENTS
 - SIGNALS, COMMUNICATION AND CONTROL
- DYNAMIC SIMULATIONS:
 - SIMULATION 1: FAULT RIDE THROUGH CAPABILITY
 - SIMULATION 2: FAST ACTING REACTIVE AND/OR ACTIVE POWER CONTRIBUTION DURING FAULTS
 - SIMULATION 3: POST FAULT ACTIVE POWER RECOVERY
 - SIMULATION 4: POWER OSCILLATIONS DAMPING CAPABILITY
 - SIMULATION 5: SYNTHETIC INERTIAL CAPABILITY



Example of Dynamic Simulation Testing Procedure

Example of Dynamic Simulation Testing Procedure

STEP 1: Building the Wind farm dynamic model in DigiSILENT PowerFactory 14.1.2

Object Filter: *.IntTemplate, *ElmSubstat

| Name | In Folder |
|--|----------------|
| BusbaSystem1_5a | Busbar Systems |
| BusbaSystem1_5b | Busbar Systems |
| BusbaSystem1_5c | Busbar Systems |
| DoubleBusBypass | Busbar Systems |
| DoubleBusTieBypass | Busbar Systems |
| DoubleBusbaWithTie | Busbar Systems |
| SingleBusTieBypass | Busbar Systems |
| SingleBusbar | Busbar Systems |
| SingleBusbarWithTie | Busbar Systems |
| BatteryWithFrequencyControl_10kV_30MVA | Templates |
| DFIG_WTG_1.0MW | Templates |
| DFIG_WTG_1.5MW | Templates |
| DFIG_WTG_2.0MW | Templates |
| DFIG_WTG_2.3MW | Templates |
| DFIG_WTG_2.5MW | Templates |
| DFIG_WTG_2.7MW | Templates |
| DFIG_WTG_3.0MW | Templates |
| DFIG_WTG_3.0MW | Templates |
| DFIG_WTG_5.0MW | Templates |
| DFIG_WTG_6.0MW | Templates |
| FullyRatedConverterWTG_1.0MW | Templates |
| FullyRatedConverterWTG_1.5MW | Templates |
| FullyRatedConverterWTG_2.0MW | Templates |
| FullyRatedConverterWTG_2.3MW | Templates |
| FullyRatedConverterWTG_2.5MW | Templates |
| FullyRatedConverterWTG_2.7MW | Templates |
| FullyRatedConverterWTG_3.0MW | Templates |
| FullyRatedConverterWTG_5.0MW | Templates |
| FullyRatedConverterWTG_6.0MW | Templates |
| PhotovoltaicSystem_0.4kV_0.5MVA | Templates |
| VariableRotorResistanceWTG_0.63kV_0.65MW | Templates |

NOTE: this example is built using templates in the global library;
 Doubly Fed Induction Generators rated 6MW → DFIG_WTG_6MW
 Wind Farm Rated Power: 60MVA
 Wind Farm Rated Voltage: 220kV



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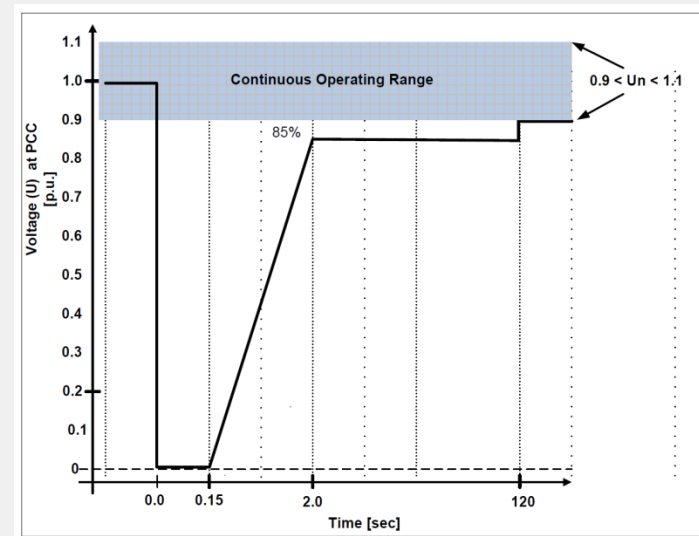
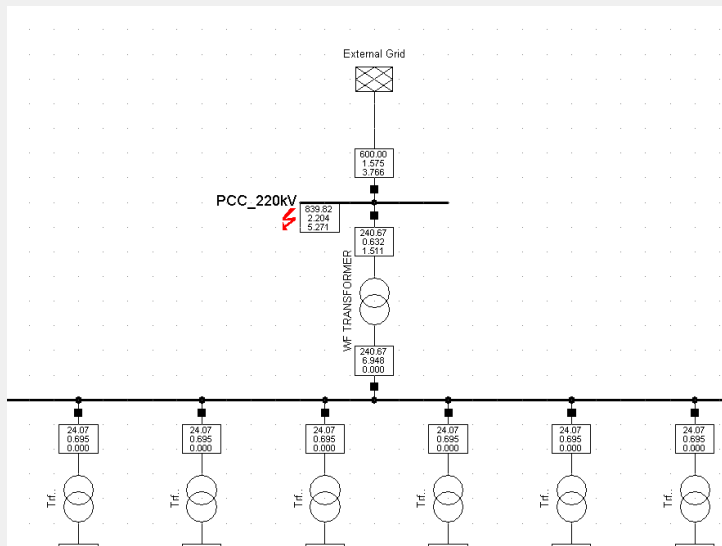
STEP 2: Simulation of LVRT events according to the South African Grid Code:

EMT simulation - 10kHz time step

Voltage dip location: at the Wind Farm PCC, 220kV side

Voltage dip depth: 0%, 50%, 85%

Voltage dip length: 150ms, 1250ms, 120s





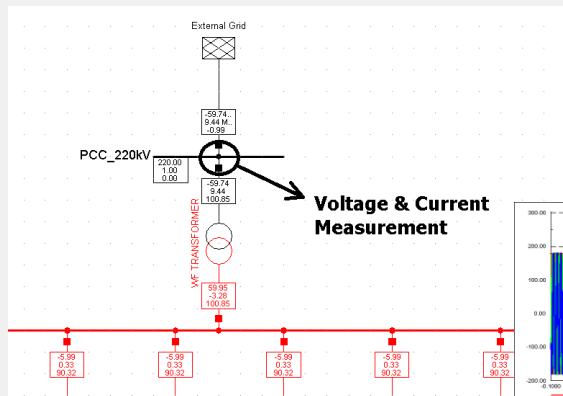
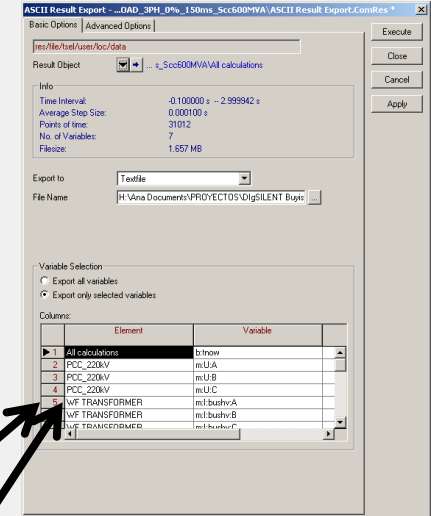
Example of Dynamic Simulation Testing Procedure

STEP 3: Export required signals from Plots in PowerFactory:

$U_a(t), U_b(t), U_c(t) \rightarrow \text{kV}$

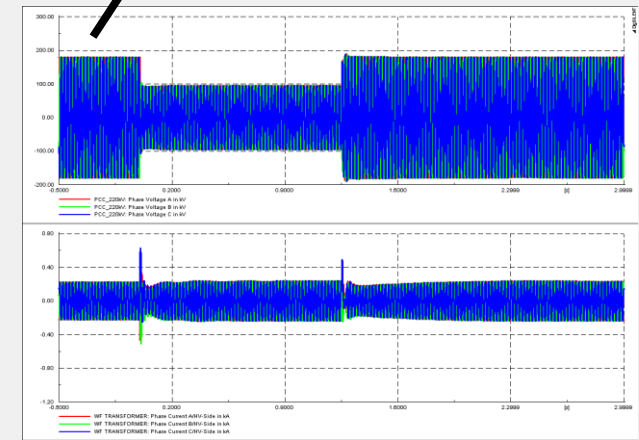
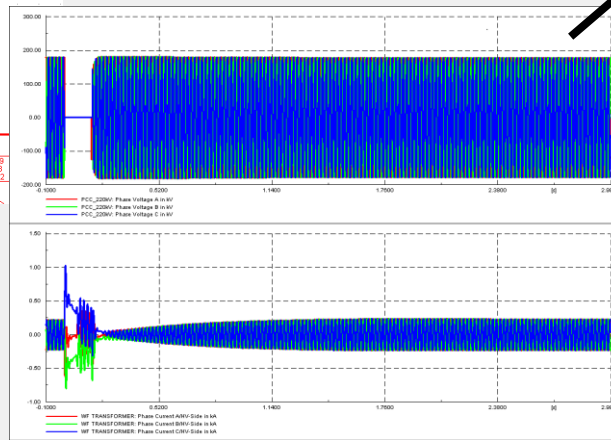
$I_a(t), I_b(t), I_c(t) \rightarrow \text{kA}$

Textfile, white space/tab separated format



Voltage dip 0%

Voltage dip 50%

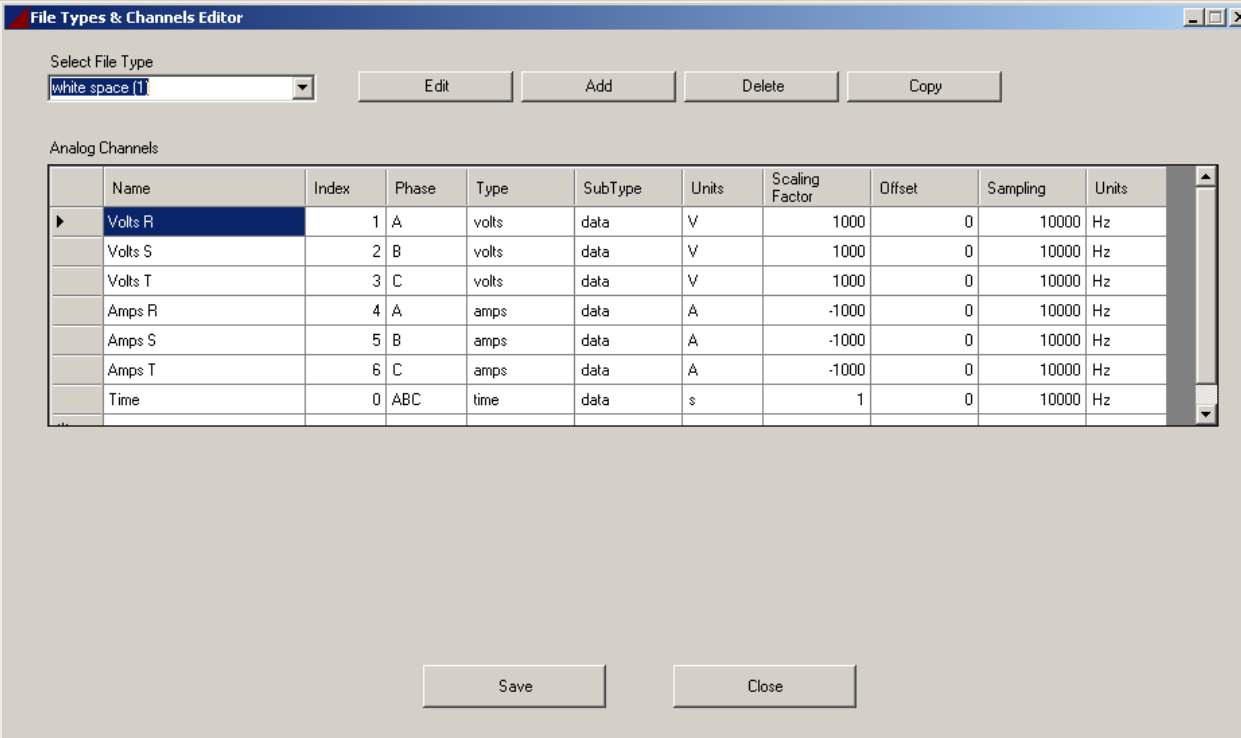




Example of Dynamic Simulation Testing Procedure

STEP 4: Analysis with DIGSILENT GridCode, checking for compliance.

STEP 4.1: File Types & Channels to read the results file.



The screenshot shows a software window titled "File Types & Channels Editor". At the top, there is a "Select File Type" dropdown menu currently showing "white space [1]". To the right of this menu are four buttons: "Edit", "Add", "Delete", and "Copy". Below this is a section labeled "Analog Channels" containing a table with the following columns: Name, Index, Phase, Type, SubType, Units, Scaling Factor, Offset, Sampling, and Units. The table contains seven rows of data, with the first row "Volts R" selected. At the bottom of the window are two buttons: "Save" and "Close".

| Name | Index | Phase | Type | SubType | Units | Scaling Factor | Offset | Sampling | Units |
|---------|-------|-------|-------|---------|-------|----------------|--------|----------|-------|
| Volts R | 1 | A | volts | data | V | 1000 | 0 | 10000 | Hz |
| Volts S | 2 | B | volts | data | V | 1000 | 0 | 10000 | Hz |
| Volts T | 3 | C | volts | data | V | 1000 | 0 | 10000 | Hz |
| Amps R | 4 | A | amps | data | A | -1000 | 0 | 10000 | Hz |
| Amps S | 5 | B | amps | data | A | -1000 | 0 | 10000 | Hz |
| Amps T | 6 | C | amps | data | A | -1000 | 0 | 10000 | Hz |
| Time | 0 | ABC | time | data | s | 1 | 0 | 10000 | Hz |



Example of Dynamic Simulation Testing Procedure

STEP 4: Analysis with DIGSILENT GridCode, checking for compliance.

STEP 4.1: File Types & Channels to read the results file.

STEP 4.2: Input of base values → 60MVA and 220kV

The screenshot shows a software configuration window with the following elements:

- Select File Type:** A dropdown menu with the selected option "white space (1)".
- Select Generator Type:** A dropdown menu with the selected option "Default".
- Rated Values:** A section containing four input fields, each with a unit dropdown:
 - Line Voltage:** Input field contains "220000", unit dropdown is "V".
 - Power:** Input field contains "60000000", unit dropdown is "VA".
 - Power Factor:** Input field contains "1", unit dropdown is "pu".
 - Frequency:** Input field contains "50", unit dropdown is "Hz".
- Line To Line Measurements:** A checkbox that is currently unchecked.



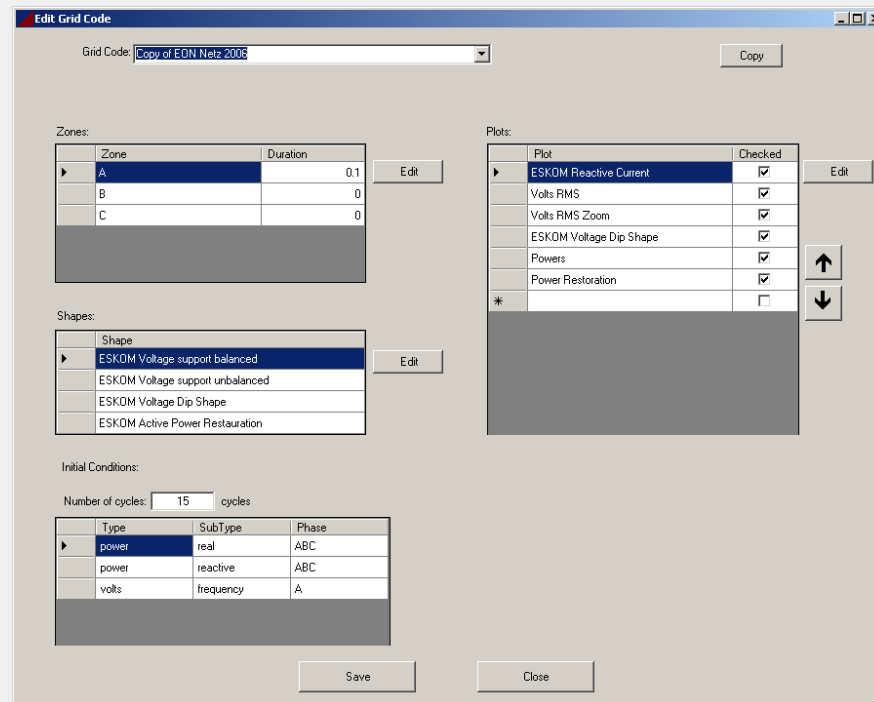
Example of Dynamic Simulation Testing Procedure

STEP 4: Analysis with DiGSILENT GridCode, checking for Grid Code compliance.

STEP 4.1: File Types & Channels to read the results file.

STEP 4.2: Input of base values → 60MVA and 220kV

STEP 4.3: With the GridCode Editor, add the South African Grid Code (copying for example the EON Netz 2006)





Example of Dynamic Simulation Testing Procedure

STEP 4: Analysis with DIGSILENT GridCode, checking for Grid Code compliance.

STEP 4.1: File Types & Channels to read the results file.

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STEP 4.3: With the GridCode Editor, add the South African Grid Code (copying for example the EON Netz 2006)

- Edit the voltage dip shape for balanced and unbalanced dips to the ESKOM dip

The image shows two screenshots from the DIGSILENT software. The left screenshot is the 'Edit Grid Code' window, showing a list of shapes under the 'ESKOM Voltage support balanced' category. The right screenshot is the 'Edit Shape' dialog box for 'ESKOM Voltage Dip Shape'. It includes a table for defining the dip shape parameters and a graph showing the resulting voltage profile over time.

| X | Y |
|------|------|
| 0 | 1 |
| 0.15 | 0 |
| 2 | 0.85 |
| 120 | 0.85 |
| 120 | 0.9 |

The graph shows Voltage [pu] at PCC vs Time [sec]. The voltage starts at 1.0 pu, drops to 0 at 0.15s, recovers to 0.85 pu at 2s, and remains at 0.85 pu until 120s. An inset graph shows the 'Continuous Operating Range' from 0.9 to 1.1 pu.



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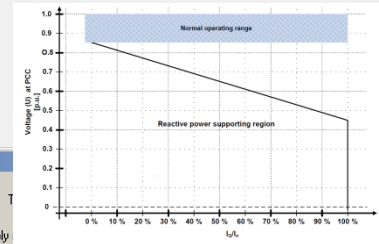
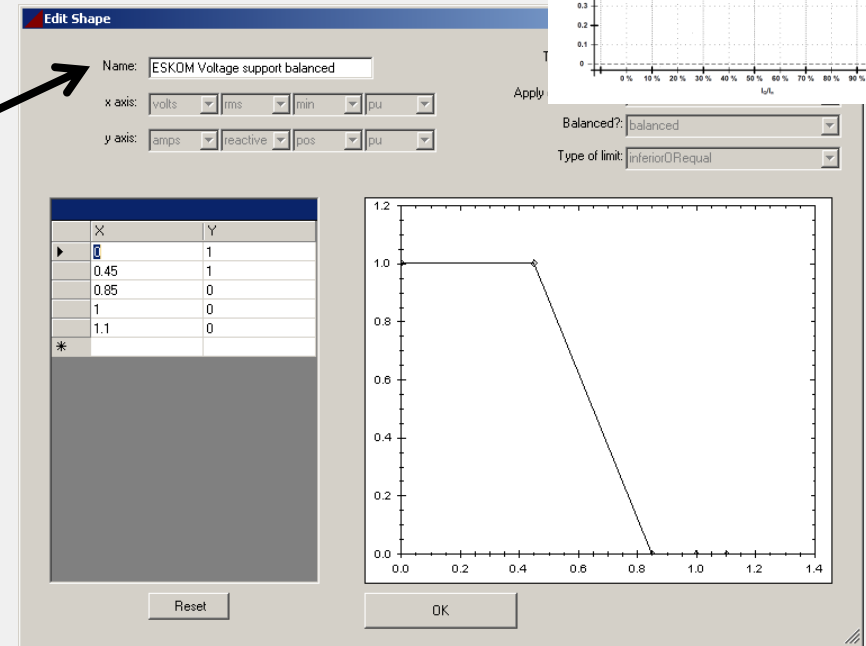
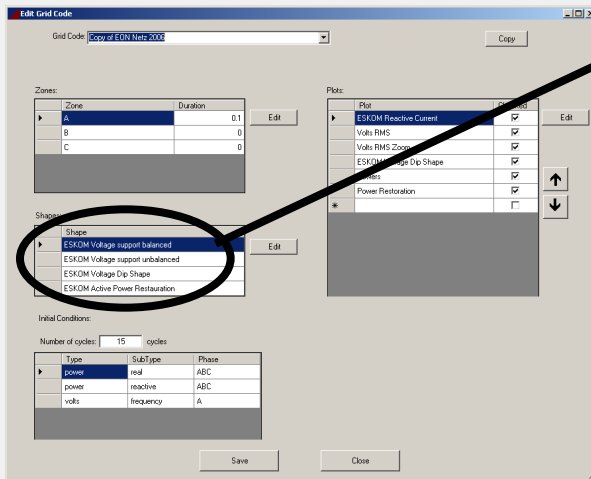
STEP 4: Analysis with DIGSILENT GridCode, checking for Grid Code compliance.

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- Edit the voltage dip shape to the ESKOM dip shape.
- Edit the voltage support requirements to the ESKOM requirements.
- Save.





Example of Dynamic Simulation Testing Procedure

STEP 4: Analysis with DIgSILENT GridCode, checking for Grid Code compliance.

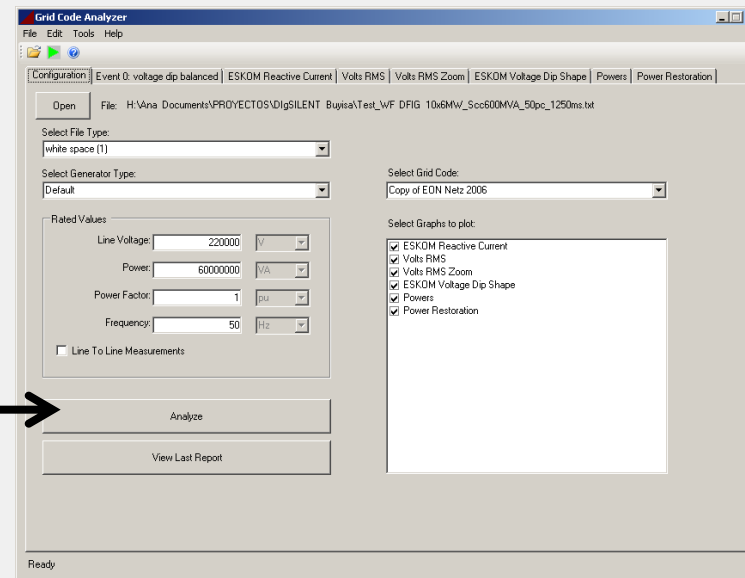
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- Edit the voltage dip shape to the ESKOM dip shape.
- Edit the voltage support requirements to the ESKOM requirements.
- Save.

STEP 4.4: Click Analyze





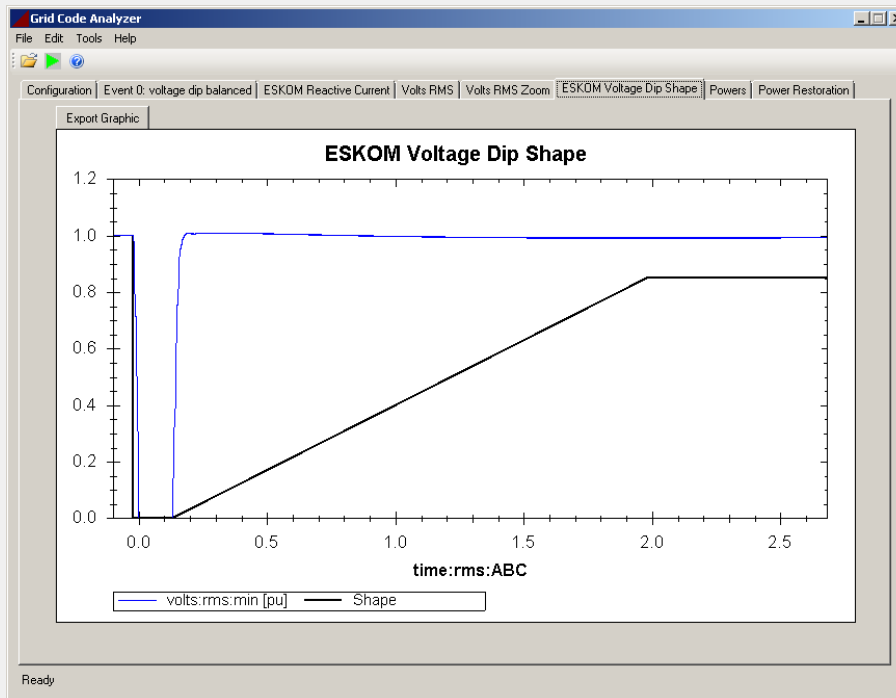
Example of Dynamic Simulation Testing Procedure

RESULTS

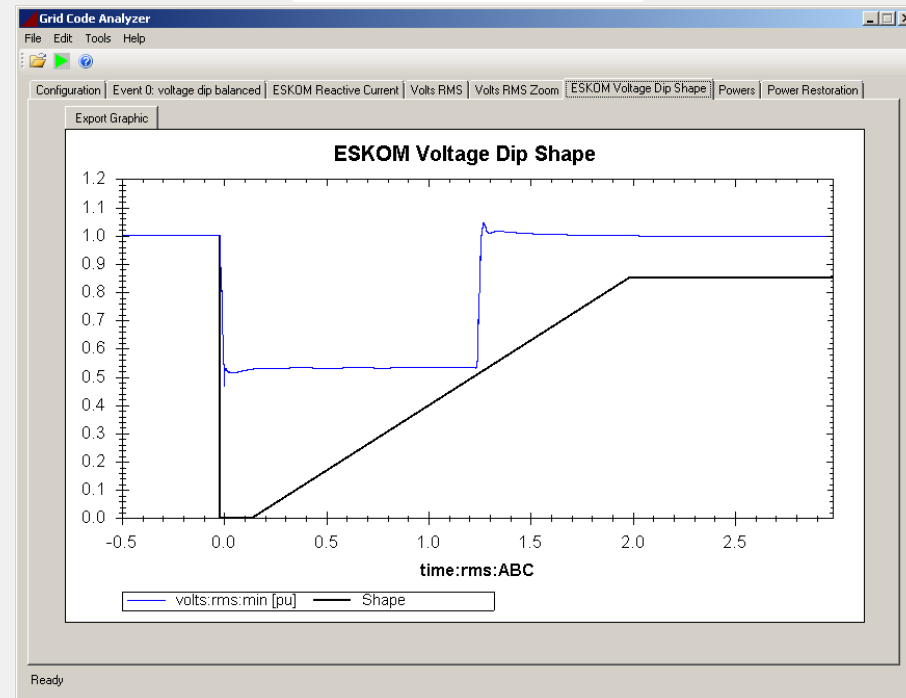
The ESKOM Voltage Dip Shape Graph allows to check if the voltage dip is “inside” the voltage dip shape → the wind farm can not disconnect and must provide reactive support

→ CHECKING FAULT RIDE THROUGH CAPABILITY

Voltage dip 0%



Voltage dip 50%





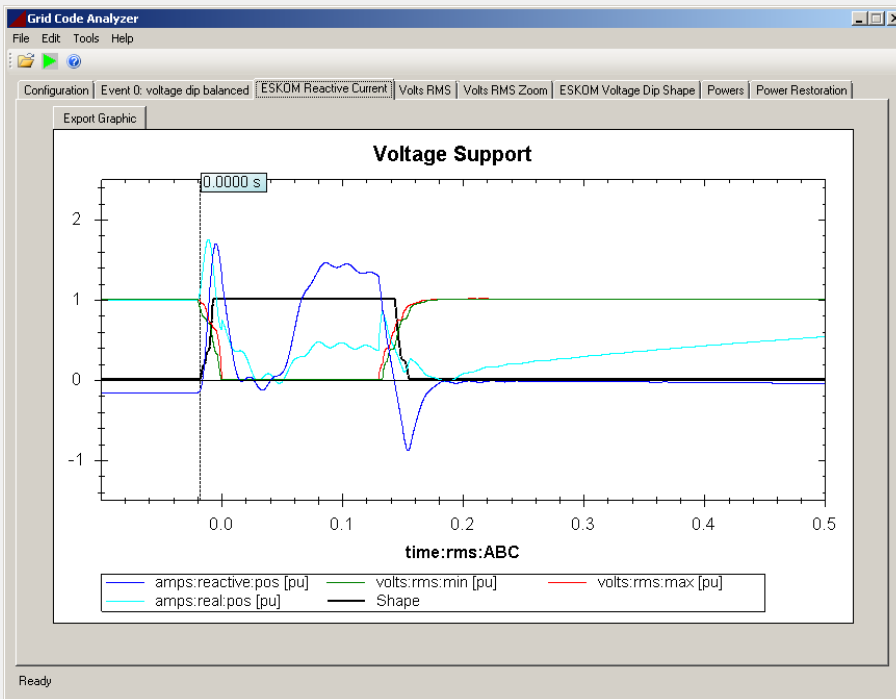
Example of Dynamic Simulation Testing Procedure

RESULTS

The Voltage Support Graph allows to check if the Wind Farm is injecting positive sequence reactive current (in dark blue) over the limit (in black) or positive sequence active current (in light blue)

→ CHECKING FAST ACTING REACTIVE AND/OR ACTIVE POWER CONTRIBUTION DURING FAULTS

Voltage dip 0%



Voltage dip 50%





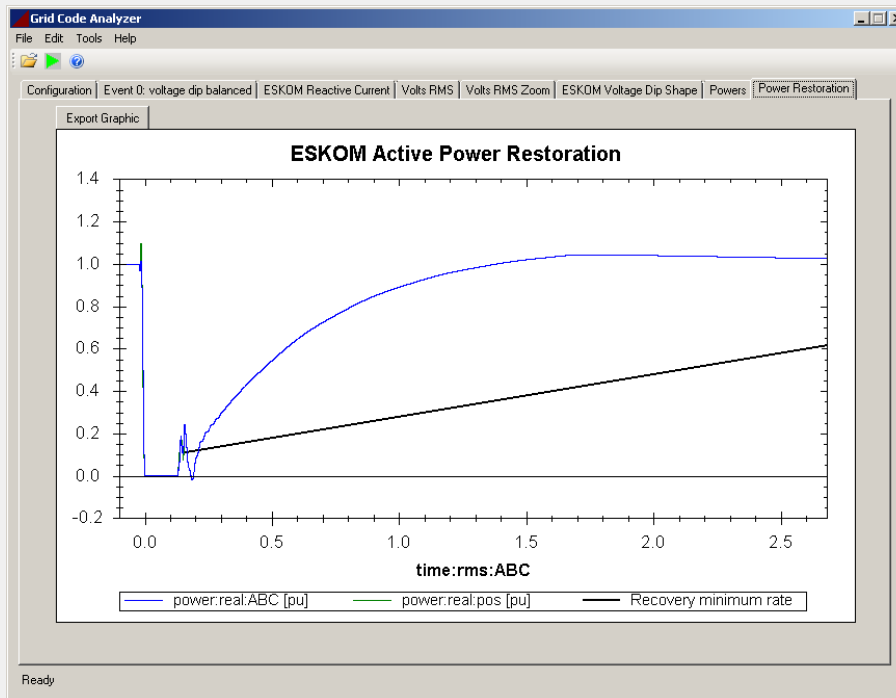
Example of Dynamic Simulation Testing Procedure

RESULTS

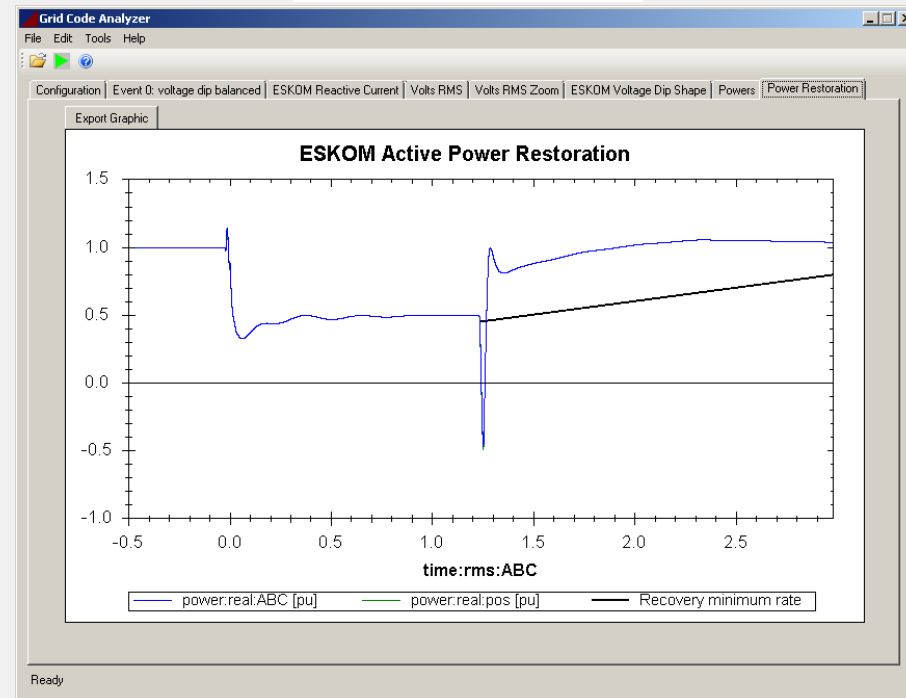
The ESKOM Active Power Restoration Graph allows to compare the required restoration active power rate and the active power from the wind farm after the voltage dip

→ CHECKING POST FAULT ACTIVE POWER RECOVERY

Voltage dip 0%



Voltage dip 50%

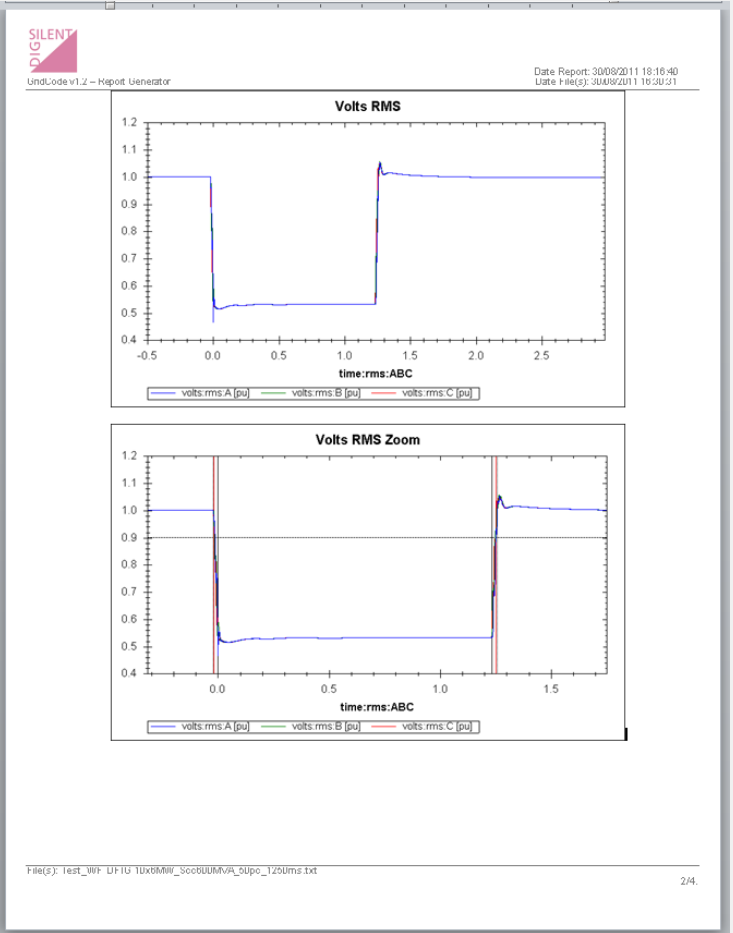
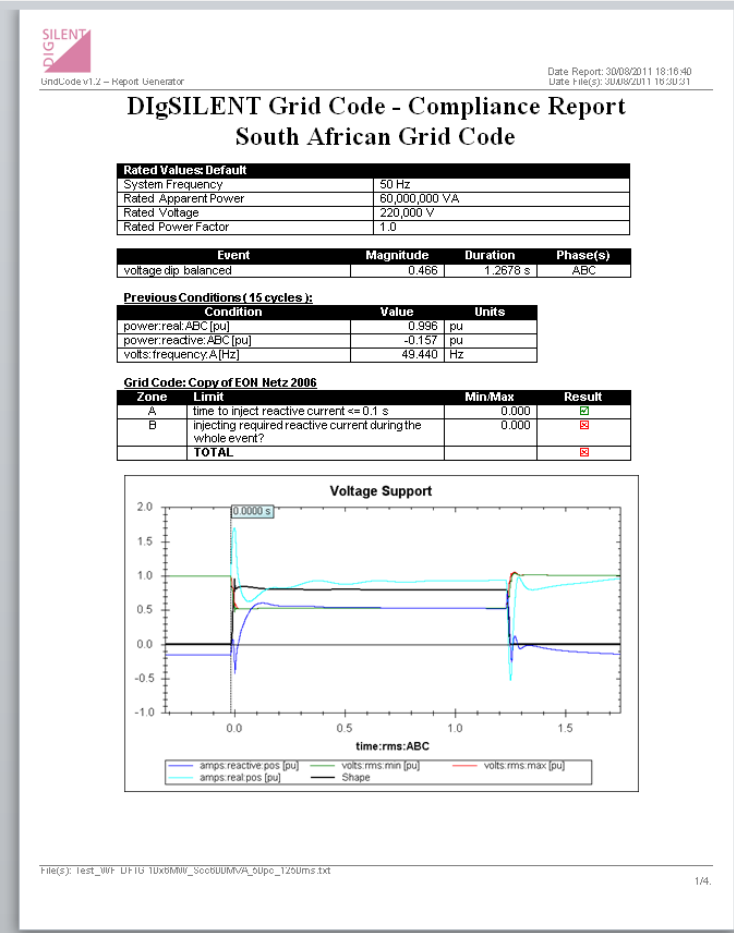




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REPORTING

Results are reported in Word format.





DlgSILENT GridCode Contact



Ana Morales/Xavier Robe
DlgSILENT Ibérica S.L.

Ribera del Loira, 46

28042 Madrid – Spain

Phone: +34 911273723/24

Email:

a.morales@digsilent.com

x.robe@digsilent.com

Website:

www.digsilent.com