

# Wind Turbine Integration into the Grid

A Manufacturers Perspective

## Business Card

Michael Nørtoft Frydensbjerg  
Grid Connection Coordinator,  
M.Sc.E.E.

## Education

M.Sc., Electrical Engineering,  
Aalborg University, 1997

B.Sc., Electrical Engineering,  
The Engineering College of Odense, 1995

## Wind Power Experience

Wind Power Business, July 2000

Siemens Wind Power, August 2005

## Agenda

§ Wind Integration

§ Manufacturers Perspective

§ Siemens Wind Turbine Capabilities

§ HPPP Capabilities

## Agenda

§ Wind Integration

§ Manufacturers Perspective

§ Wind Turbine Capabilities

§ Wind Farm Capabilities



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## Agenda

§ Wind Integration

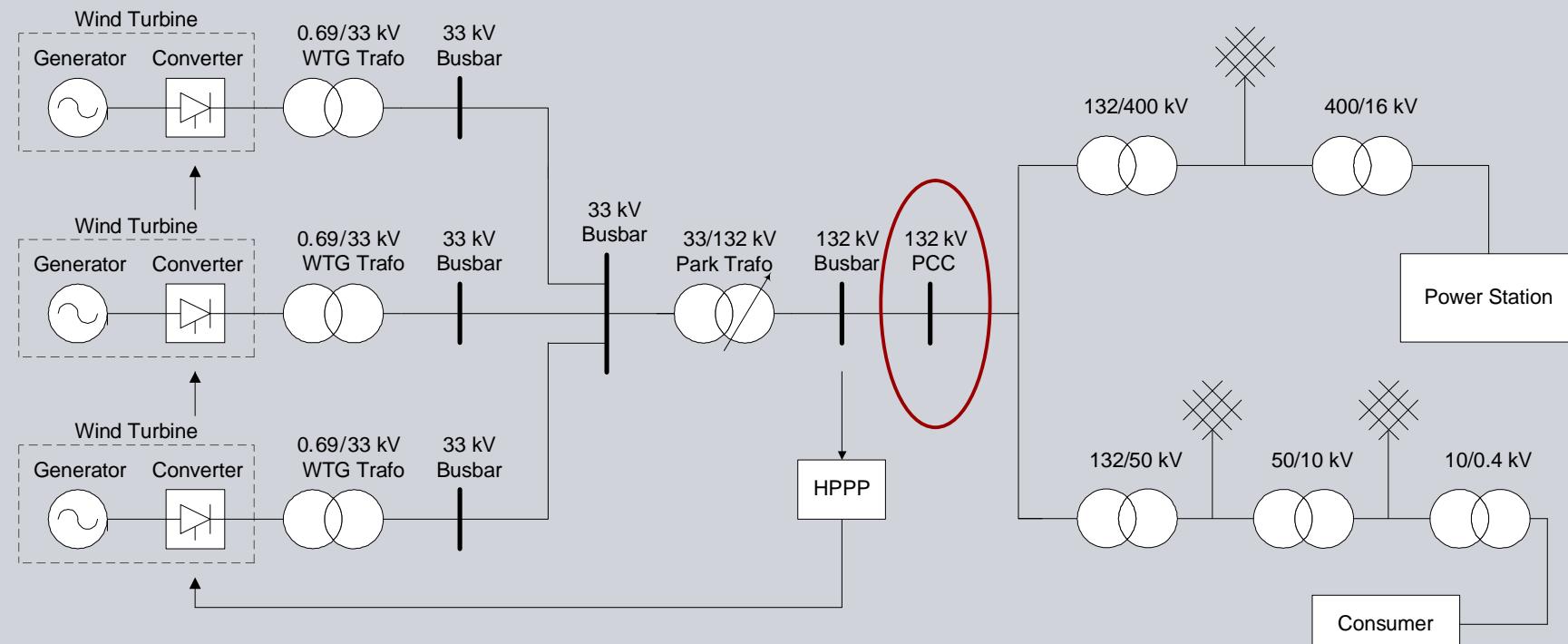
§ Manufacturers Perspective

§ Siemens Wind Turbine Capabilities

§ HPPP Capabilities

## Manufacturers Perspective

**Grid Code requirements are related to the PCC**



## Agenda

- § Wind Integration
- § Manufacturers Perspective
- § **Siemens Wind Turbine Capabilities**
- § HPPP Farm Capabilities

## Wind Turbine Capabilities

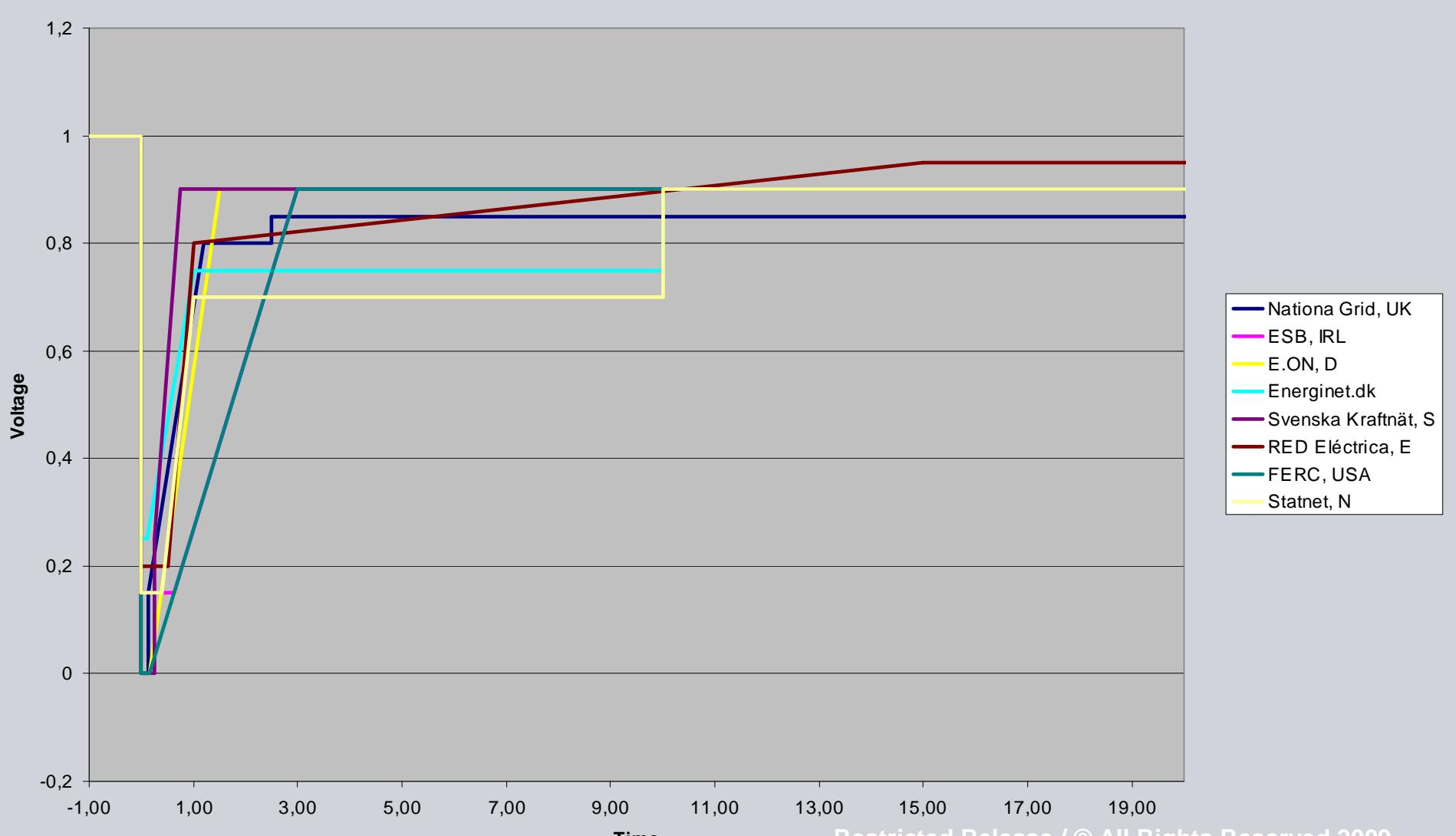
### § Operation Range

- Voltage: 90 % – 110 % of nominal voltage (up to 120 % for 1 s)
- Frequency: 47 Hz – 52 Hz

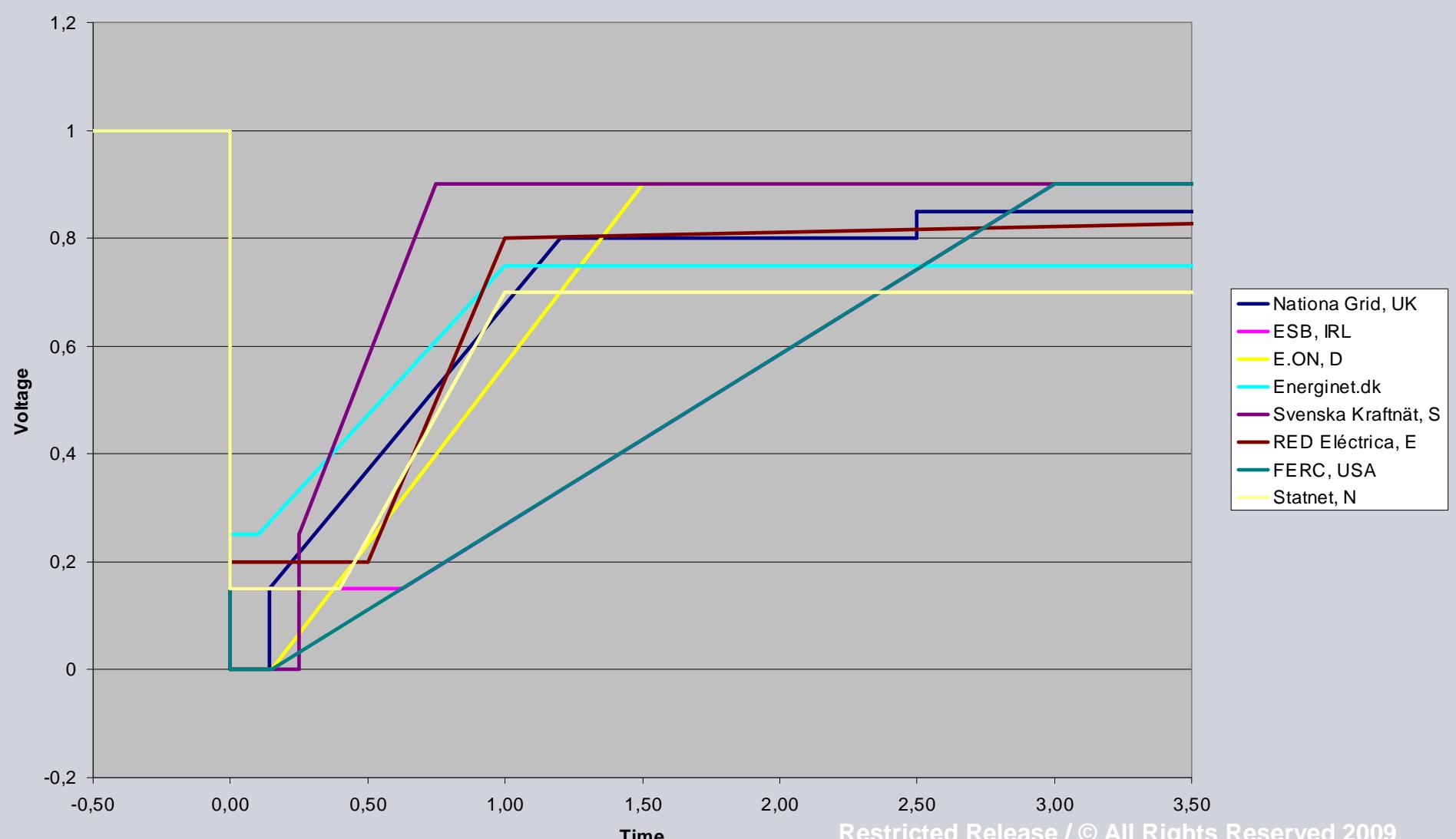
### § Fault Ride Through

- Low Voltage Ride Through

## Low Voltage Ride Through Requirements



## Low Voltage Ride Through Requirements



## Wind Turbine Capabilities

### § Operation Range

- Voltage: 90 % – 110 % of nominal voltage (up to 120 % for 1 s)
- Frequency: 47 Hz – 52 Hz

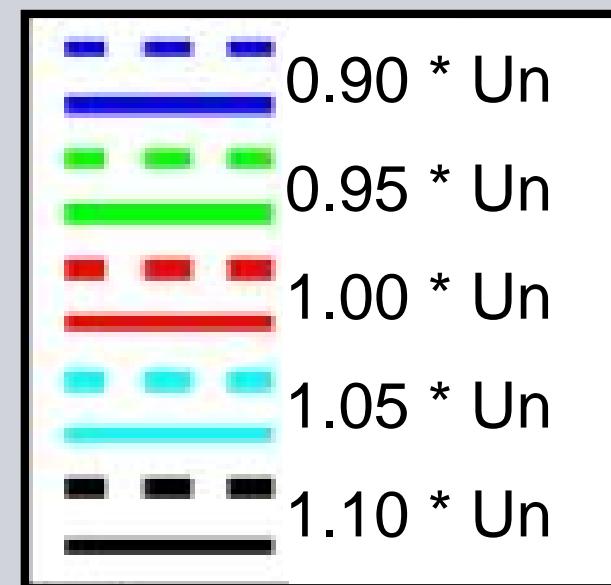
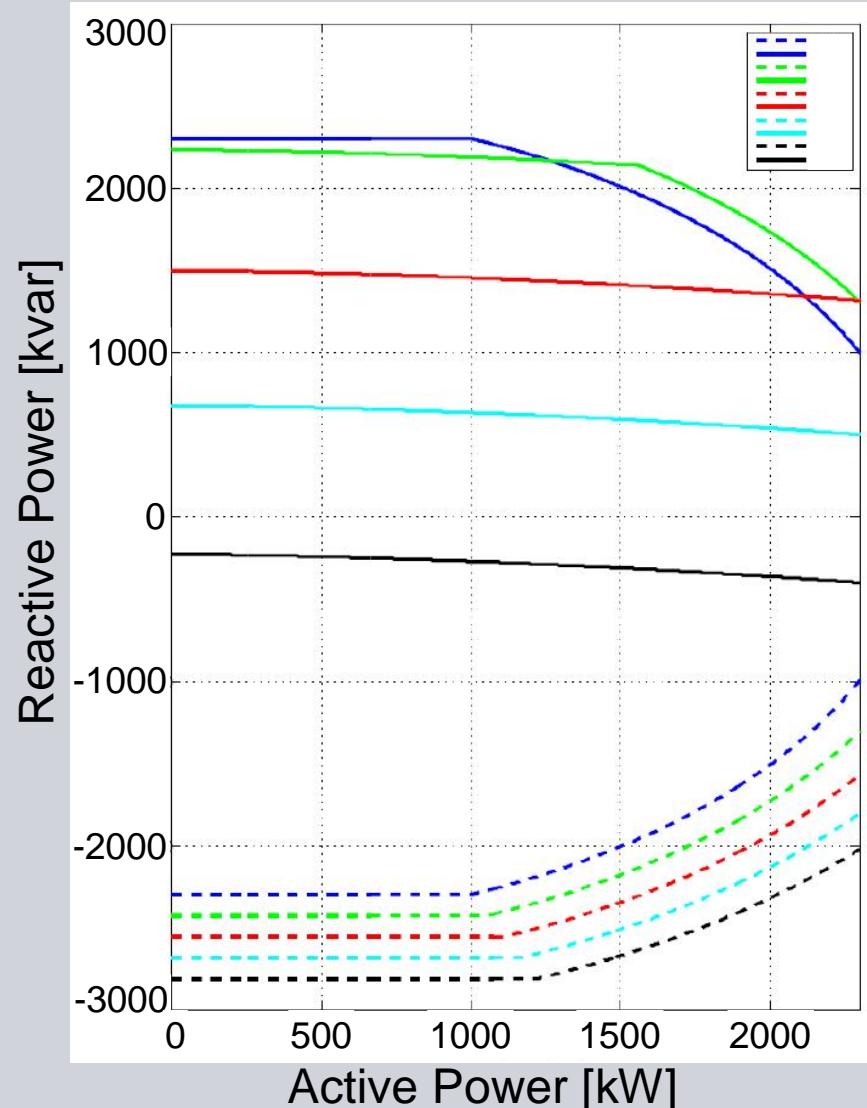
### § Fault Ride Through

- Low Voltage Ride Through

### § Reactive Power Capability

- Normal Operation

## Reactive Power Capability



Reactive Power Limits Curves example

## Wind Turbine Capabilities

### § Operation Range

- Voltage: 90 % – 110 % of nominal voltage (up to 120 % for 1 s)
- Frequency: 47 Hz – 52 Hz

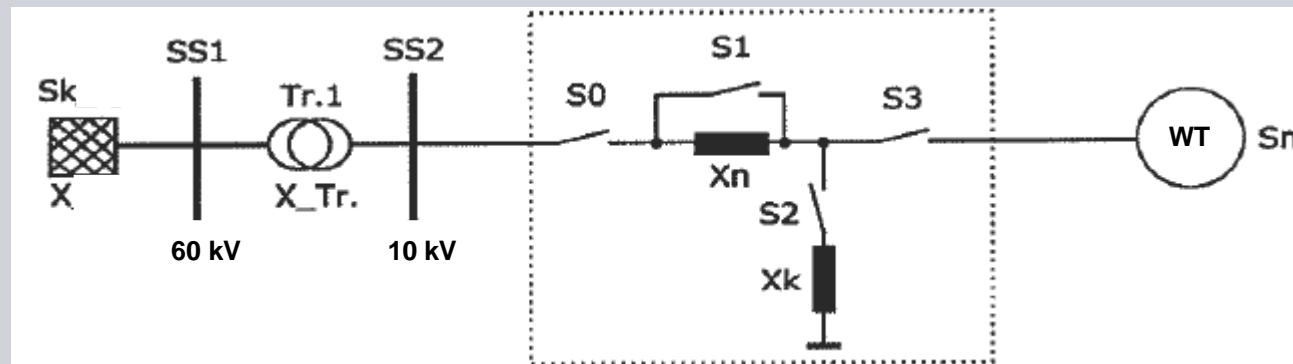
### § Fault Ride Through

- Low Voltage Ride Through

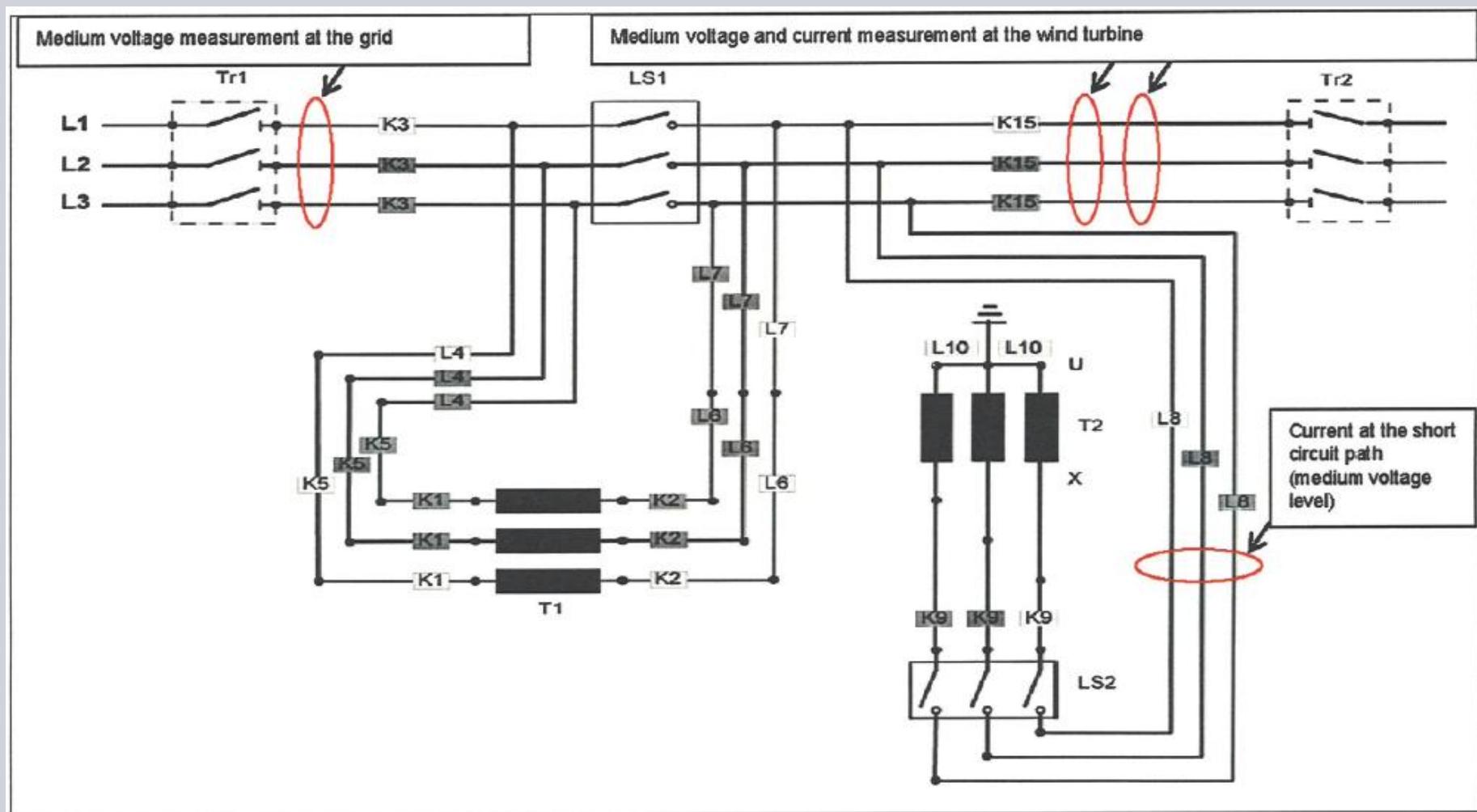
### § Reactive Power Capability

- Normal Operation
- Fault Ride Through

## Fault Ride Through Test Setup



## Fault Ride Through Test Setup



**SIEMENS**

## Fault Ride Through Test Site - Høvsøre



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## Test Specification

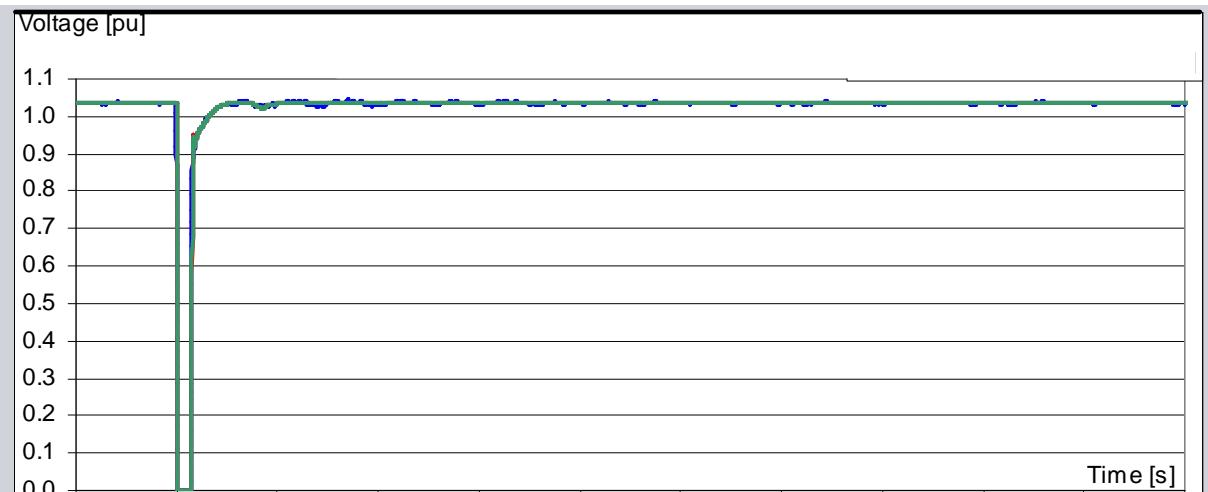
### Validation tests:

§ 0 % Retain Voltage in 140 ms

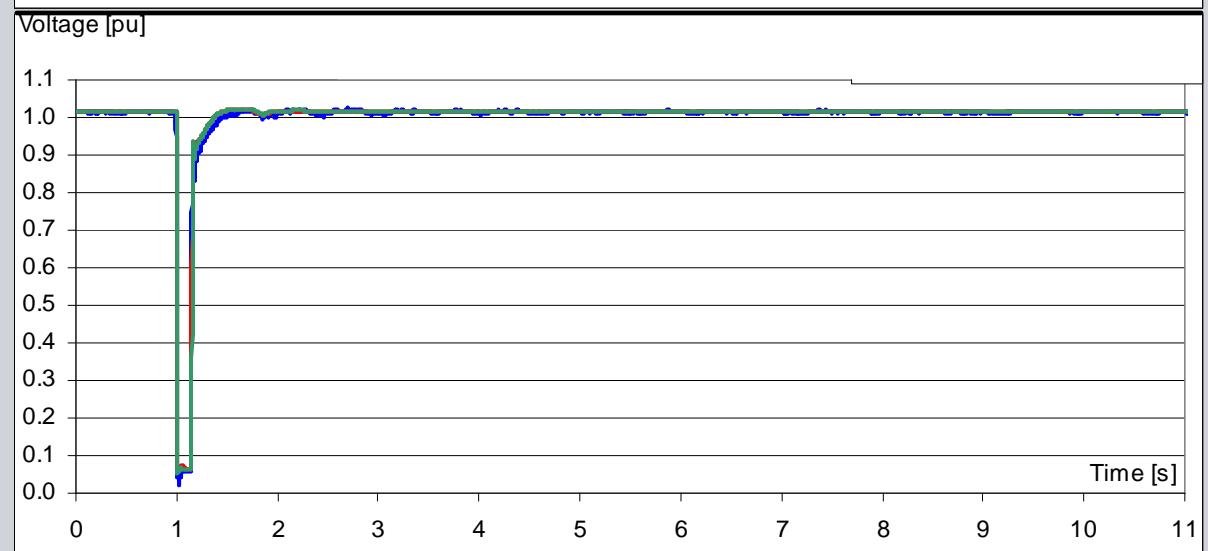
§ 50 % Retain Voltage in 710 ms

## 0 % Retain Voltage in 140 ms

**Transformer  
10 kV Voltage**



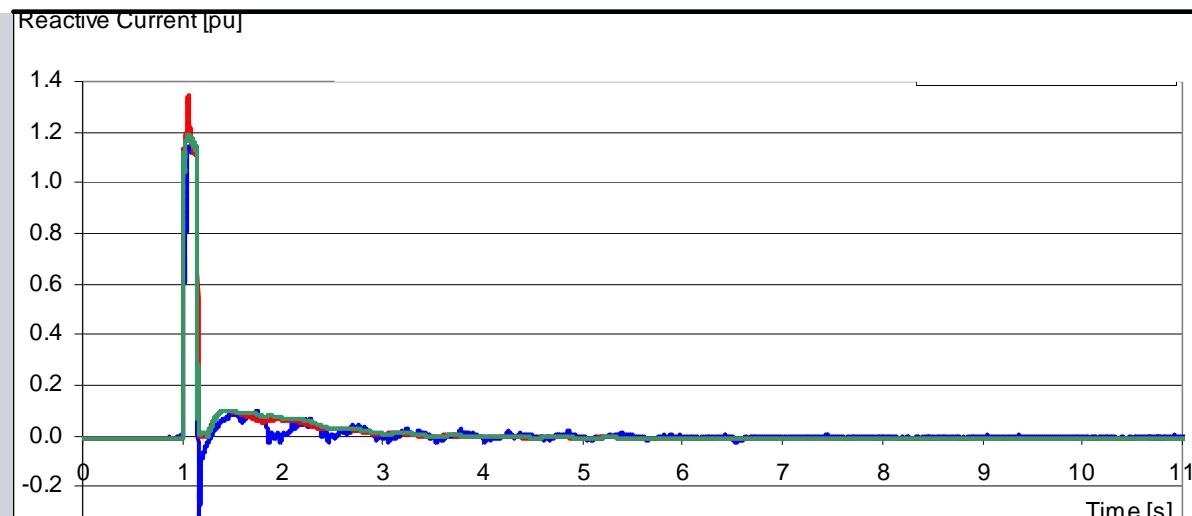
**Wind Turbine  
0.69 kV Voltage**



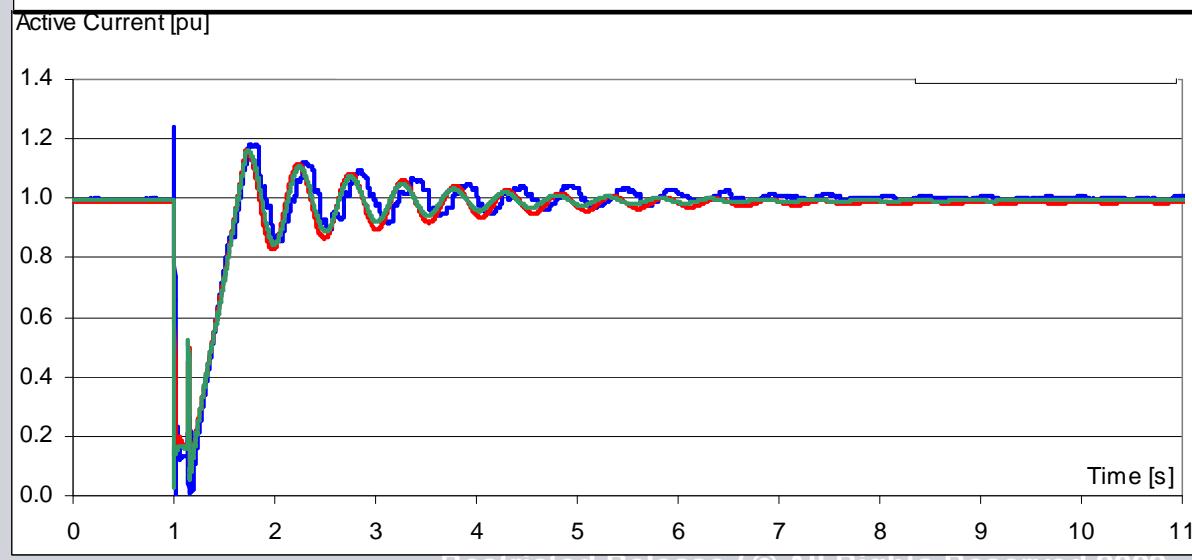
- RMS [pu]
- PSSE [pu]
- DIgSILENT [pu]

## 0 % Retain Voltage in 140 ms

### Wind turbine Reactive Current



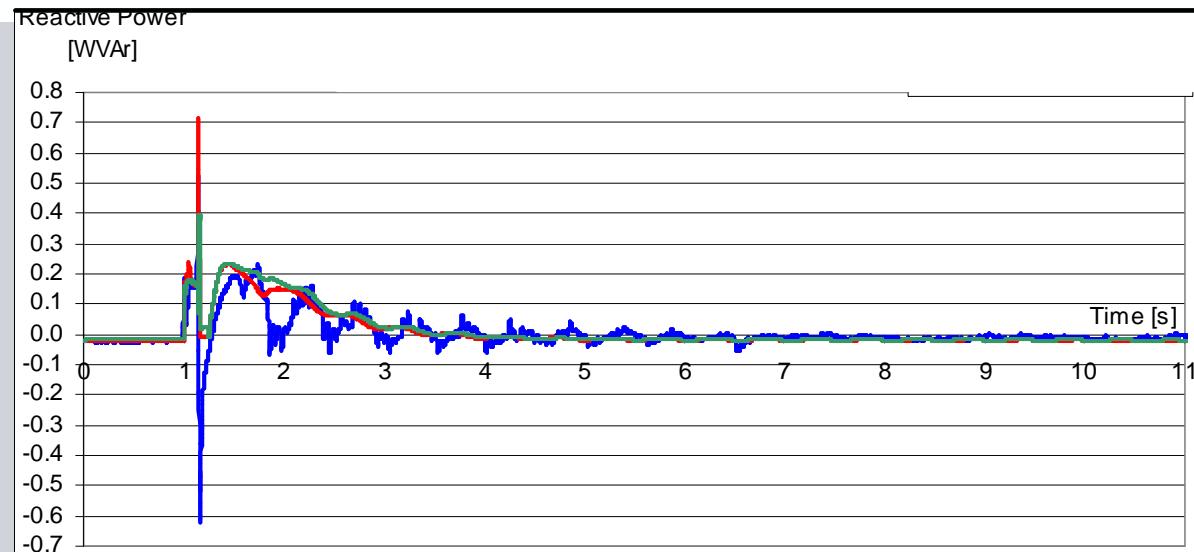
### Wind Turbine Active Current



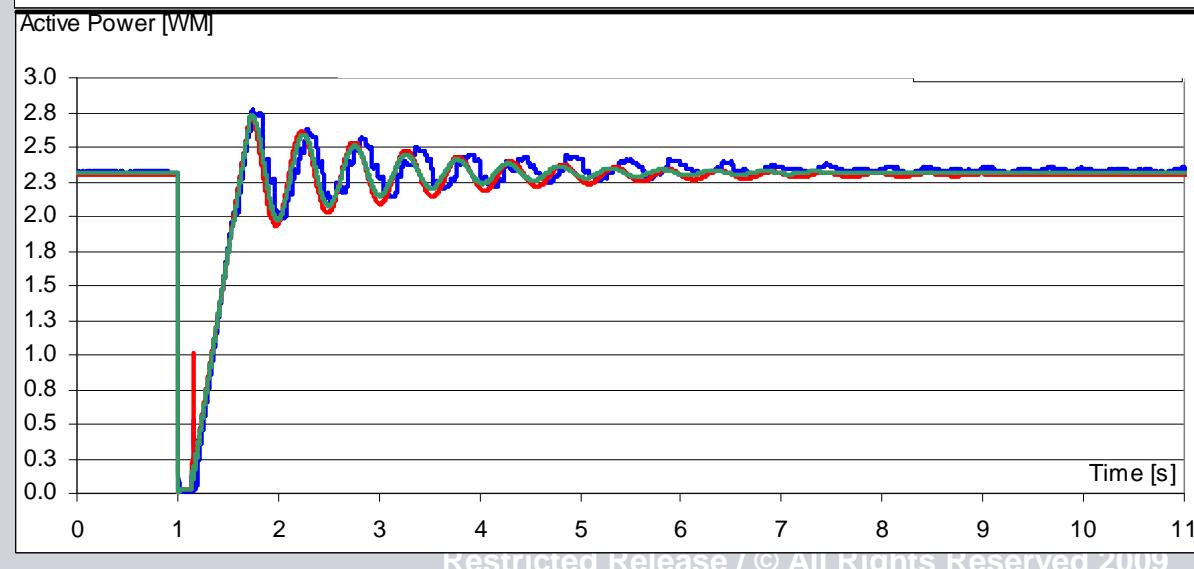
- RMS [pu]
- PSSE [pu]
- DLgSILENT [pu]

## 0 % Retain Voltage in 140 ms

### Wind Turbine Reactive Power



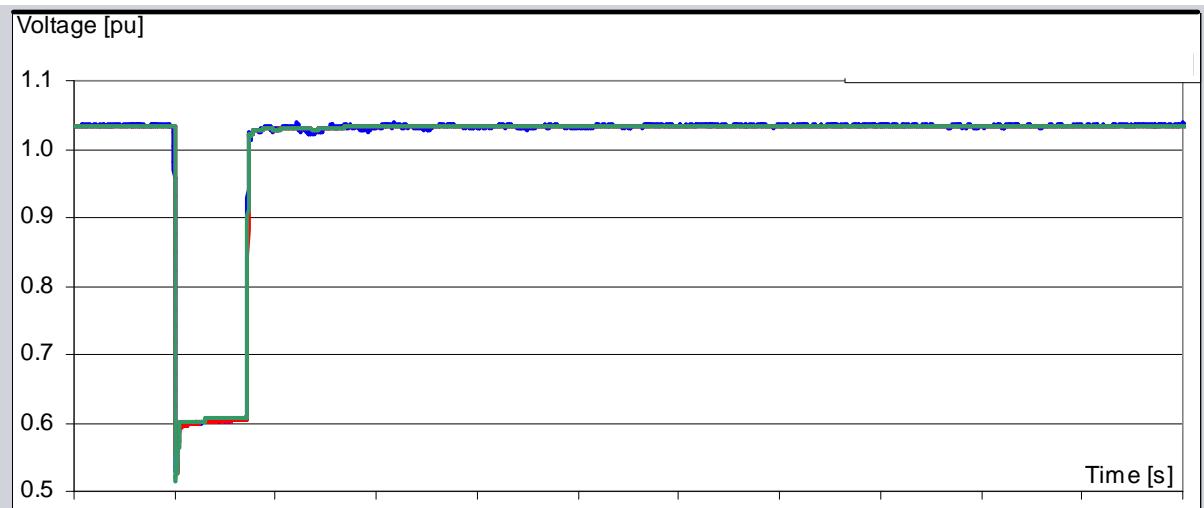
### Wind Turbine Active Power



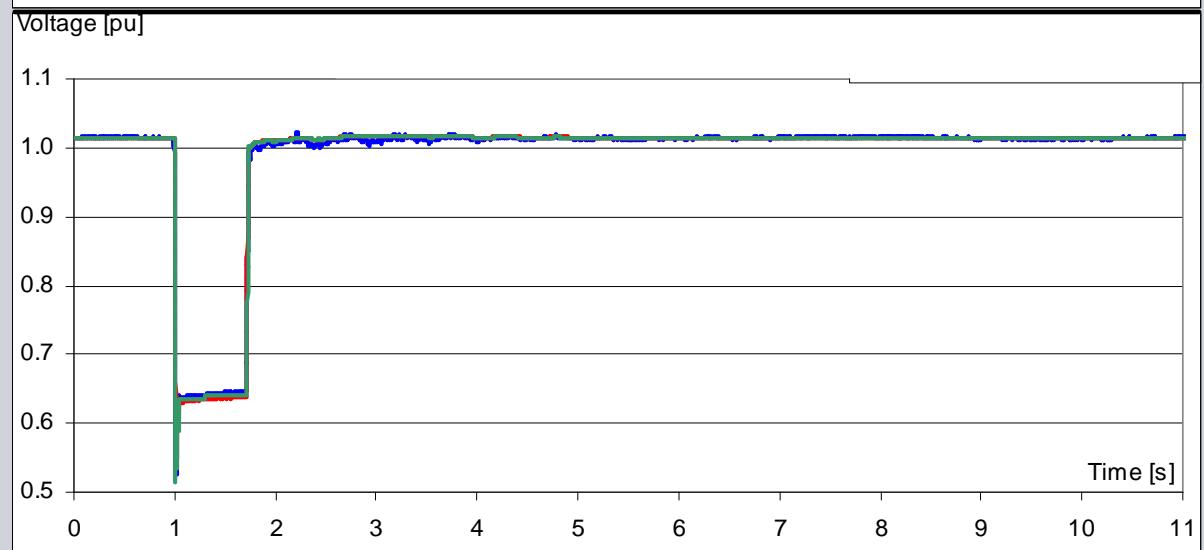
- RMS [pu]
- PSSE [pu]
- DLgSILENT [pu]

## 50 % Retain Voltage in 710 ms

**Transformer  
10 kV Voltage**



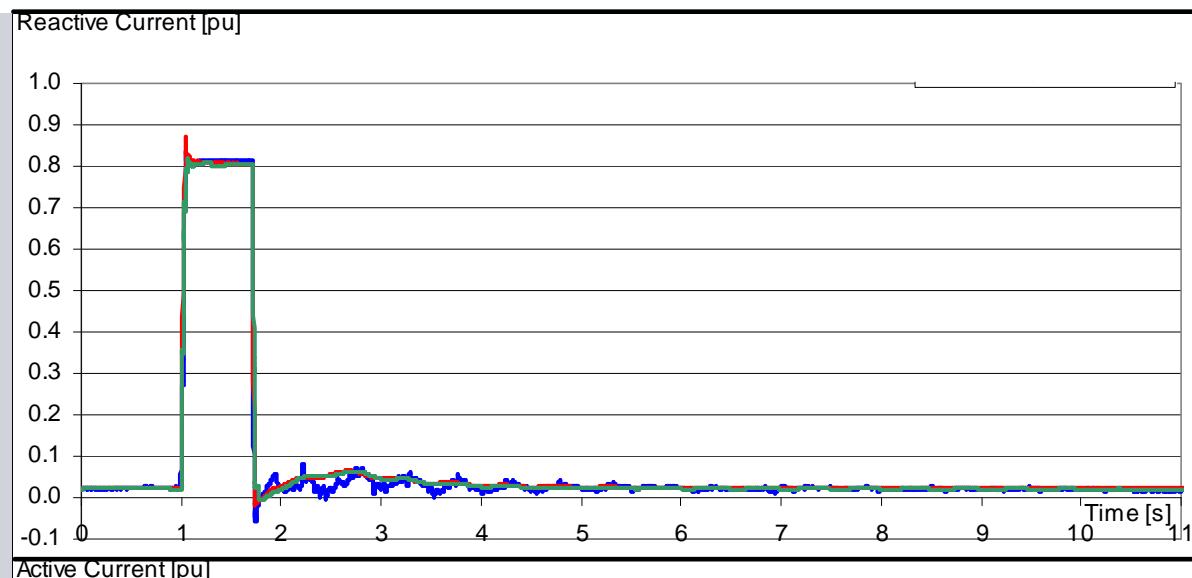
**Wind Turbine  
0.69 kV Voltage**



- RMS [pu]
- PSSE [pu]
- DIgSILENT [pu]

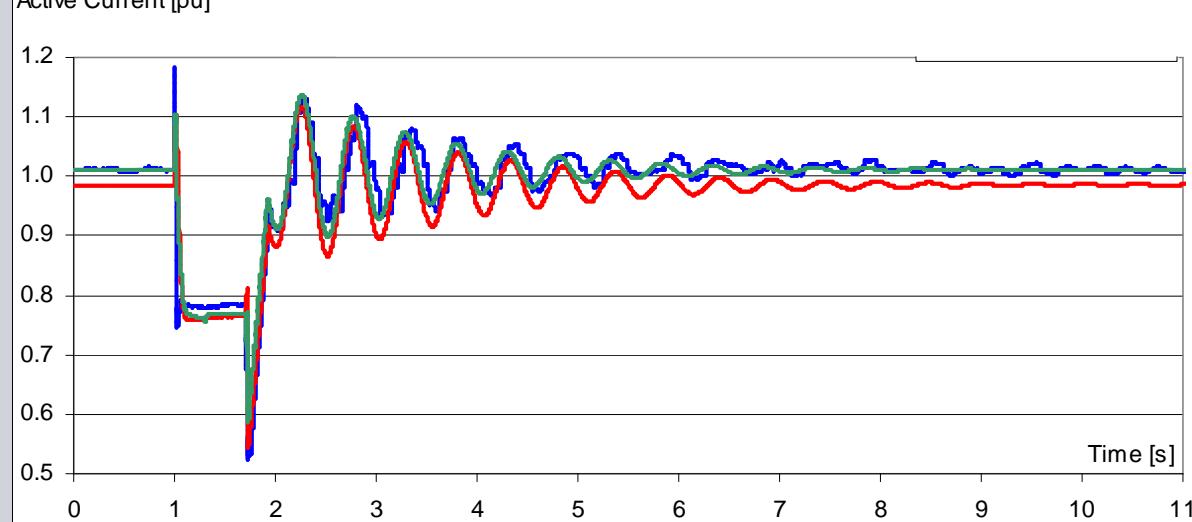
## 50 % Retain Voltage in 710 ms

### Wind turbine Reactive Current



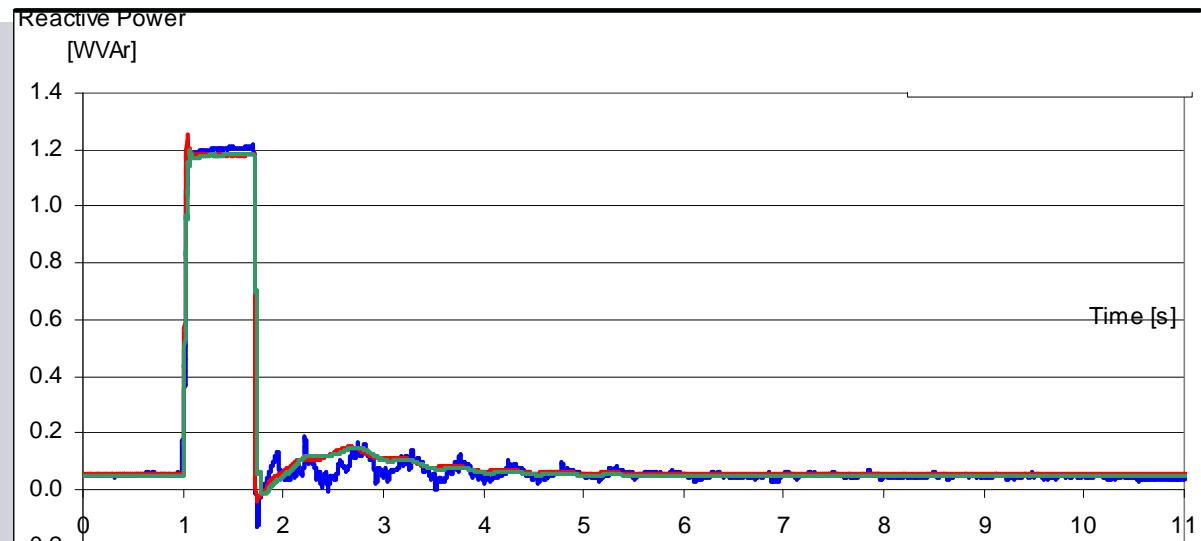
### Wind Turbine Active Current

- RMS [pu]
- PSSE [pu]
- DlgsILENT [pu]

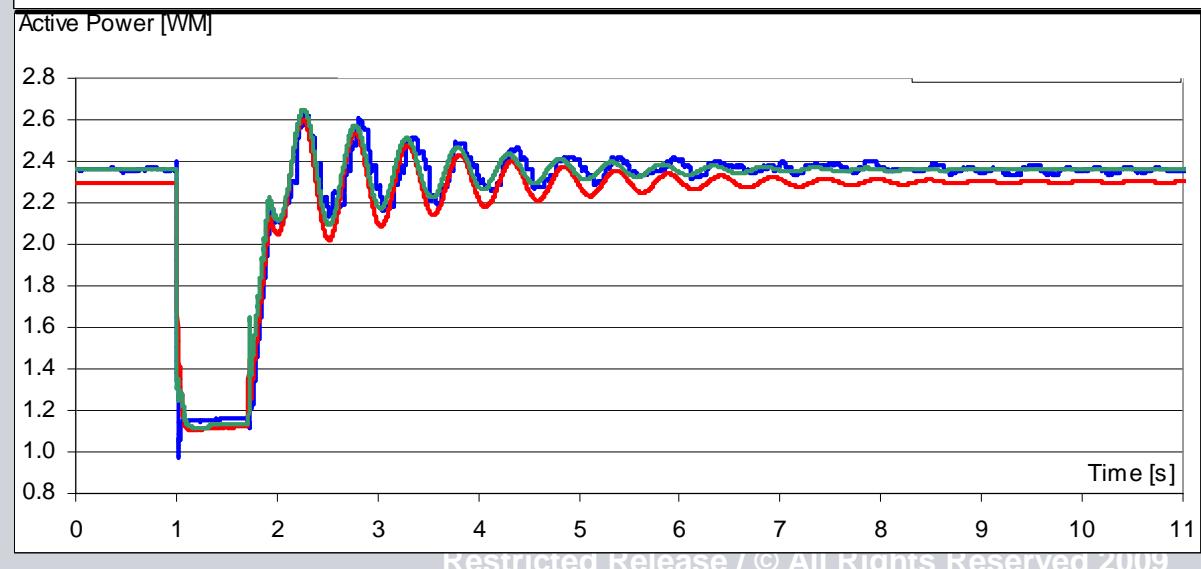


## 50 % Retain Voltage in 710 ms

### Wind Turbine Reactive Power



### Wind Turbine Active Power



- RMS [pu]
- PSSE [pu]
- DLgSILENT [pu]

## Agenda

§ Wind Integration

§ Manufacturers Perspective

§ Siemens Wind Turbine Capabilities

§ **HPPP Capabilities**

## HPPP Capabilities

### § Active Power Control

- MW Control

## Active Power Control - MW Control

### User Interface

The screenshot displays two Microsoft Internet Explorer windows showing the 'Wind Power Supervisor - Rothes' interface.

**Top Window:** The title is 'Utility, Park Pilot Status and Schedule, Rothes'. It shows a table of power status and a summary table. A red circle highlights the table under 'Park Pilot Status' and the 'Schedule' and 'History Graph' buttons.

	Total
Active Power	55.0 MW
Active Power Actual	4.8 MW
Frequency Controller	Idle
Available Power	4.9 MW
Curtailment Power	0.1 MW
Curtailment	2.1%
Reactive Power Setpoint	-1 MVar
Reactive Power Actual	0.0 MVar
Voltage Controller	Active

**Bottom Window:** The title is 'Utility, Park Pilot Status and Schedule, Rothes'. It shows a 'Park Pilot Schedule' table. A red circle highlights the 'Add New' button, the 'Date' field (10/7/2005 8:55:00 PM), and the 'Power [MW]' field (55 MW).

Date	Power [MW]
10/7/2005 8:55:00 PM	55 MW

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## HPPP Capabilities

### § Active Power Control

- MW Control
- Frequency Control

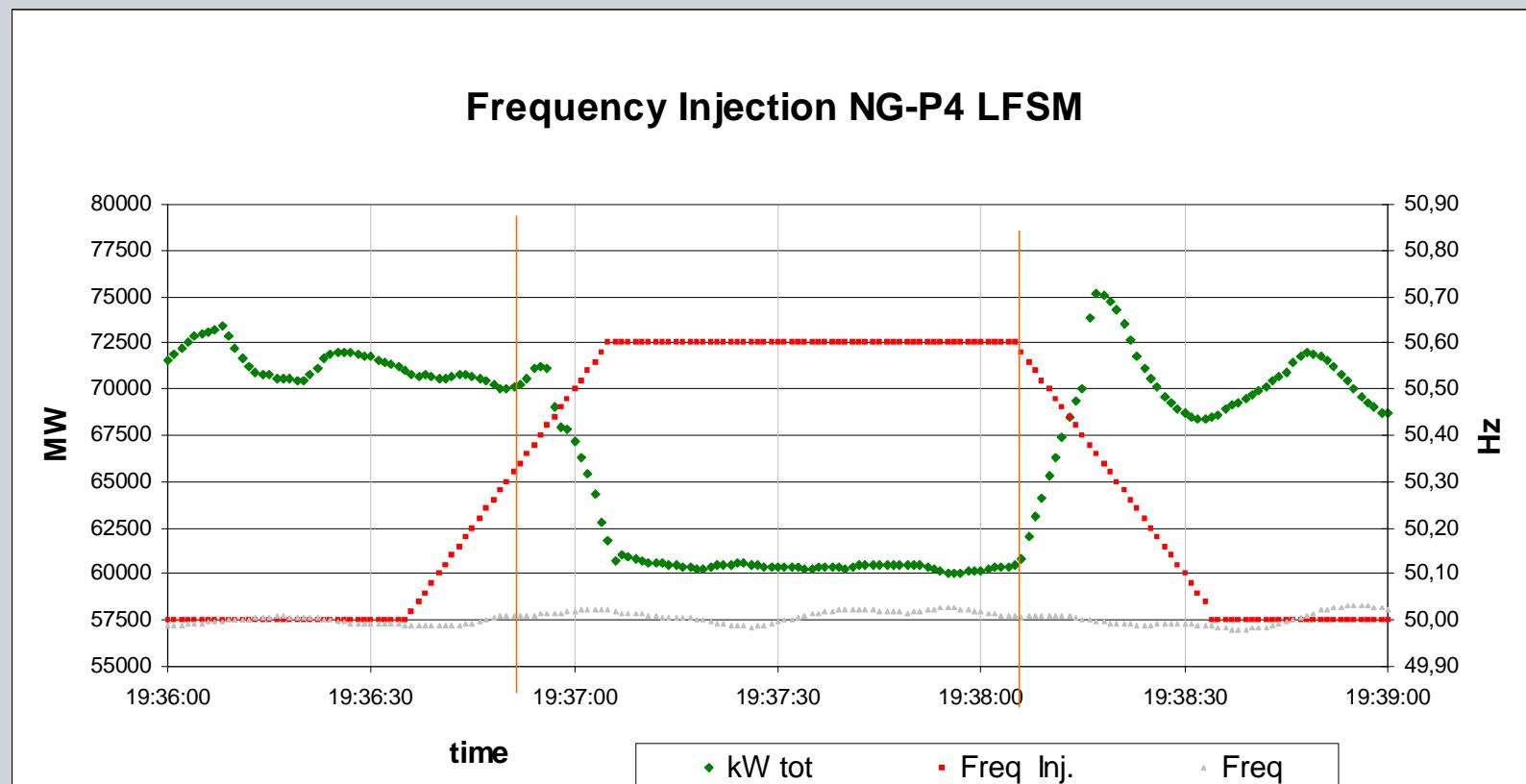
## Active Power Control - Frequency Control

### User Interface

Park Pilot Parameters		
<b>Frequency Response</b>		
<b>Mode :</b>	Limited Frequency Response	<input type="button" value="Edit"/>
<b>Limited Frequency Response</b>		
<b>Upper Frequency :</b>	50.4 Hz	<input type="button" value="Edit"/>
<b>Droop :</b>	1 %	<input type="button" value="Edit"/>
<b>Frequency Sensitive Mode</b>		
<b>Target Frequency :</b>	50 Hz	<input type="button" value="Edit"/>
<b>Deadband :</b>	0.03 Hz	<input type="button" value="Edit"/>
<b>Droop :</b>	1 %	<input type="button" value="Edit"/>

Only one set of parameters are active, depending on the selected mode.

## Active Power Control - Frequency Control



## HPPP Capabilities

### § Active Power Control

- MW Control
- Frequency Control

### § Reactive Power Control

- Mvar Control

## Reactive Power Control - Mvar Control

### User Interface

The screenshot displays two windows of the Siemens Wind Power Supervisor - Rothes interface, both running in Microsoft Internet Explorer.

**Top Window:** Utility, Park Pilot Status and Schedule, Rothes

	Total
Active Power	55.0 MW
Active Power Actual	4.8 MW
Frequency Controller	Idle
Available Power	4.9 MW
Curtailment Power	0.1 MW
Curtailment	2.1%
Reactive Power Setpoint	-1 MVar
Reactive Power Actual	0.0 MVar
Voltage Controller	Active

**Bottom Window:** Utility, Park Pilot Schedule

Add New

Date	Power [MW]
10/7/2005 8:55:00 PM	65 MW

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## HPPP Capabilities

### § Active Power Control

- MW Control
- Frequency Control

### § Reactive Power Control

- Mvar Control
- Power Factor Control
- Voltage Control

## Reactive Power Control - Voltage Control

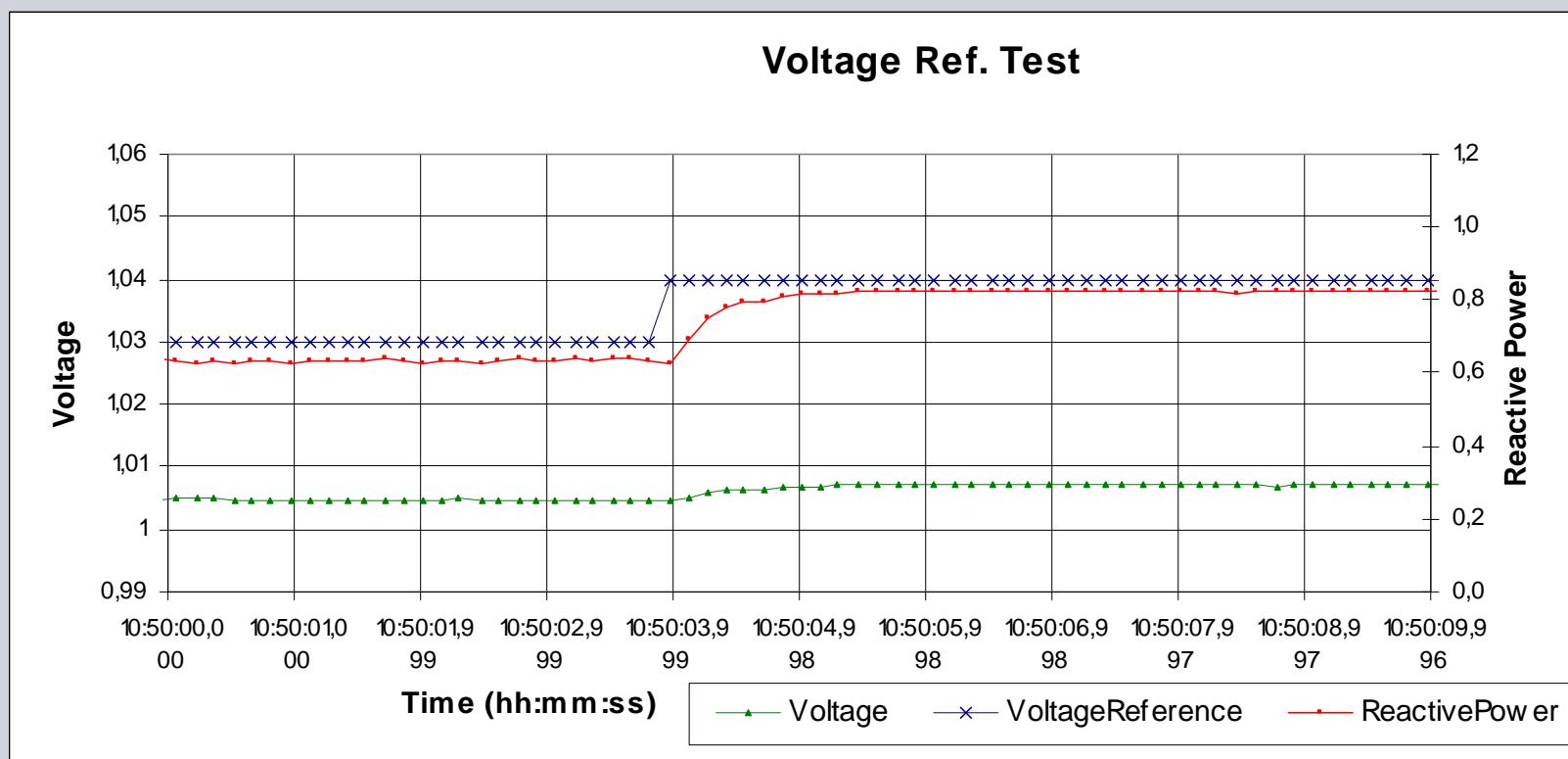
### User Interface

Park Pilot Parameters

Voltage Control [Show Graph](#)

<b>Kp :</b>	600 [0/00 / p.u.]	<a href="#">Edit</a>
<b>RateNeg :</b>	1000000 [0/00 / s]	<a href="#">Edit</a>
<b>RatePos :</b>	1000000 [0/00 / s]	<a href="#">Edit</a>
<b>Ti :</b>	2 [s]	<a href="#">Edit</a>
<b>Droop Compensation :</b>	Yes	<a href="#">Edit</a>
<b>Droop Gain :</b>	0.04 [p.u. / p.u.]	<a href="#">Edit</a>
<b>Rated Reactive Power :</b>	8 [MVAr]	<a href="#">Edit</a>
<b>Rated Connection Point Voltage :</b>	33000 [V]	<a href="#">Edit</a>
<b>Turbine Voltage Min :</b>	950 [0/00]	<a href="#">Edit</a>
<b>Turbine Voltage Max :</b>	1050 [0/00]	<a href="#">Edit</a>
<b>Voltage Reference :</b>	1 [p.u.]	<a href="#">Edit</a>

## Reactive Power Control - Voltage Control



## Conclusion



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**Thank you for your attention**

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