

# 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

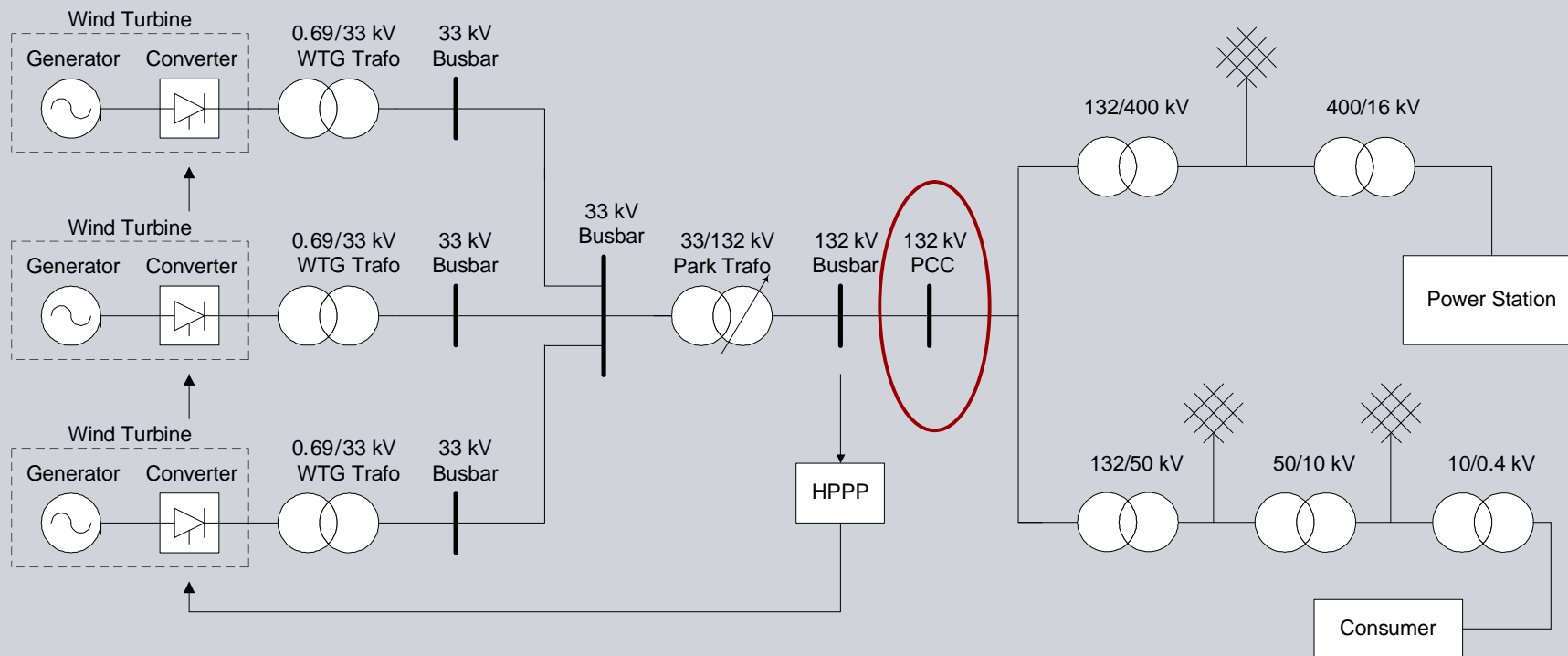


## Agenda

- § 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

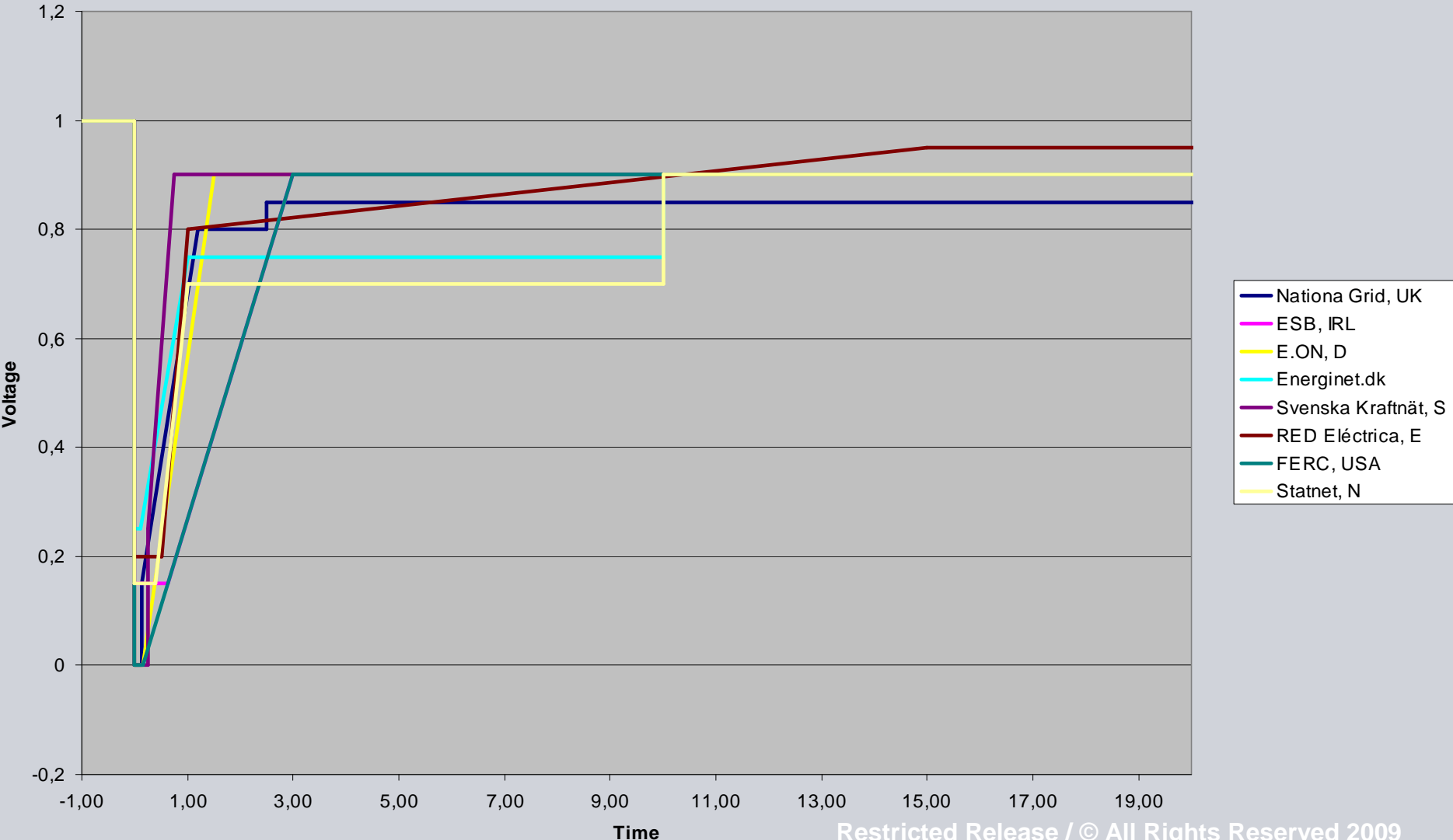
- Voltage: 90 % – 110 % of nominal voltage (up to 120 % for 1 s)
- Frequency: 47 Hz – 52 Hz

### § Fault Ride Through

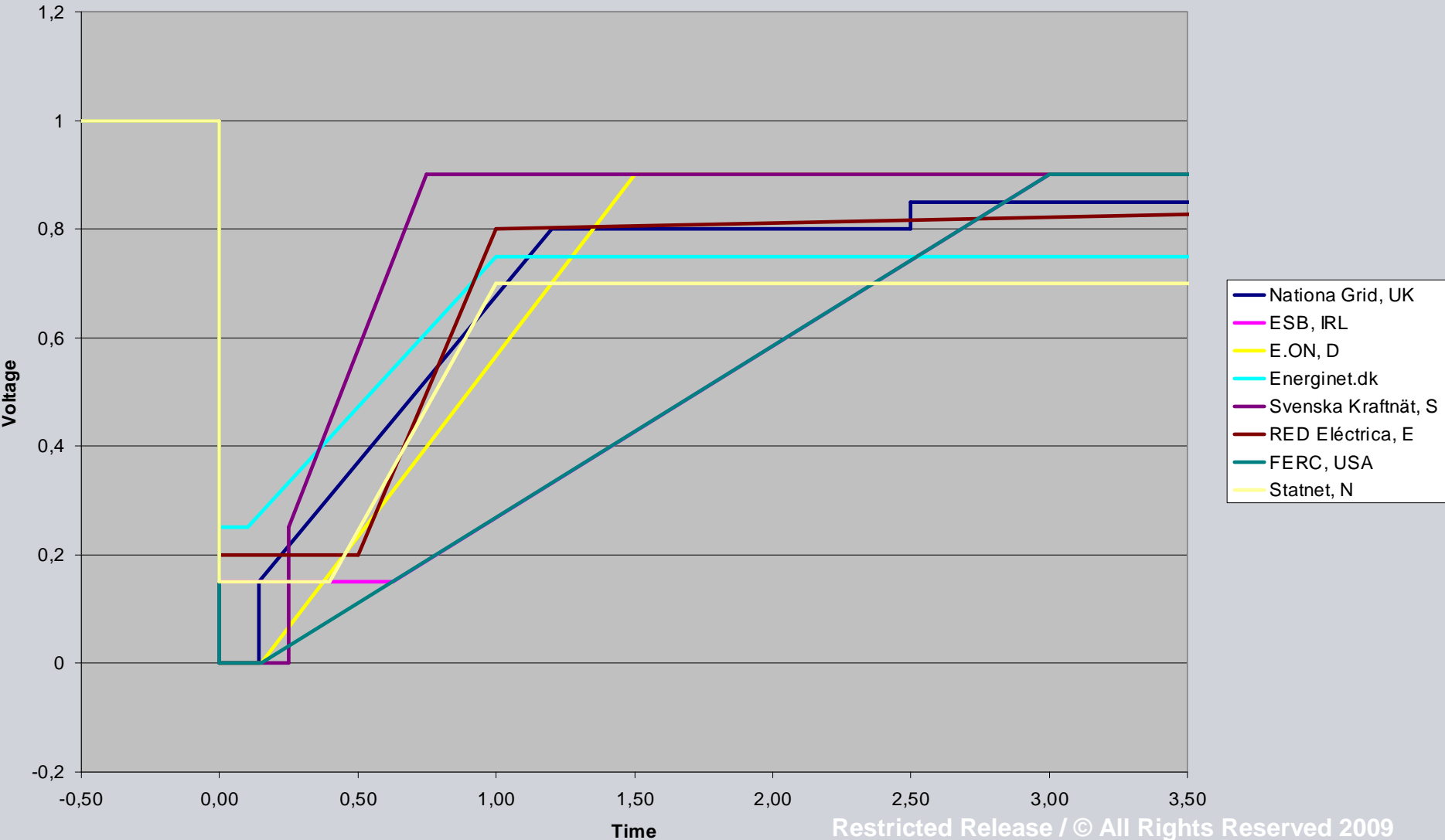
- Low Voltage Ride Through



# 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

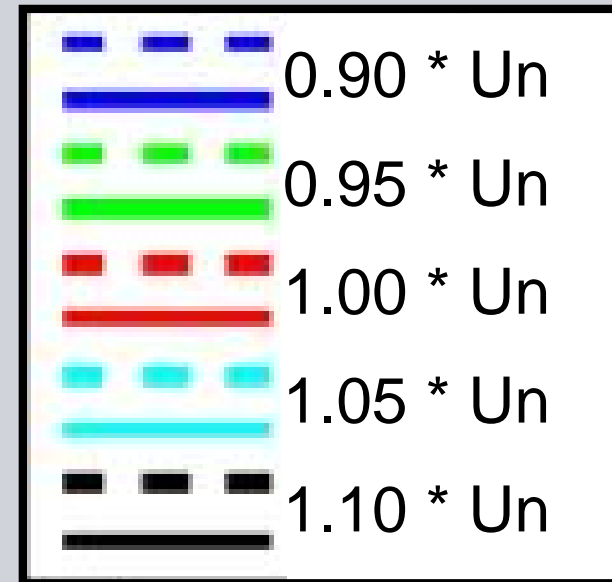
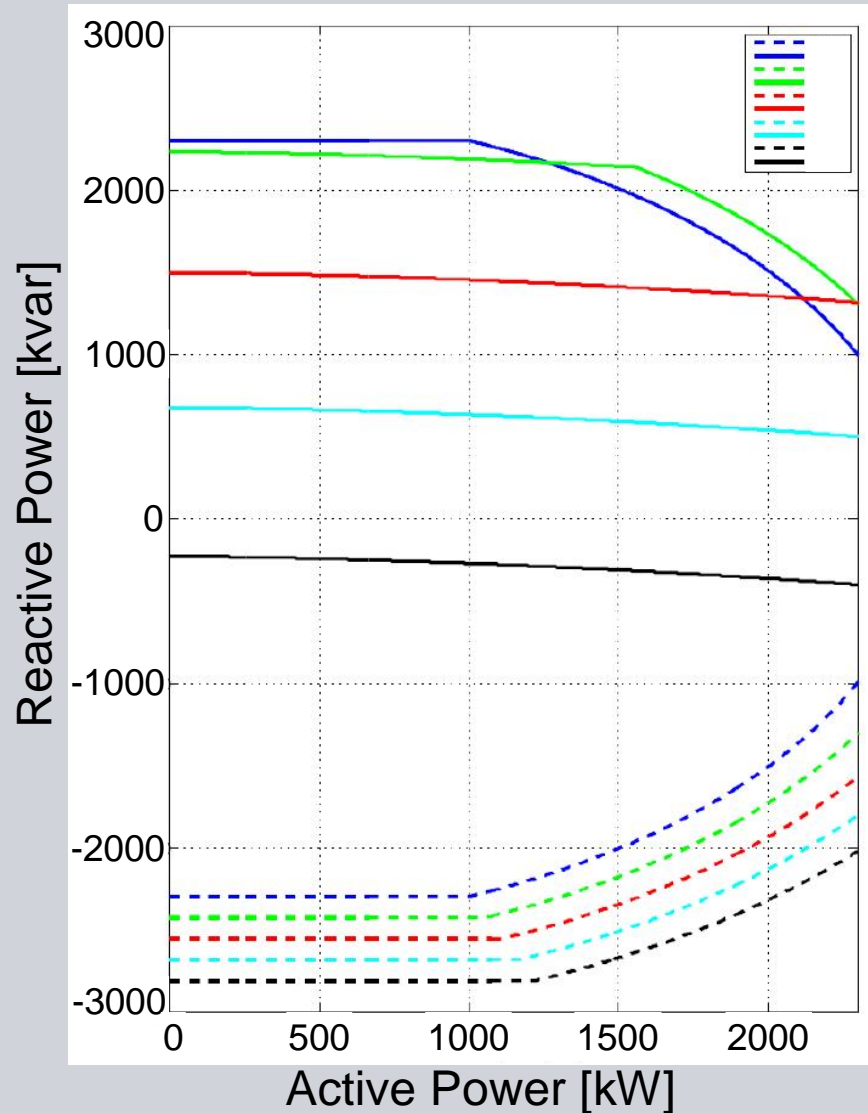
### § Fault Ride Through

- 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

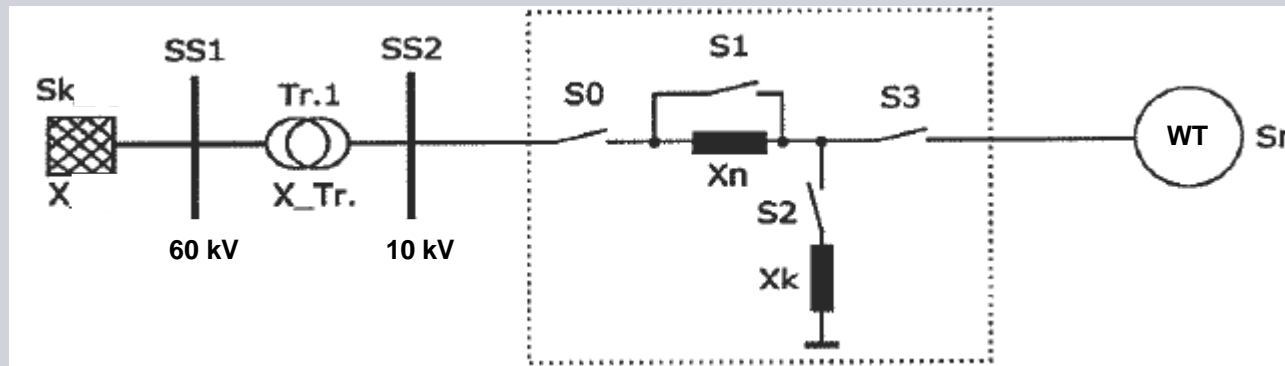
### § Fault Ride Through

- Low Voltage Ride Through

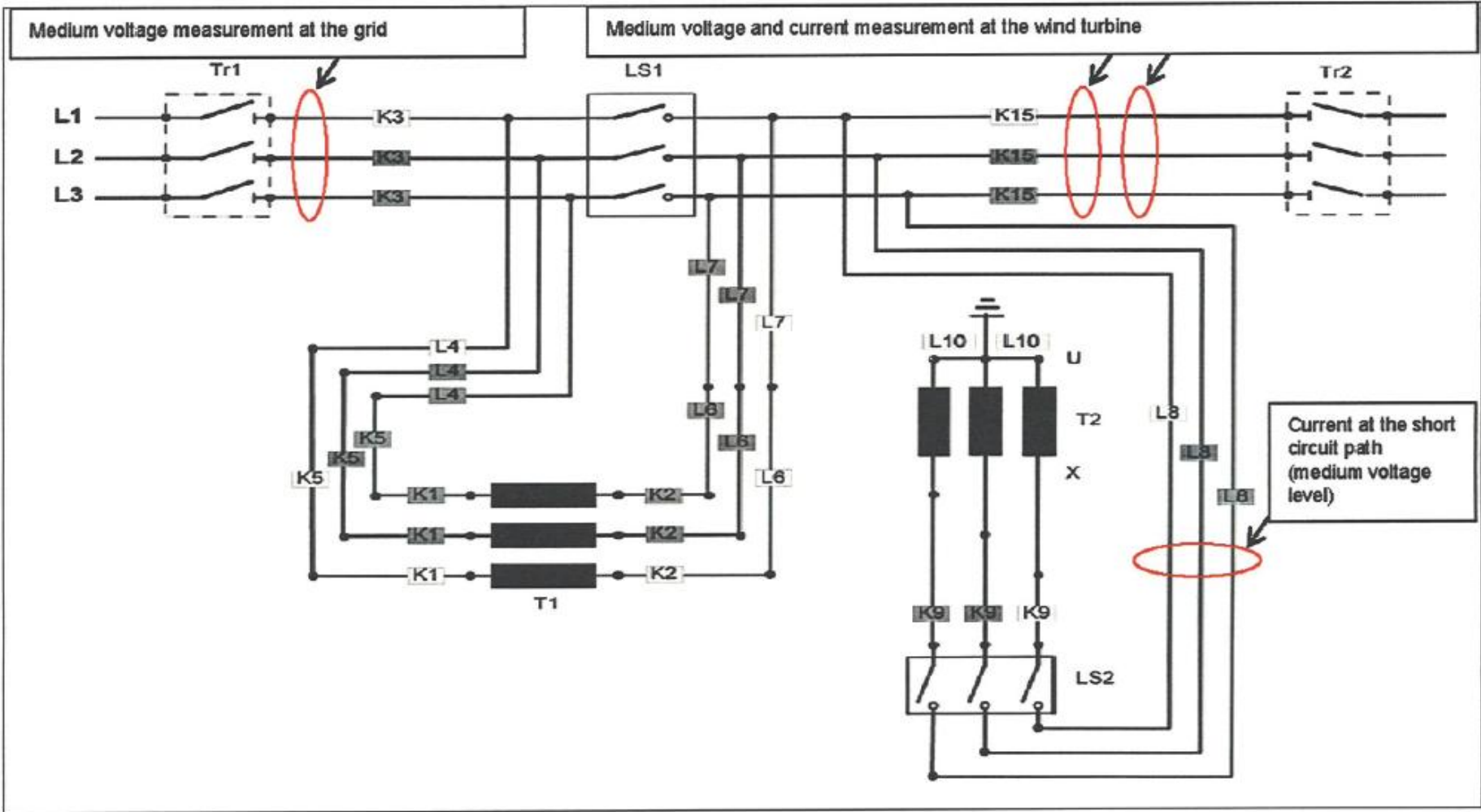
### § Reactive Power Capability

- Normal Operation
- Fault Ride Through

# Fault Ride Through Test Setup



# Fault Ride Through Test Setup



## Fault Ride Through Test Site - Høvsøre



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## Test Specification

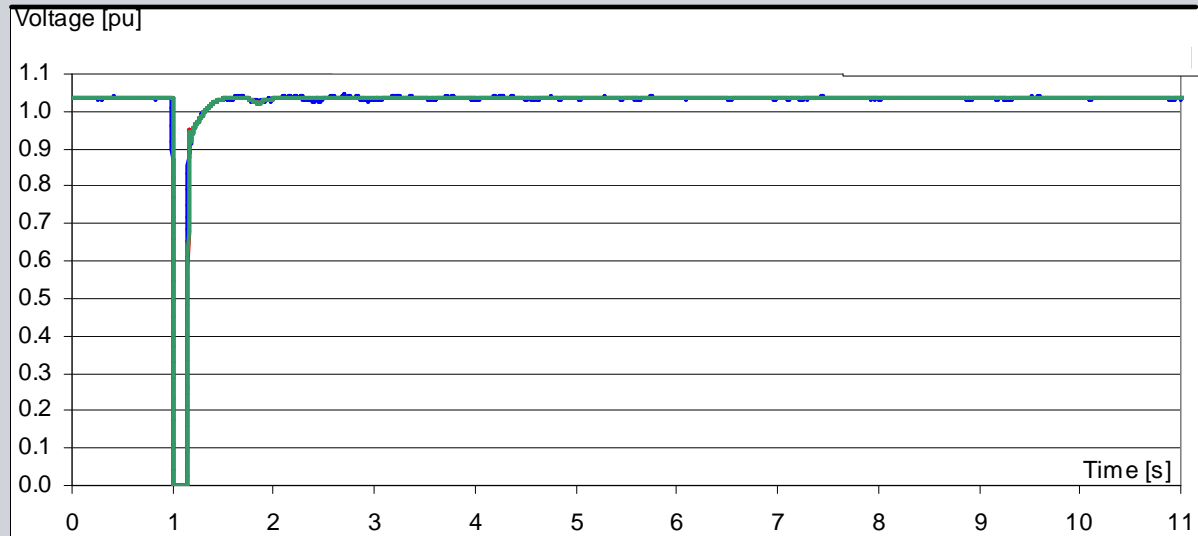
### Validation tests:

§ 0 % Retain Voltage in 140 ms

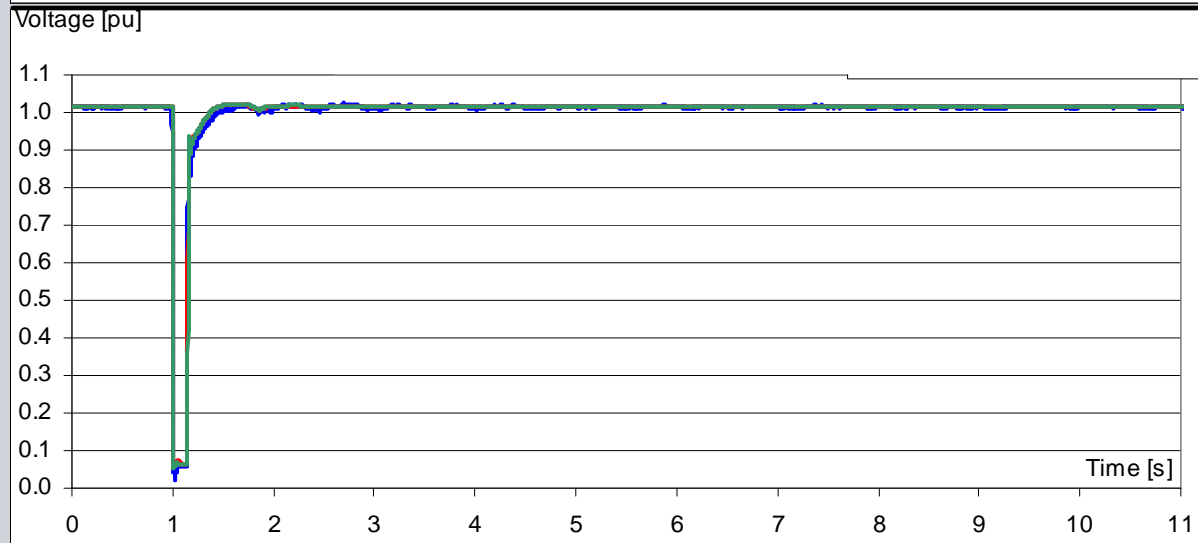
§ 50 % Retain Voltage in 710 ms

**0 % Retain Voltage in 140 ms**

**Transformer  
10 kV Voltage**



**Wind Turbine  
0.69 kV Voltage**

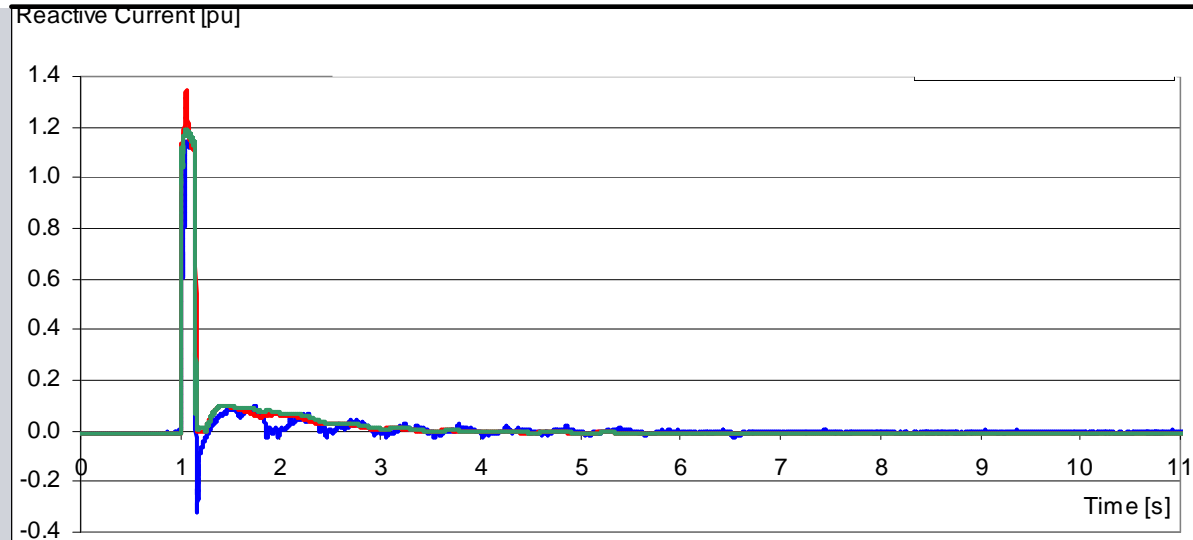


- RMS [pu]
- PSSE [pu]
- DigSILENT [pu]

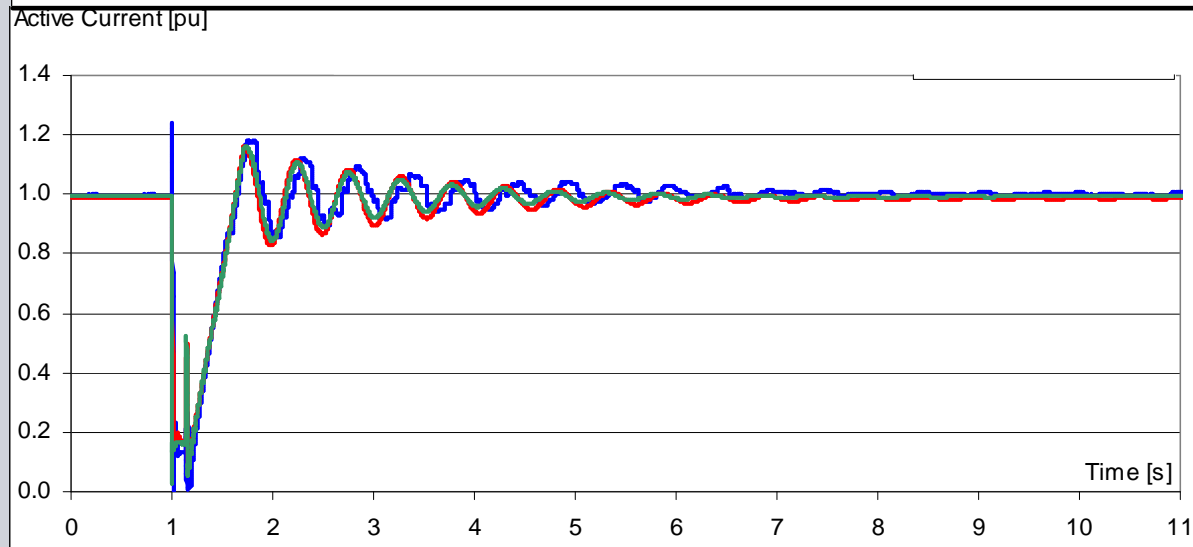
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0 % Retain Voltage in 140 ms

Wind turbine  
Reactive Current



Wind Turbine  
Active Current

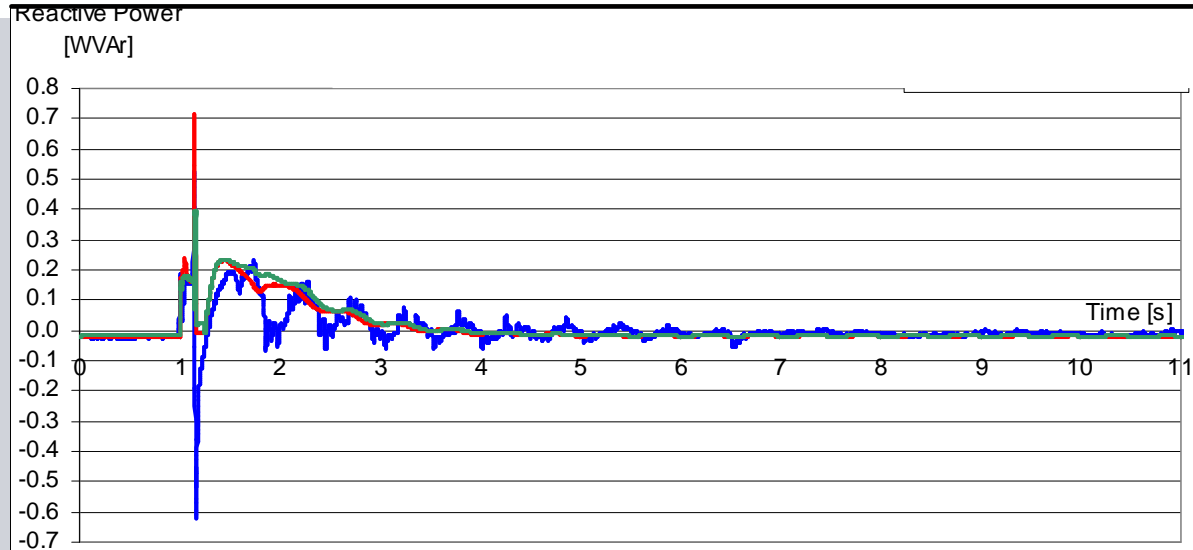


- RMS [pu]
- PSSE [pu]
- DIgSILENT [pu]

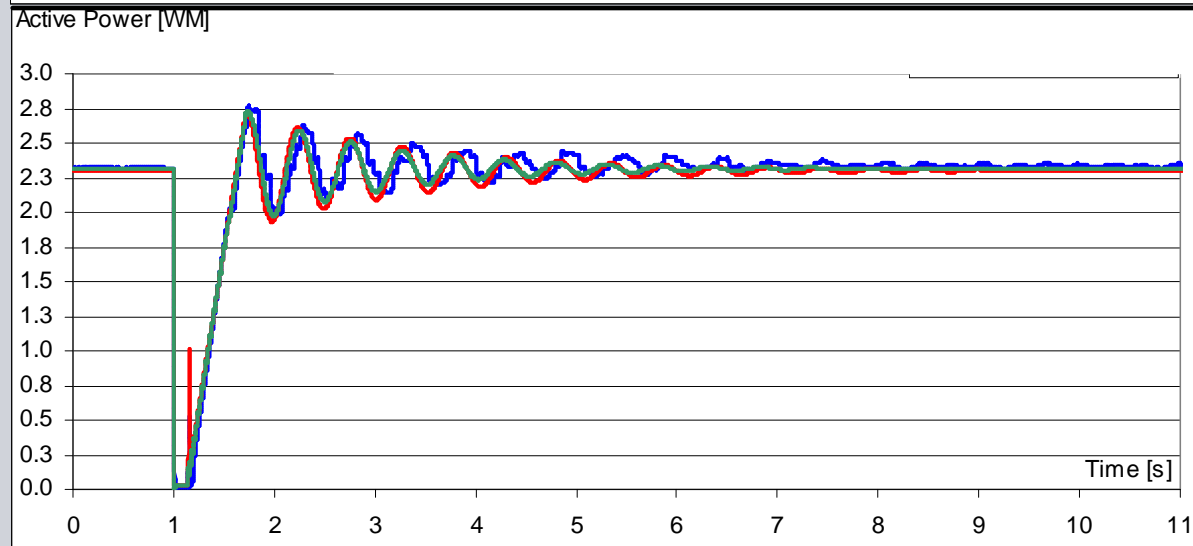
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0 % Retain Voltage in 140 ms

Wind Turbine  
Reactive Power



Wind Turbine  
Active Power

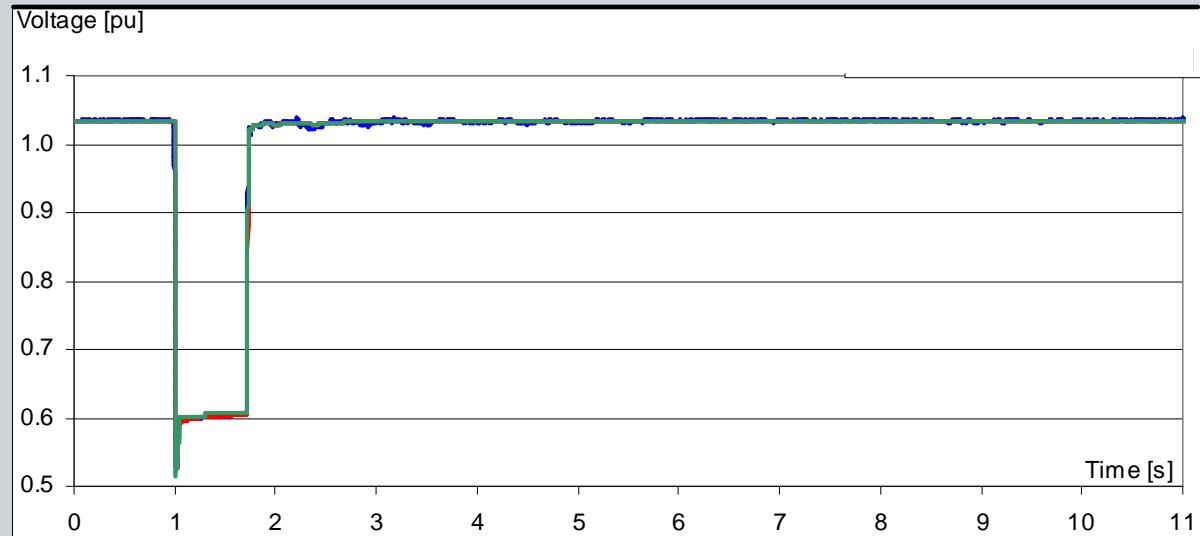


- RMS [pu]
- PSSE [pu]
- DlgSILENT [pu]

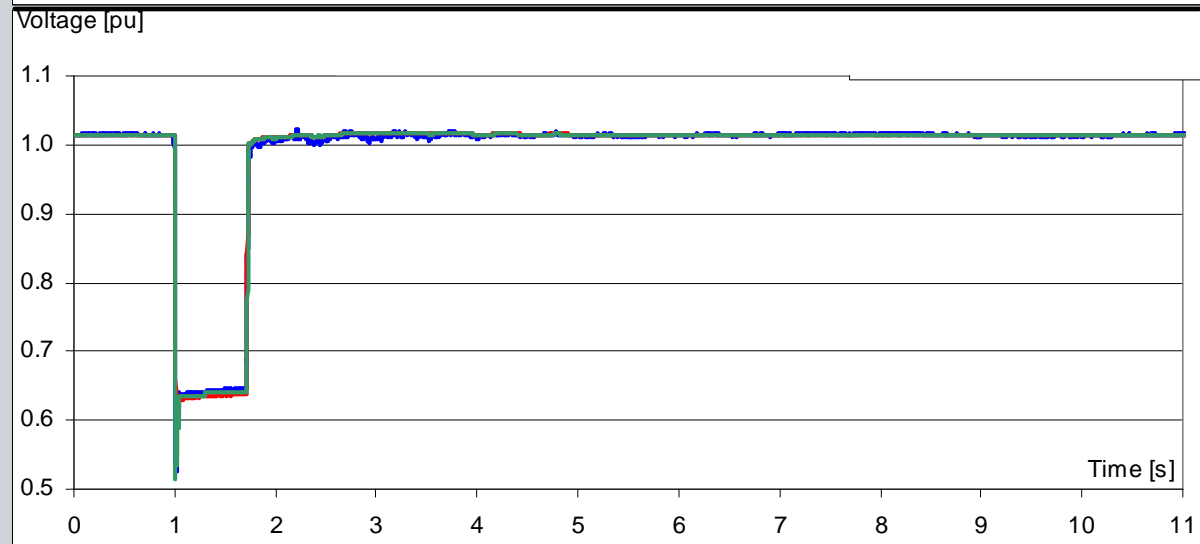
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**50 % Retain Voltage in 710 ms**

**Transformer  
10 kV Voltage**



**Wind Turbine  
0.69 kV Voltage**

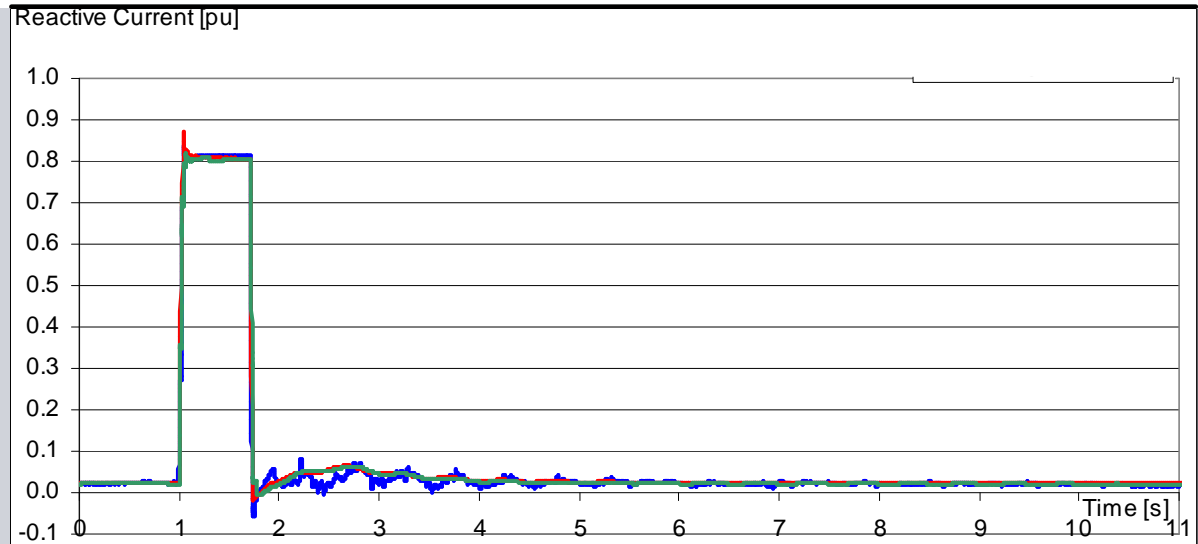


- RMS [pu]
- PSSE [pu]
- DigSILENT [pu]

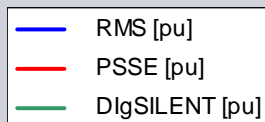
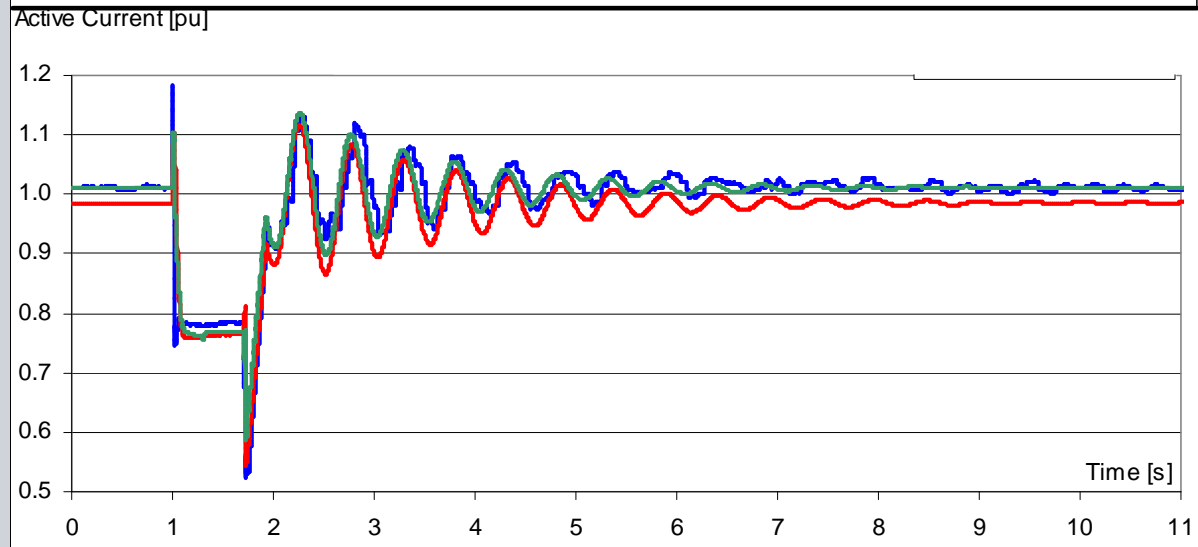
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50 % Retain Voltage in 710 ms

Wind turbine  
Reactive Current



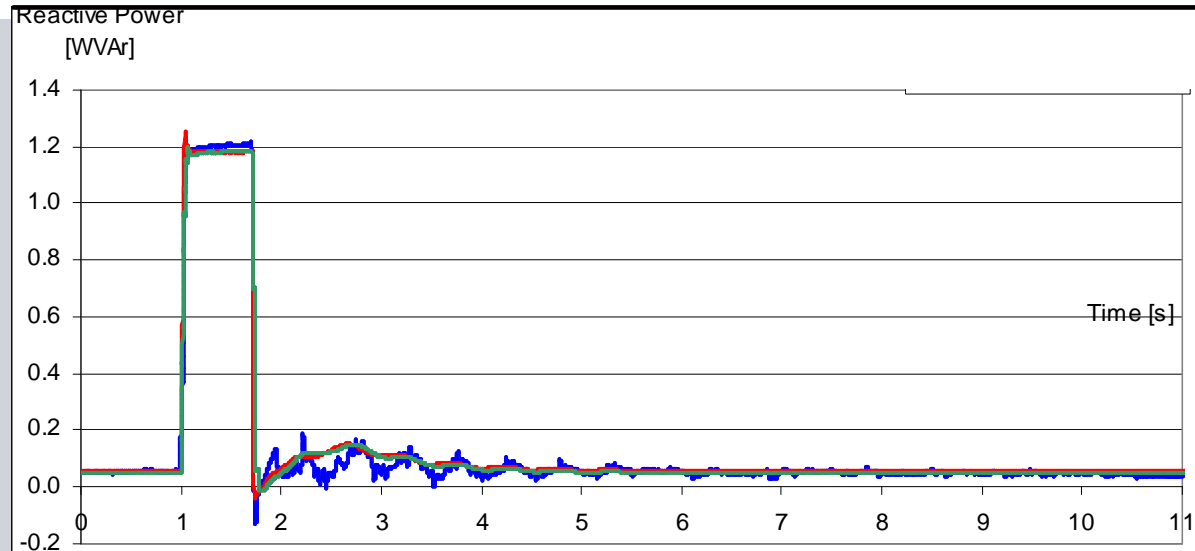
Wind Turbine  
Active Current



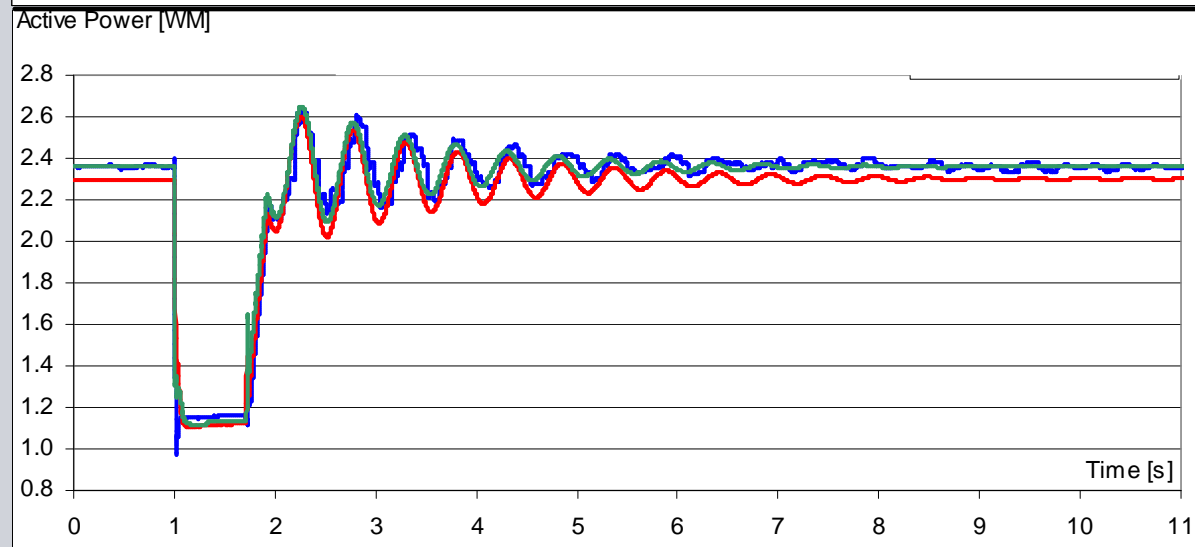
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50 % Retain Voltage in 710 ms

Wind Turbine  
Reactive Power



Wind Turbine  
Active Power



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

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## Agenda

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

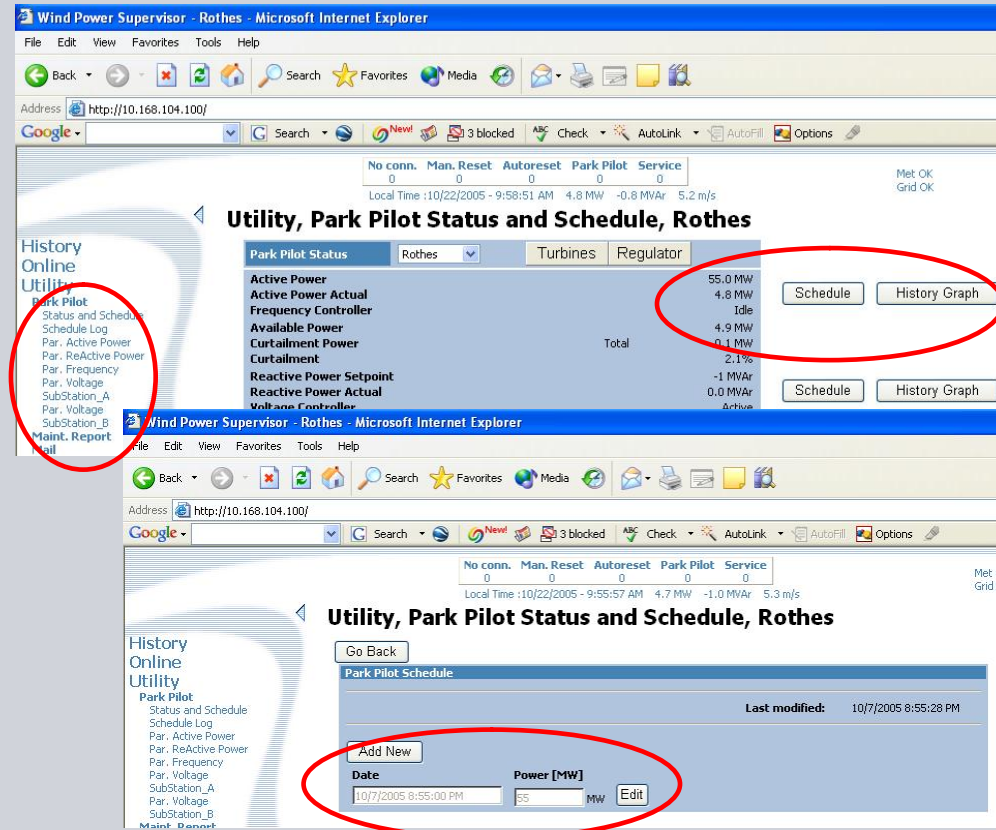


## **HPPP Capabilities**

### § Active Power Control - MW Control

# Active Power Control - MW Control

## User Interface



## HPPP Capabilities

### § Active Power Control

- MW Control
- Frequency Control

# Active Power Control - Frequency Control

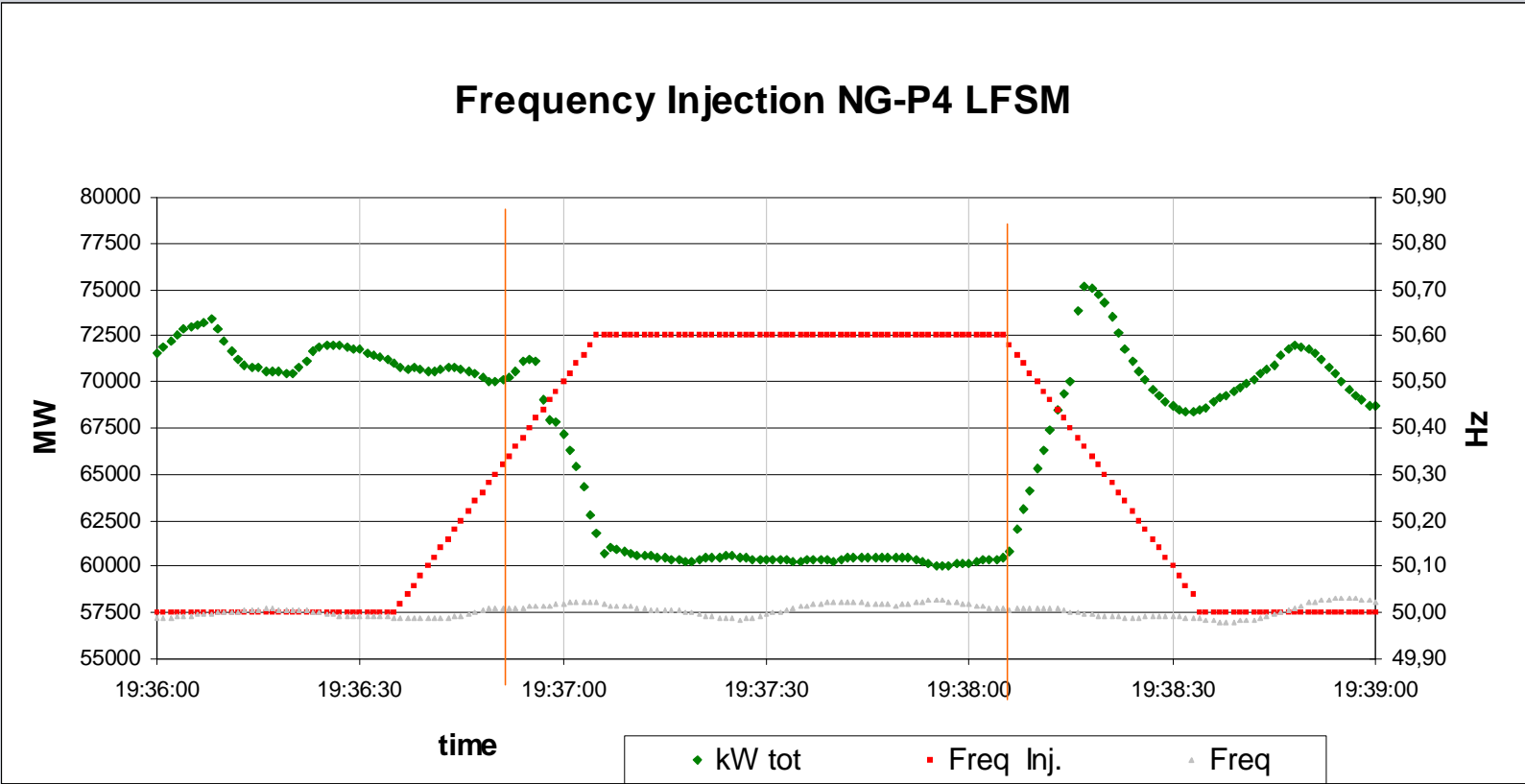
## User Interface

The screenshot displays the 'Park Pilot Parameters' configuration window. It is divided into three sections, each with its own set of parameters and an 'Edit' button:

- Frequency Response**
  - Mode :** Limited Frequency Response [Edit]
- Limited Frequency Response**
  - Upper Frequency :** 50.4 Hz [Edit]
  - Droop :** 1 % [Edit]
- Frequency Sensitive Mode**
  - Target Frequency :** 50 Hz [Edit]
  - Deadband :** 0.03 Hz [Edit]
  - Droop :** 1 % [Edit]

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

# Active Power Control - Frequency Control



## HPPP Capabilities

### § Active Power Control

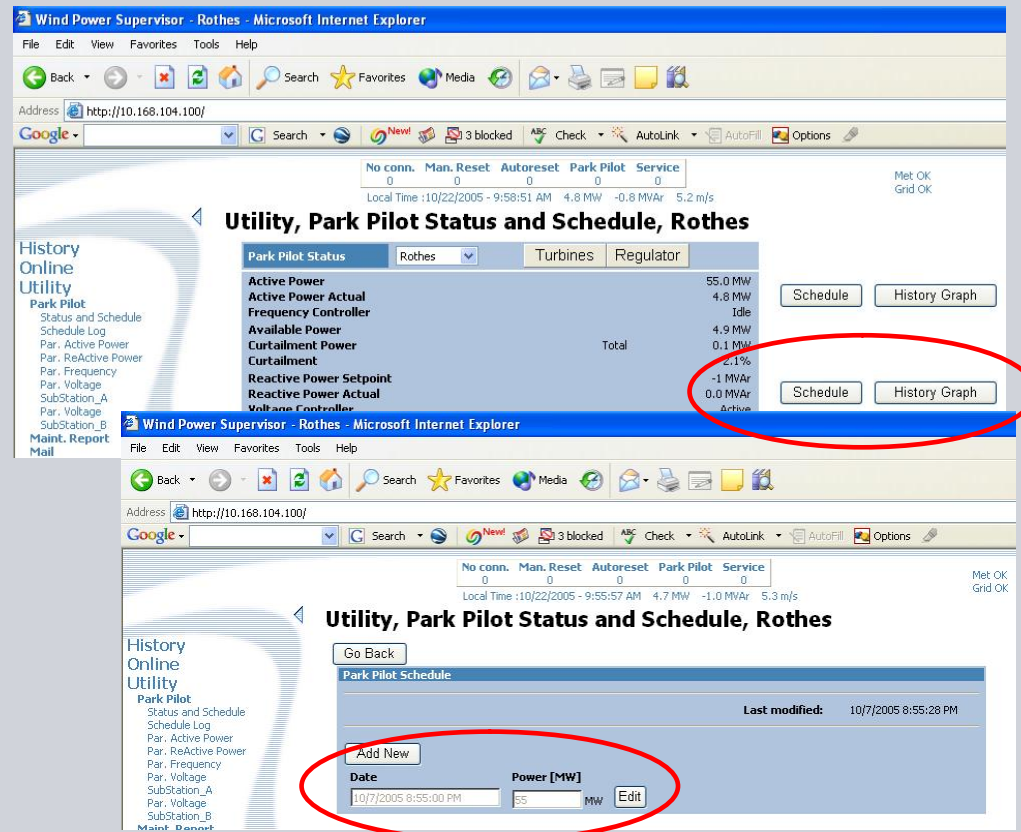
- MW Control
- Frequency Control

### § Reactive Power Control

- Mvar Control

# Reactive Power Control - Mvar Control

## User Interface



## HPPP Capabilities

### § Active Power Control

- MW Control
- Frequency Control

### § Reactive Power Control

- Mvar Control
- Power Factor Control
- Voltage Control



# Reactive Power Control - Voltage Control

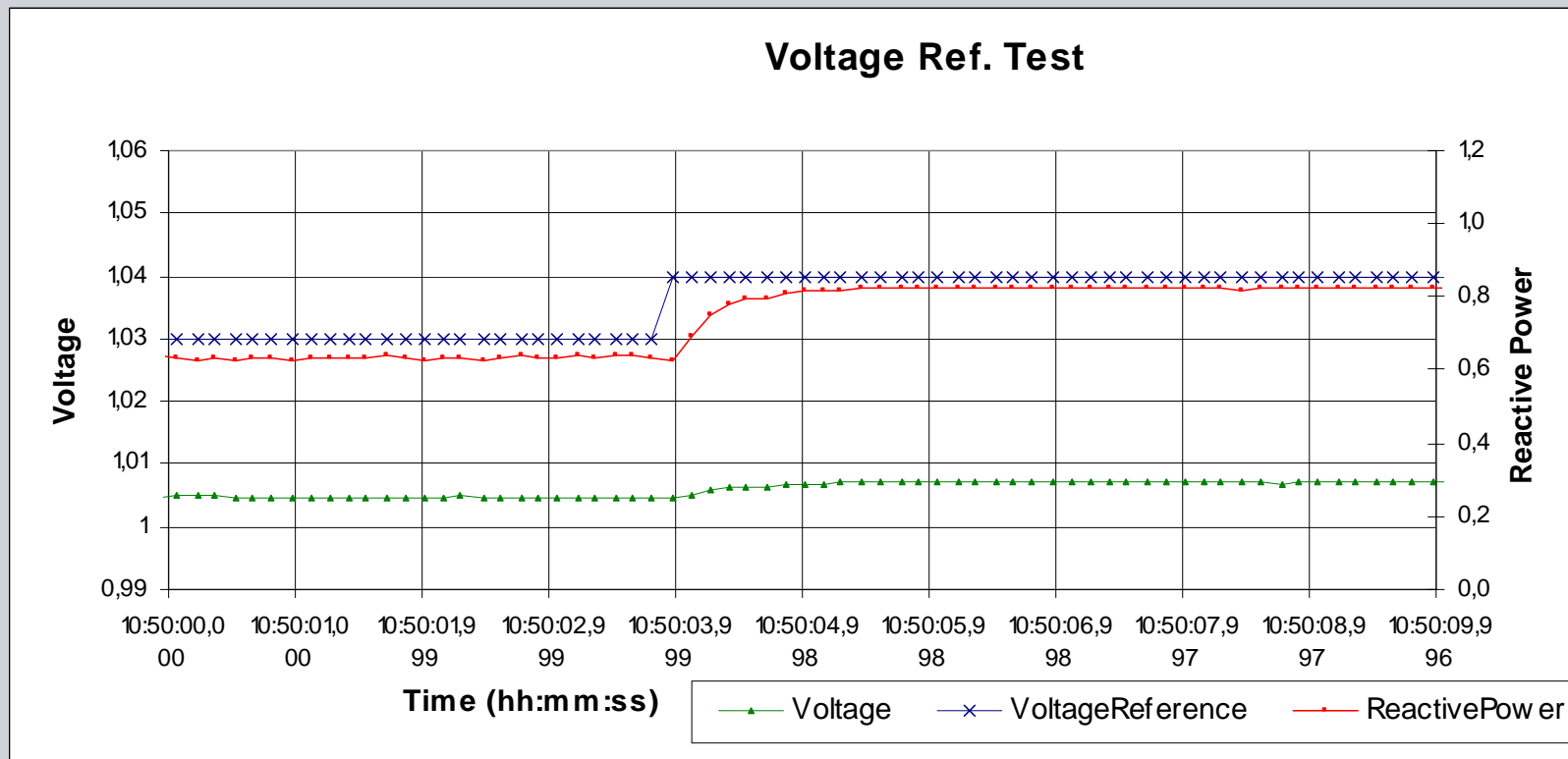
## User Interface

**Park Pilot Parameters**

**Voltage Control**

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

# Reactive Power Control - Voltage Control



## Conclusion



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**SIEMENS**

**Thank you for your attention**

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