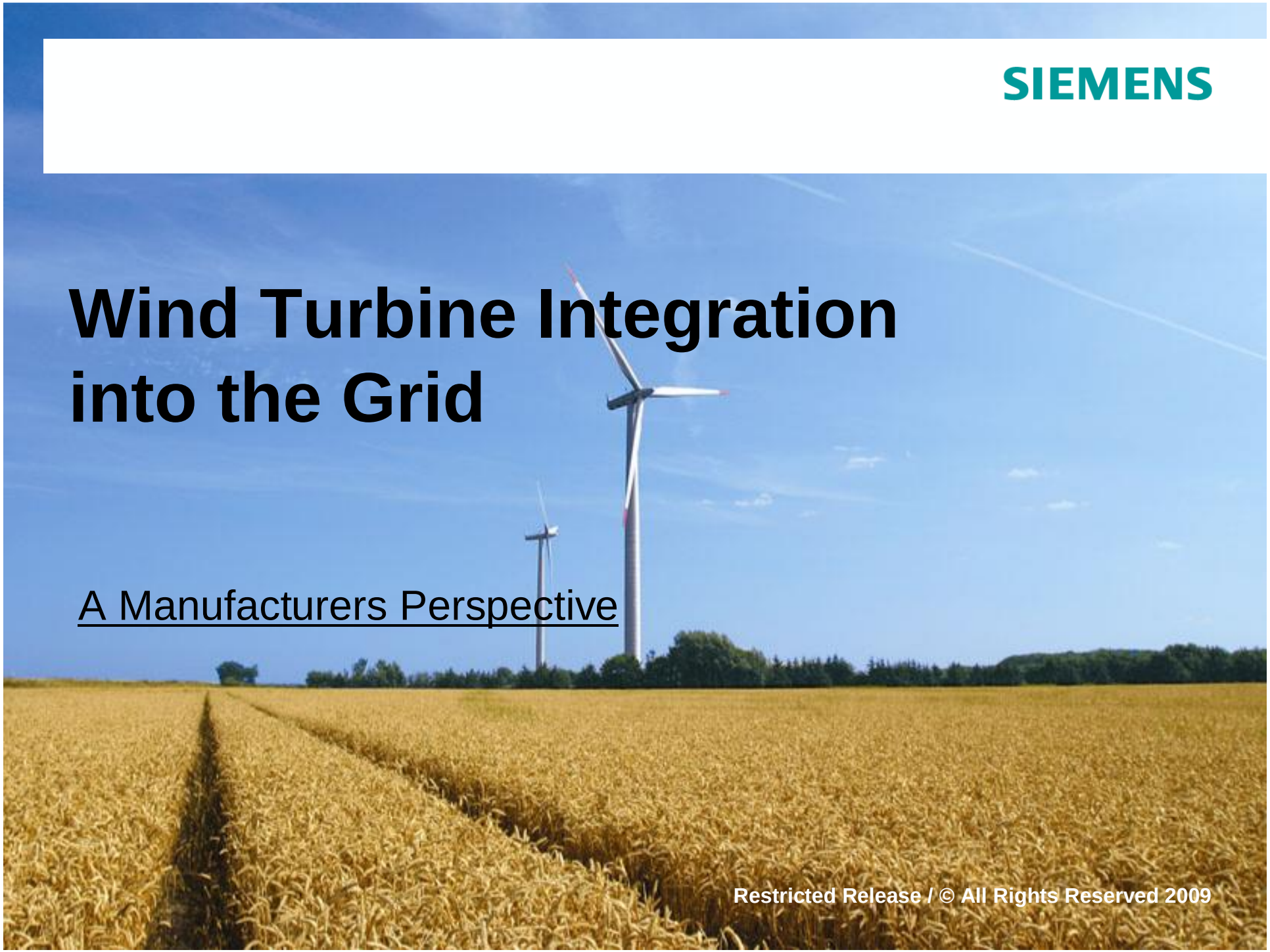


SIEMENS

Wind Turbine Integration into the Grid

A Manufacturers Perspective

Restricted Release / © All Rights Reserved 2009

SIEMENS

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

Restricted Release / © All Rights Reserved 2009

SIEMENS

Agenda

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

Restricted Release / © All Rights Reserved 2009

Agenda

- **Wind Integration**
- Manufacturers Perspective
- Wind Turbine Capabilities
- Wind Farm Capabilities

/ © All Rights Reserved 2009

SIEMENS

Agenda

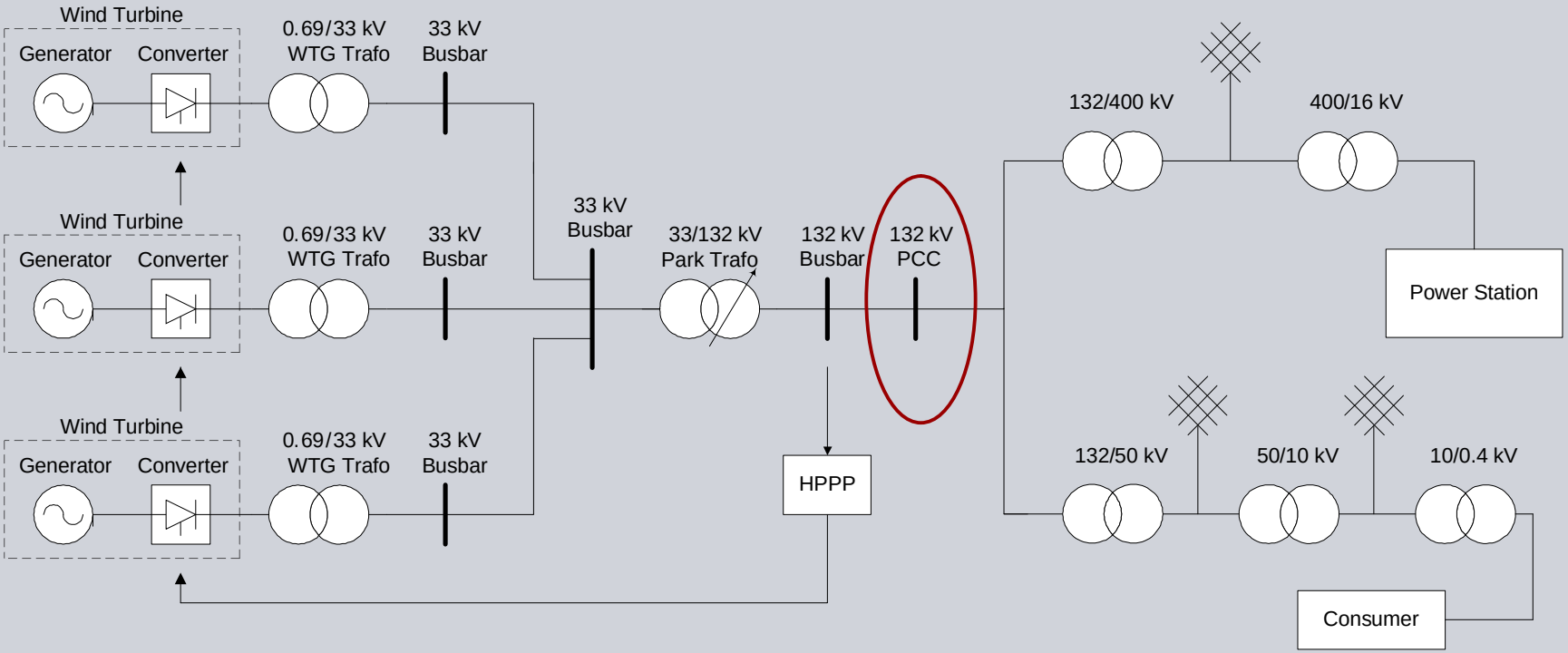
- Wind Integration
- **Manufacturers Perspective**
- Siemens Wind Turbine Capabilities
- HPPP Capabilities

Restricted Release / © All Rights Reserved 2009

SIEMENS

Manufacturers Perspective

Grid Code requirements are related to the PCC



Restricted Release / © All Rights Reserved 2009

SIEMENS

Agenda

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

Restricted Release / © All Rights Reserved 2009

SIEMENS

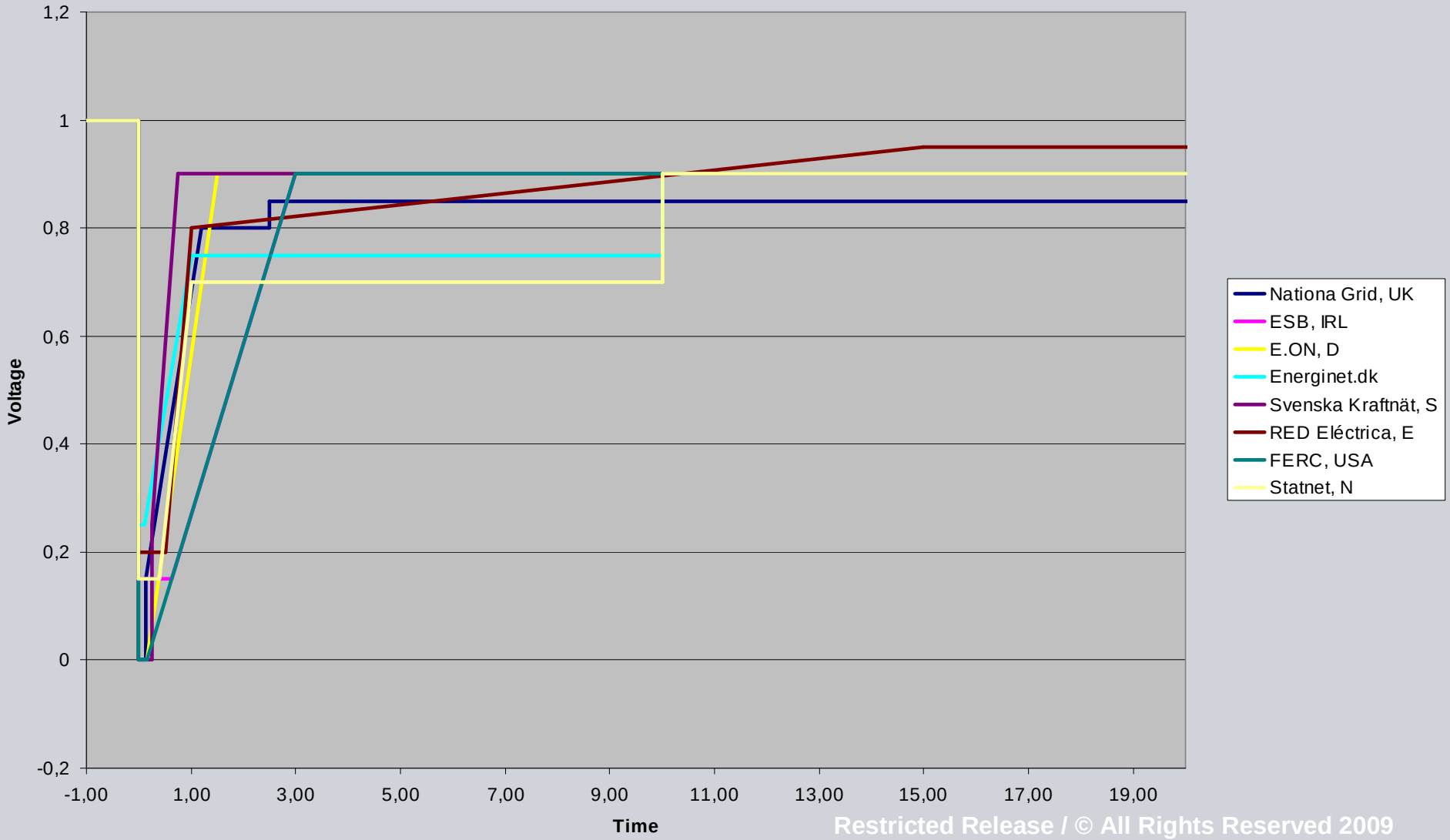
Wind Turbine Capabilities

- 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

Restricted Release / © All Rights Reserved 2009

SIEMENS

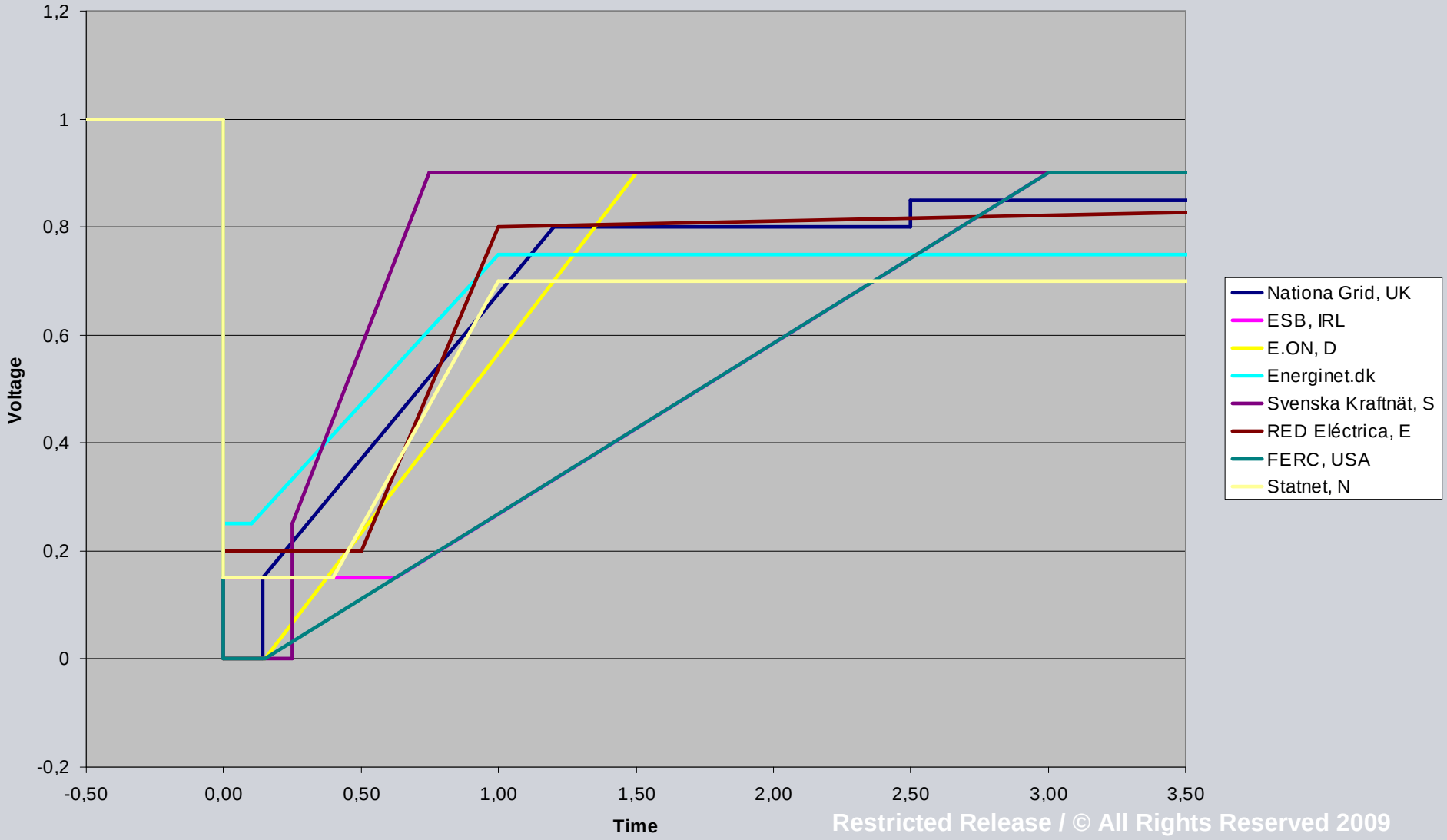
Low Voltage Ride Through Requirements



Restricted Release / © All Rights Reserved 2009

SIEMENS

Low Voltage Ride Through Requirements



Restricted Release / © All Rights Reserved 2009

SIEMENS

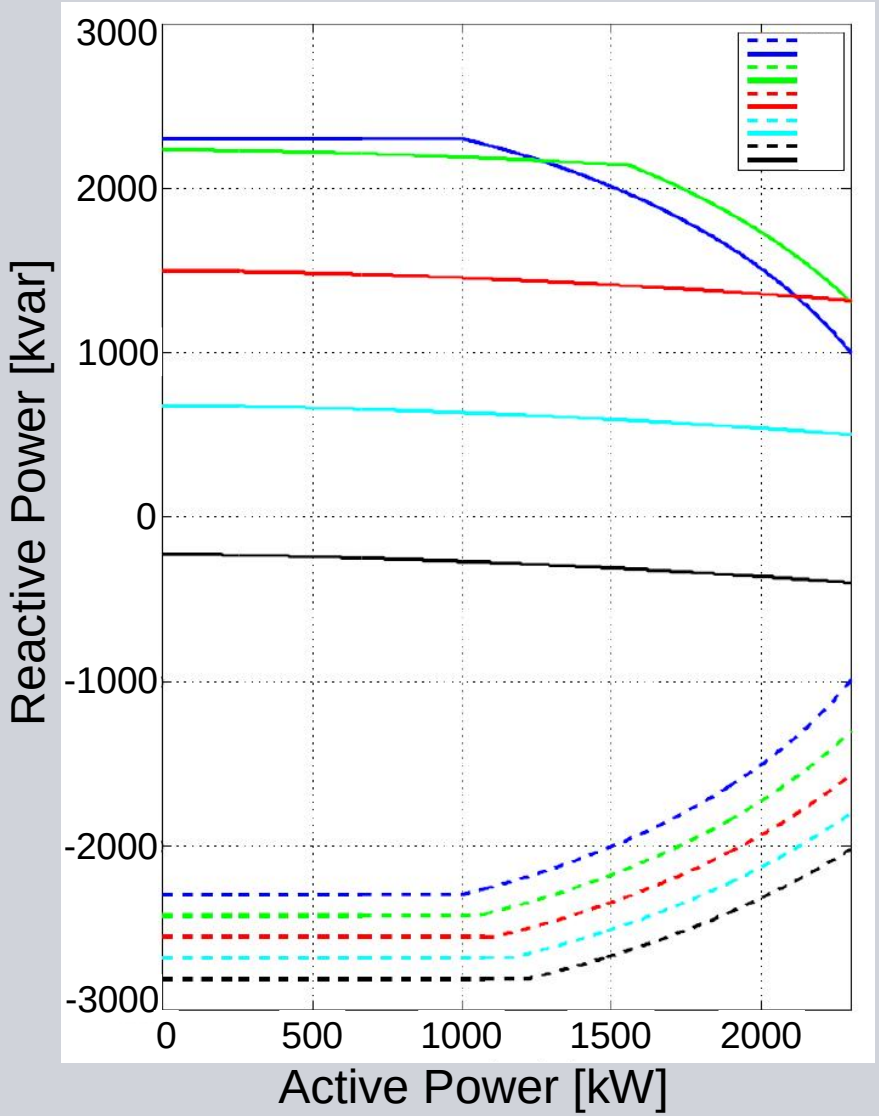
Wind Turbine Capabilities

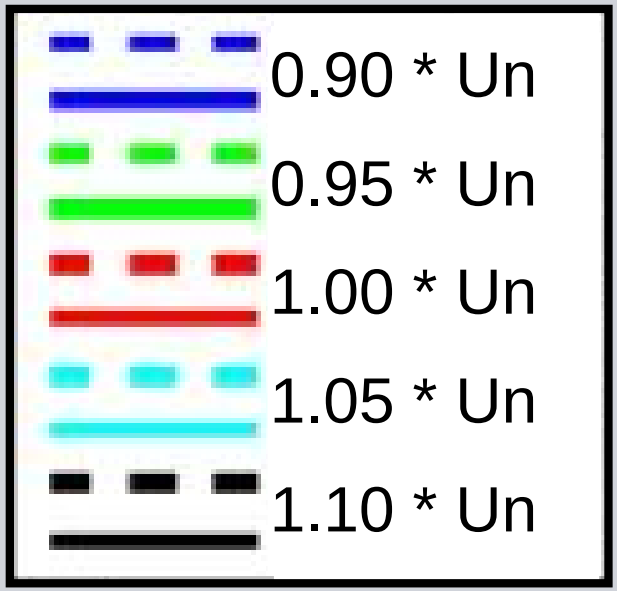
- Operation Range
  - Voltage: 90 % – 110 % of nominal voltage (up to 120 % for 1 s)
  - Frequency: 47 Hz – 52 Hz
- Fault Ride Through
  - Low Voltage Ride Through
- Reactive Power Capability
  - Normal Operation

Restricted Release / © All Rights Reserved 2009

SIEMENS

Reactive Power Capability





Reactive Power Limits Curves example

Restricted Release / © All Rights Reserved 2009

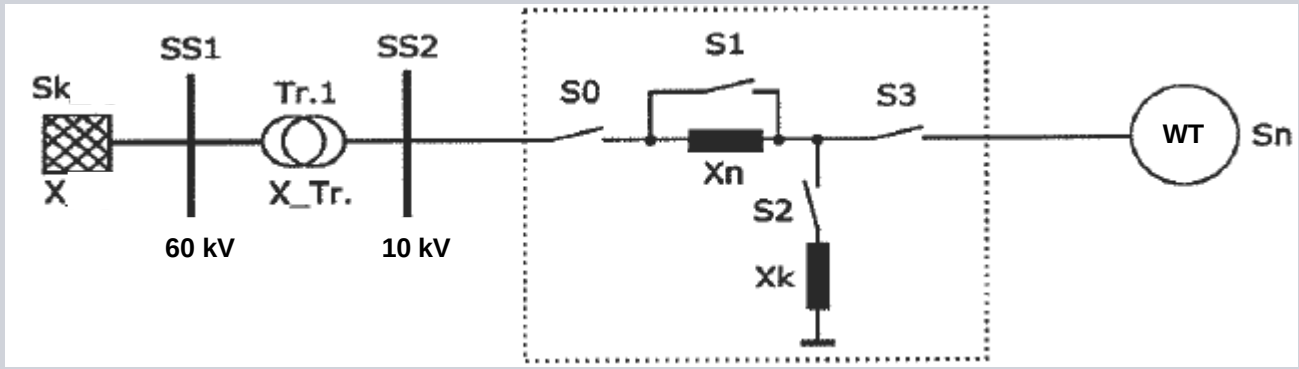
SIEMENS

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

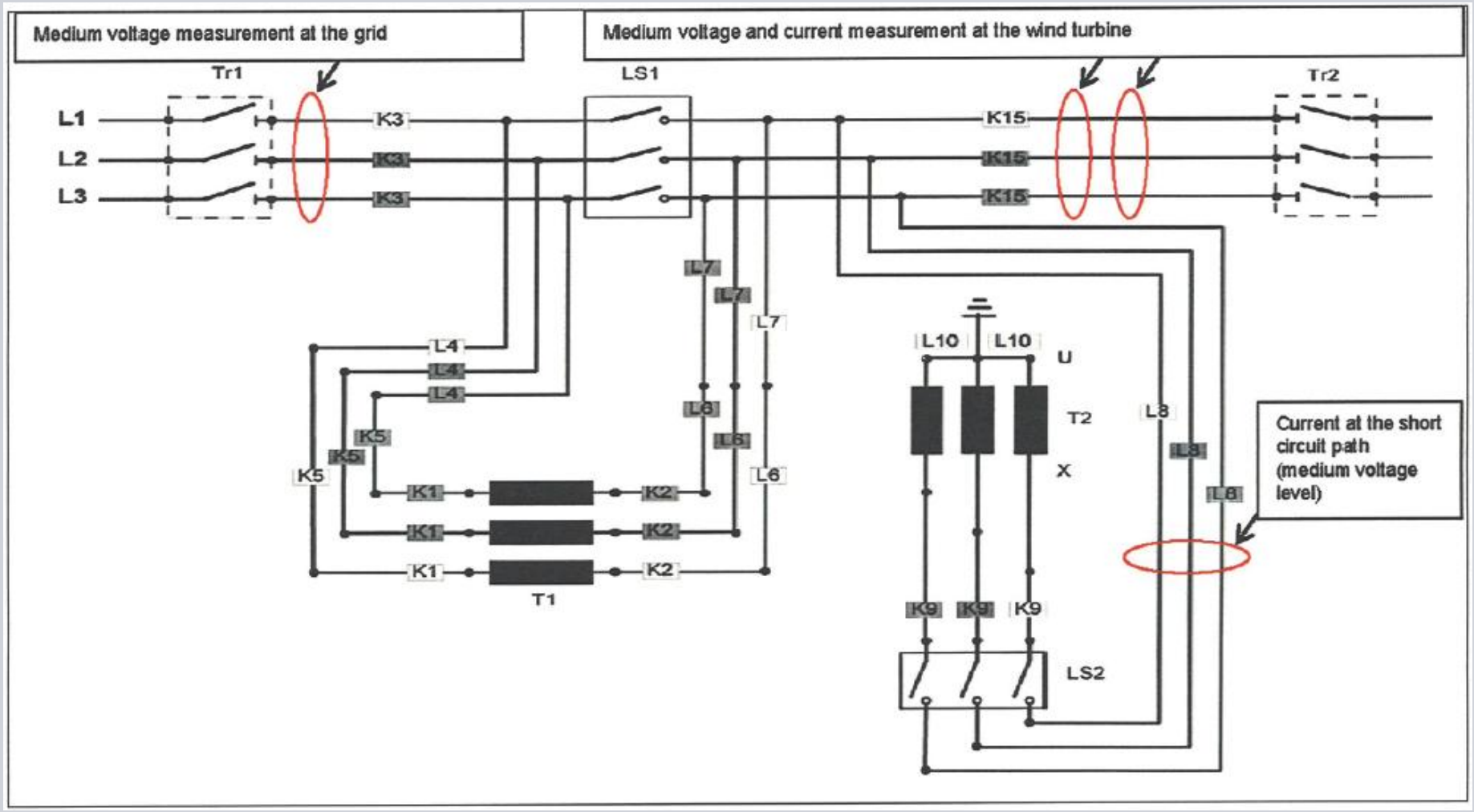
Restricted Release / © All Rights Reserved 2009

Fault Ride Through Test Setup



Restricted Release / © All Rights Reserved 2009

Fault Ride Through Test Setup



Restricted Release / © All Rights Reserved 2009

Fault Ride Through Test Site - Høvsøre

Restricted Release / © All Rights Reserved 2009

Validation tests:

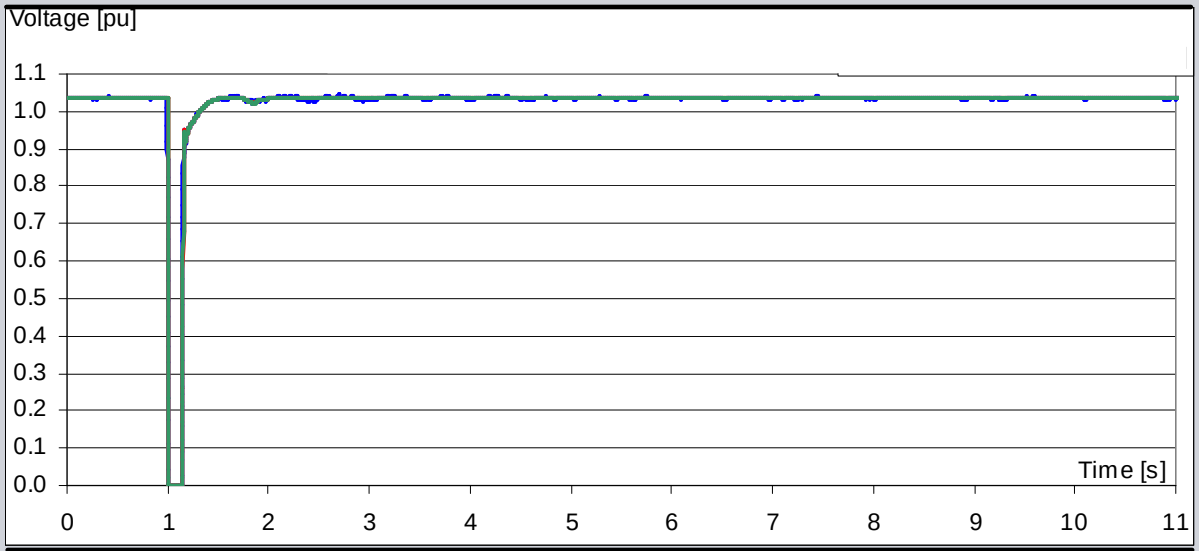
§ 0 % Retain Voltage in 140 ms

§ 50 % Retain Voltage in 710 ms

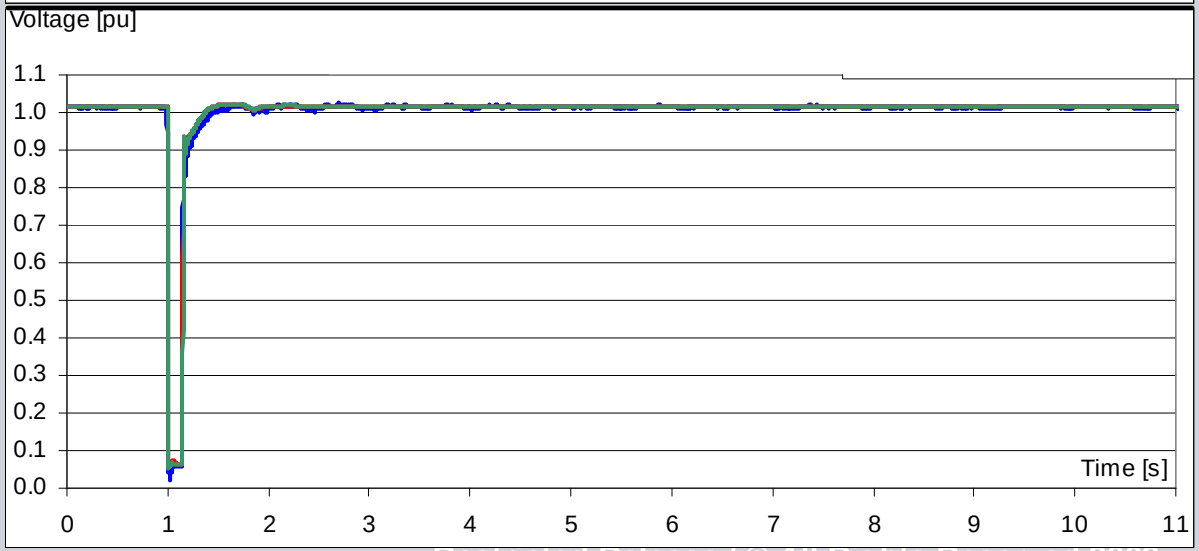
Restricted Release / © All Rights Reserved 2009

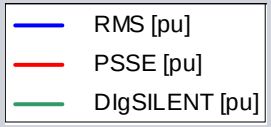
0 % Retain Voltage in 140 ms

Transformer
10 kV Voltage



Wind Turbine
0.69 kV Voltage

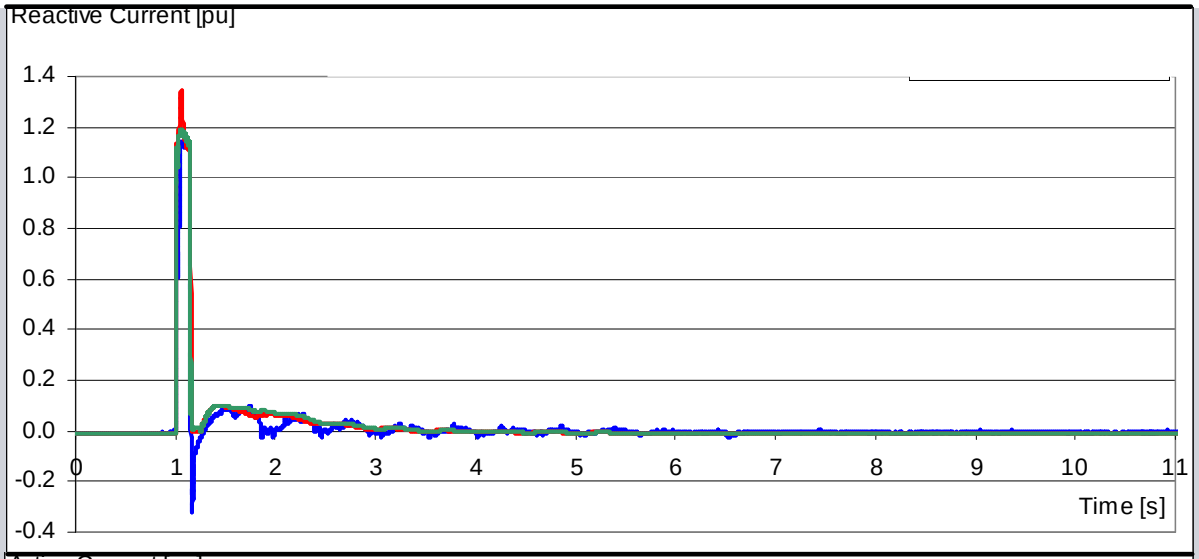




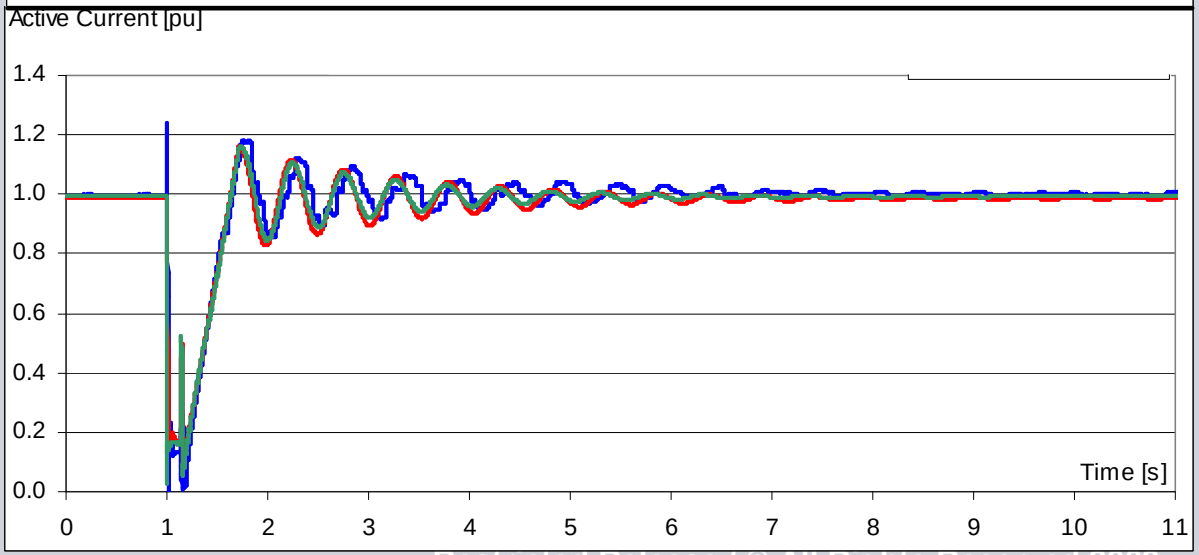
Restricted Release / © All Rights Reserved 2009

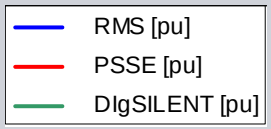
0 % Retain Voltage in 140 ms

Wind turbine Reactive Current



Wind Turbine Active Current

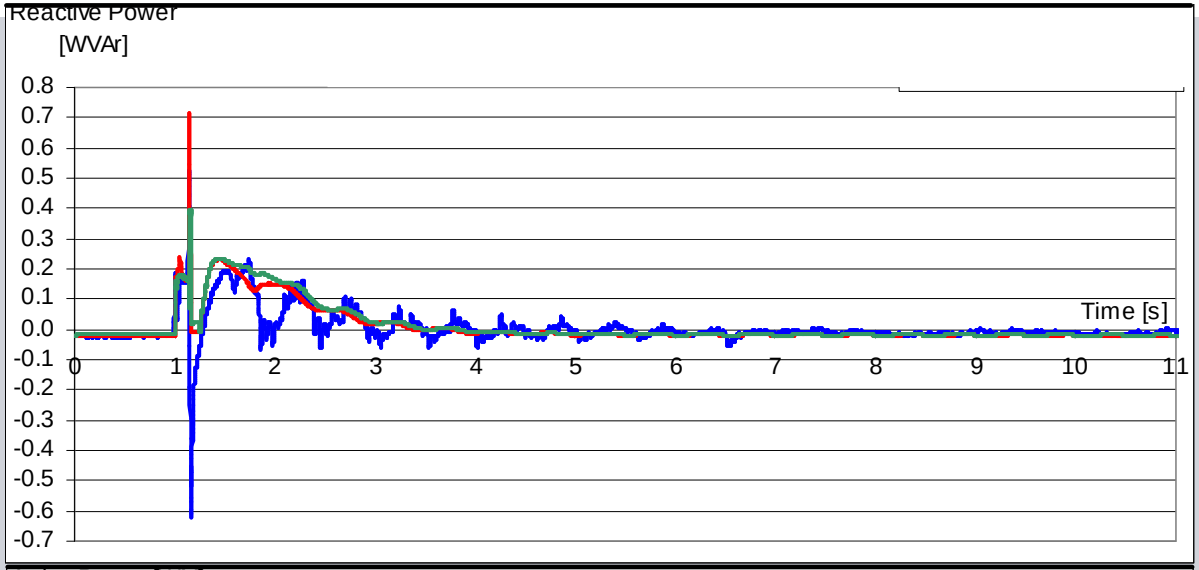




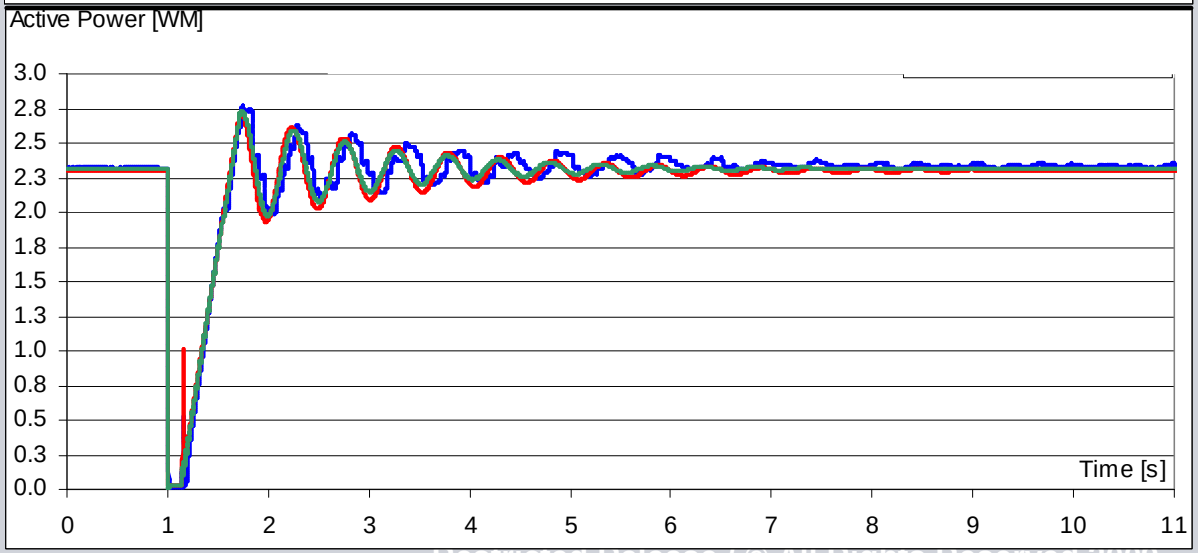
Restricted Release / © All Rights Reserved 2009

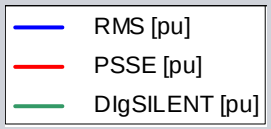
0 % Retain Voltage in 140 ms

Wind Turbine Reactive Power



Wind Turbine Active Power

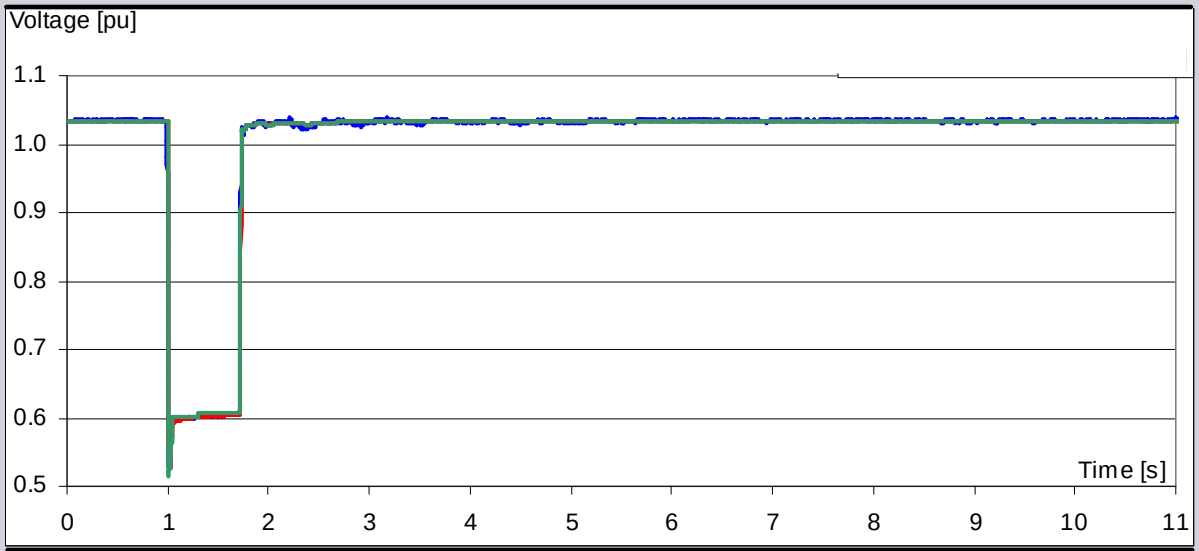




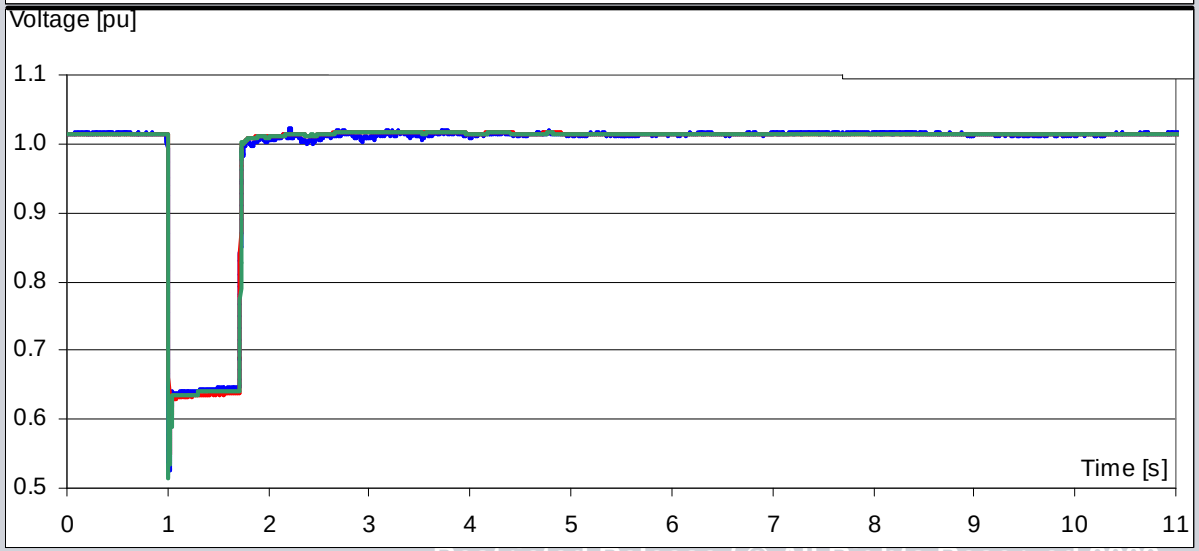
Restricted Release / © All Rights Reserved 2009

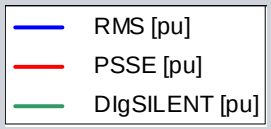
50 % Retain Voltage in 710 ms

Transformer
10 kV Voltage



Wind Turbine
0.69 kV Voltage





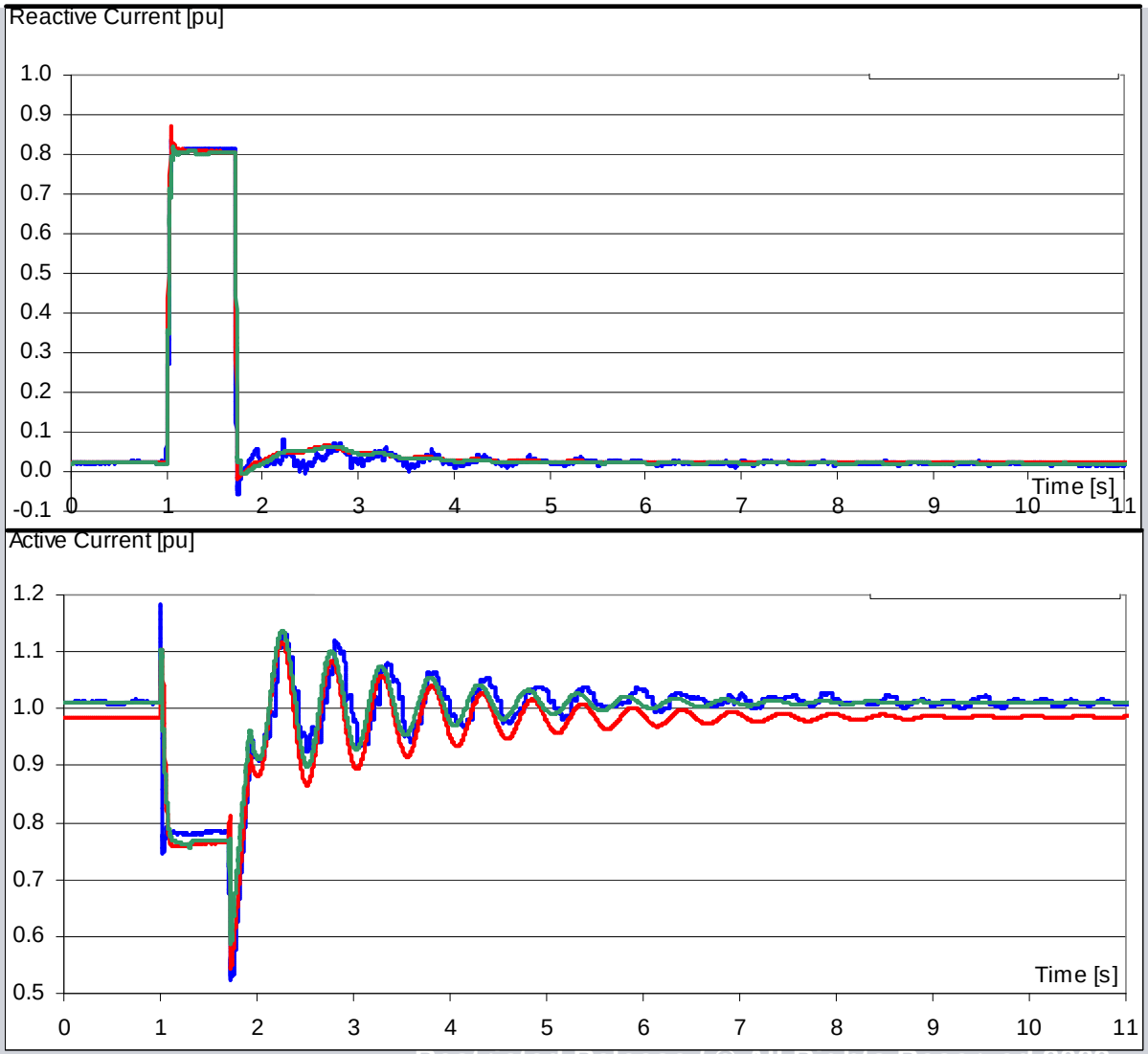
Restricted Release / © All Rights Reserved 2009

SIEMENS

50 % Retain Voltage in 710 ms

Wind turbine Reactive Current

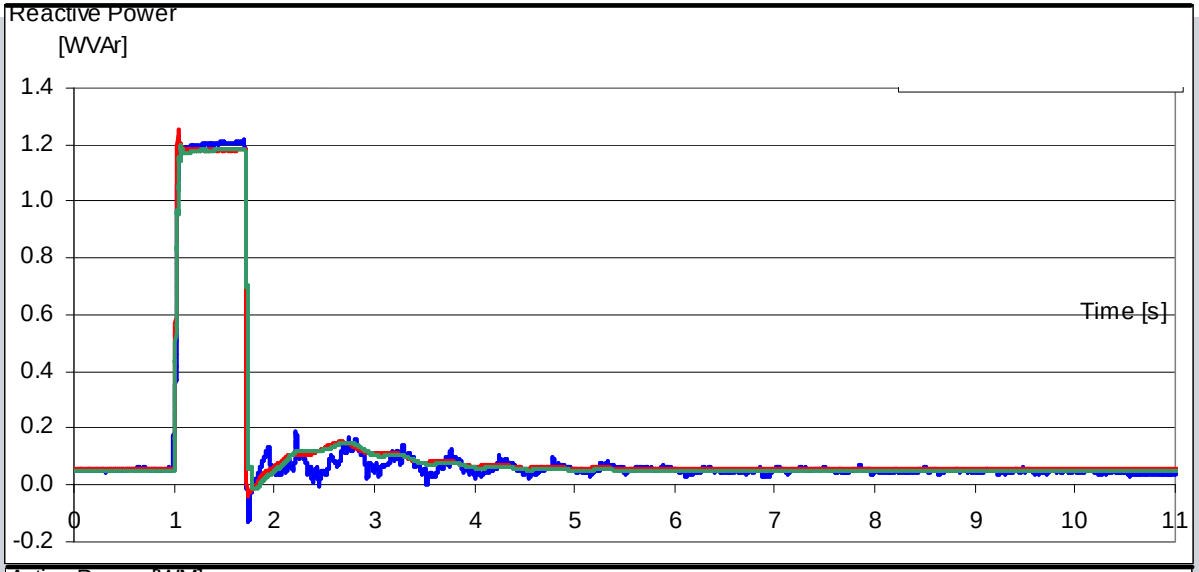
Wind Turbine Active Current



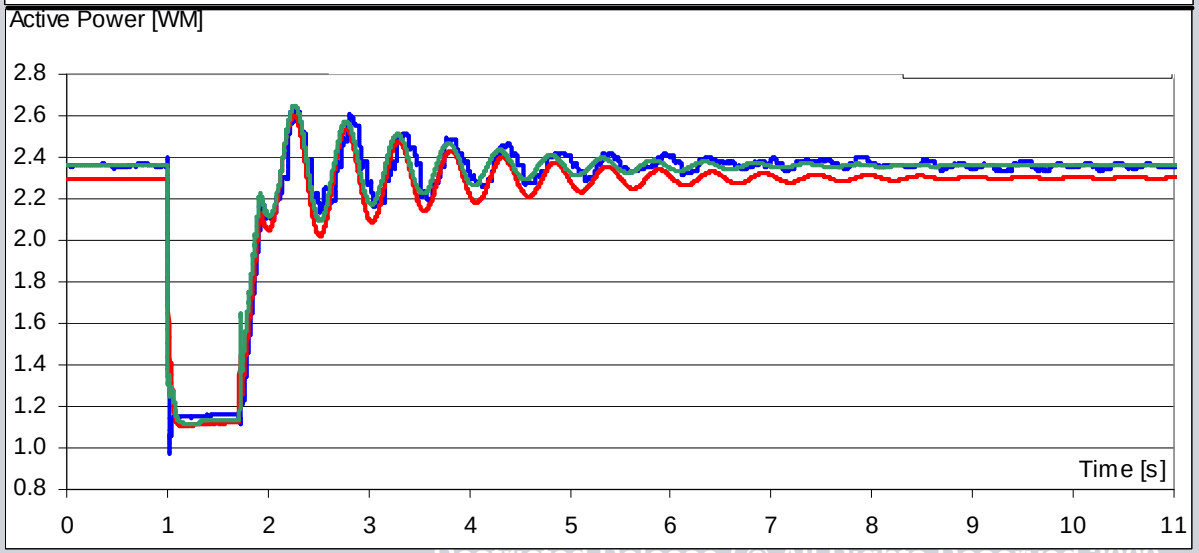
Restricted Release / © All Rights Reserved 2009

50 % Retain Voltage in 710 ms

Wind Turbine Reactive Power



Wind Turbine Active Power



Restricted Release / © All Rights Reserved 2009

SIEMENS

Agenda

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

Restricted Release / © All Rights Reserved 2009

SIEMENS

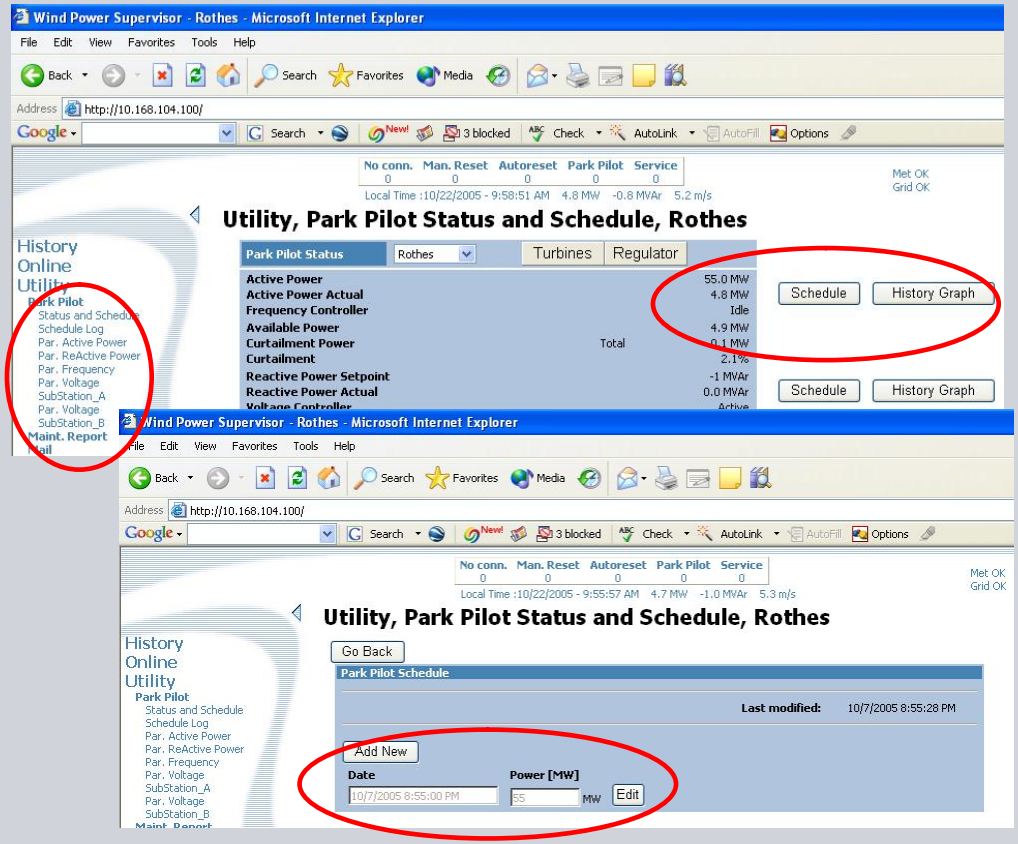
HPPP Capabilities

- Active Power Control
  - MW Control

Restricted Release / © All Rights Reserved 2009

Active Power Control - MW Control

User Interface



Restricted Release / © All Rights Reserved 2009

SIEMENS

HPPP Capabilities

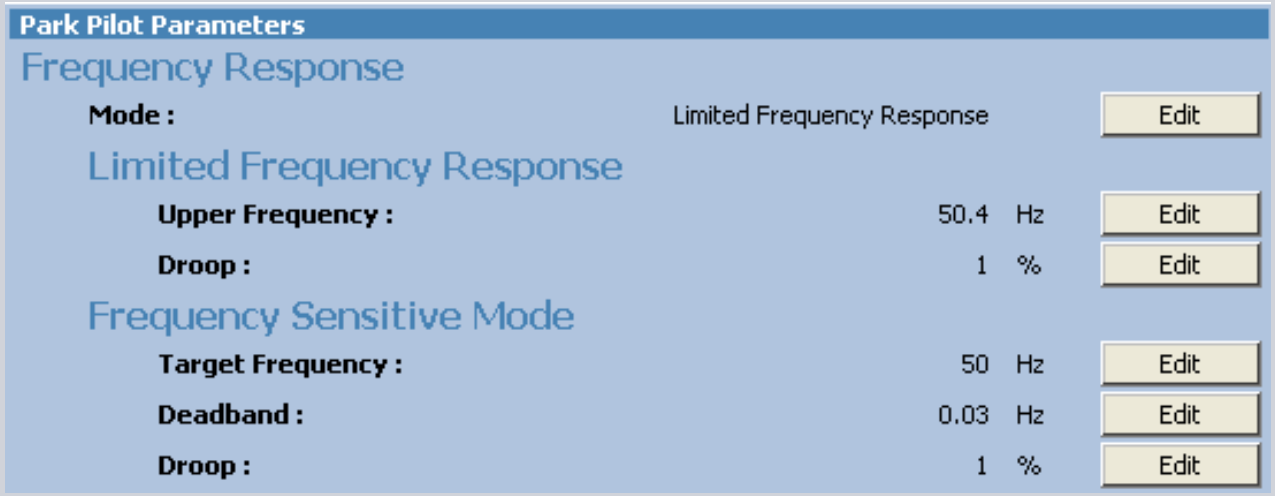
- Active Power Control
  - MW Control
  - Frequency Control

Restricted Release / © All Rights Reserved 2009

SIEMENS

Active Power Control - Frequency Control

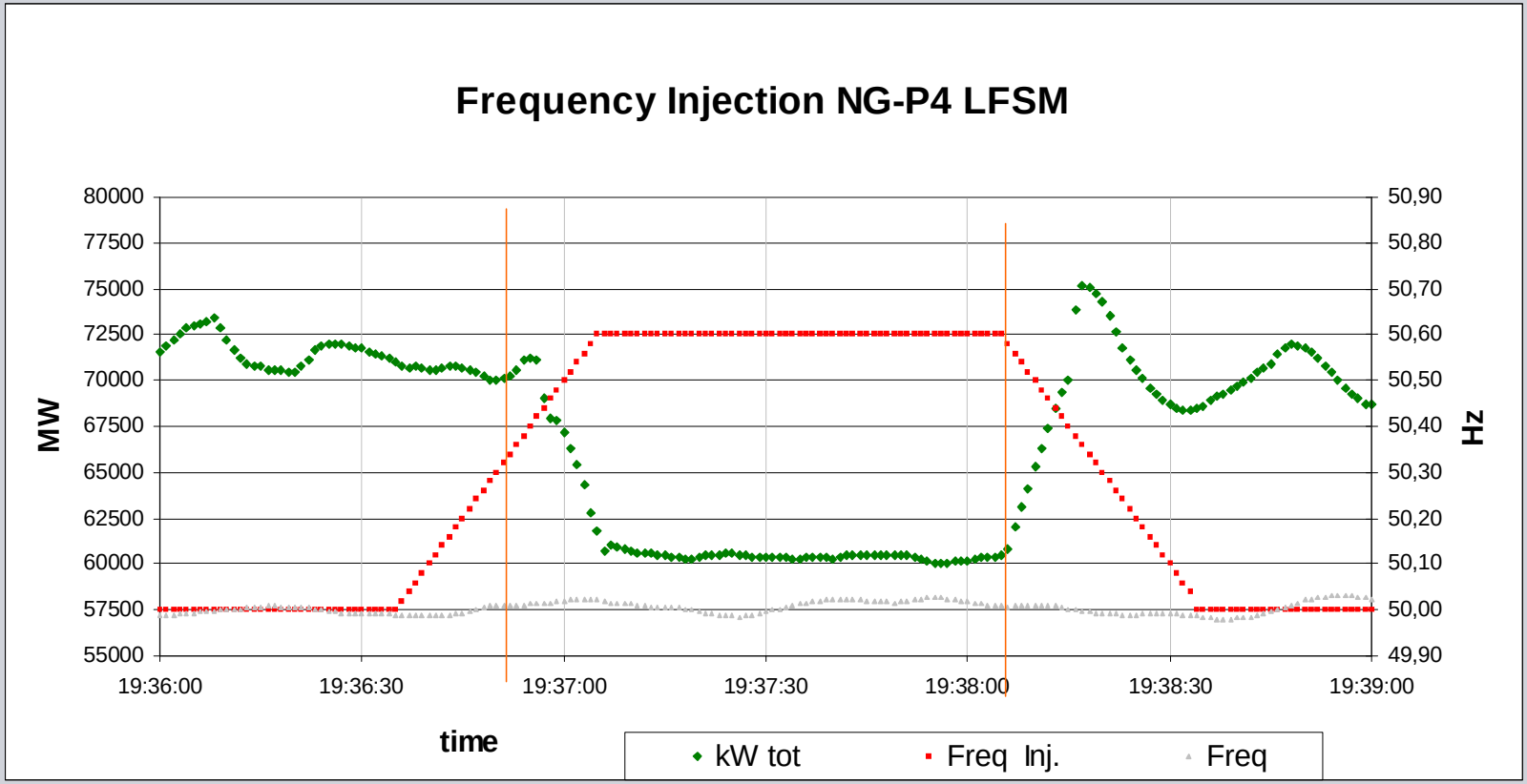
User Interface



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

Restricted Release / © All Rights Reserved 2009

Active Power Control - Frequency Control



Restricted Release / © All Rights Reserved 2009

SIEMENS

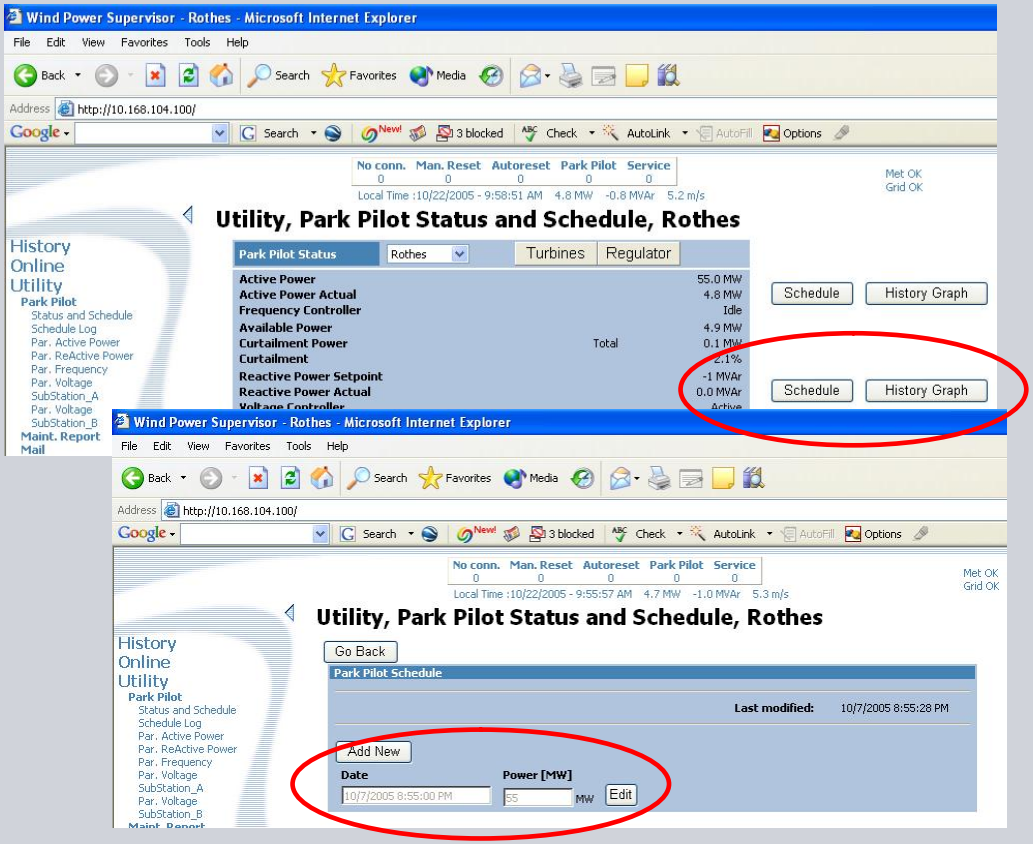
HPPP Capabilities

- Active Power Control
  - MW Control
  - Frequency Control
- Reactive Power Control
  - Mvar Control

Restricted Release / © All Rights Reserved 2009

Reactive Power Control - Mvar Control

User Interface



Restricted Release / © All Rights Reserved 2009

SIEMENS

HPPP Capabilities

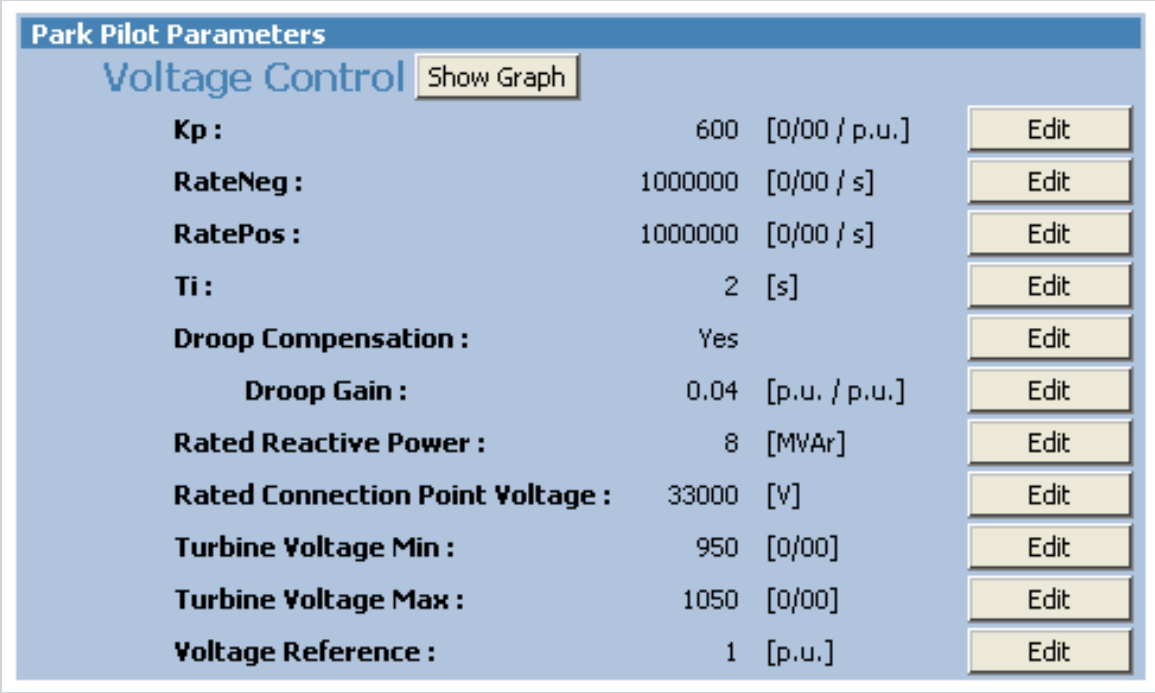
- Active Power Control
  - MW Control
  - Frequency Control
- Reactive Power Control
  - Mvar Control
  - Power Factor Control
  - Voltage Control

Restricted Release / © All Rights Reserved 2009

SIEMENS

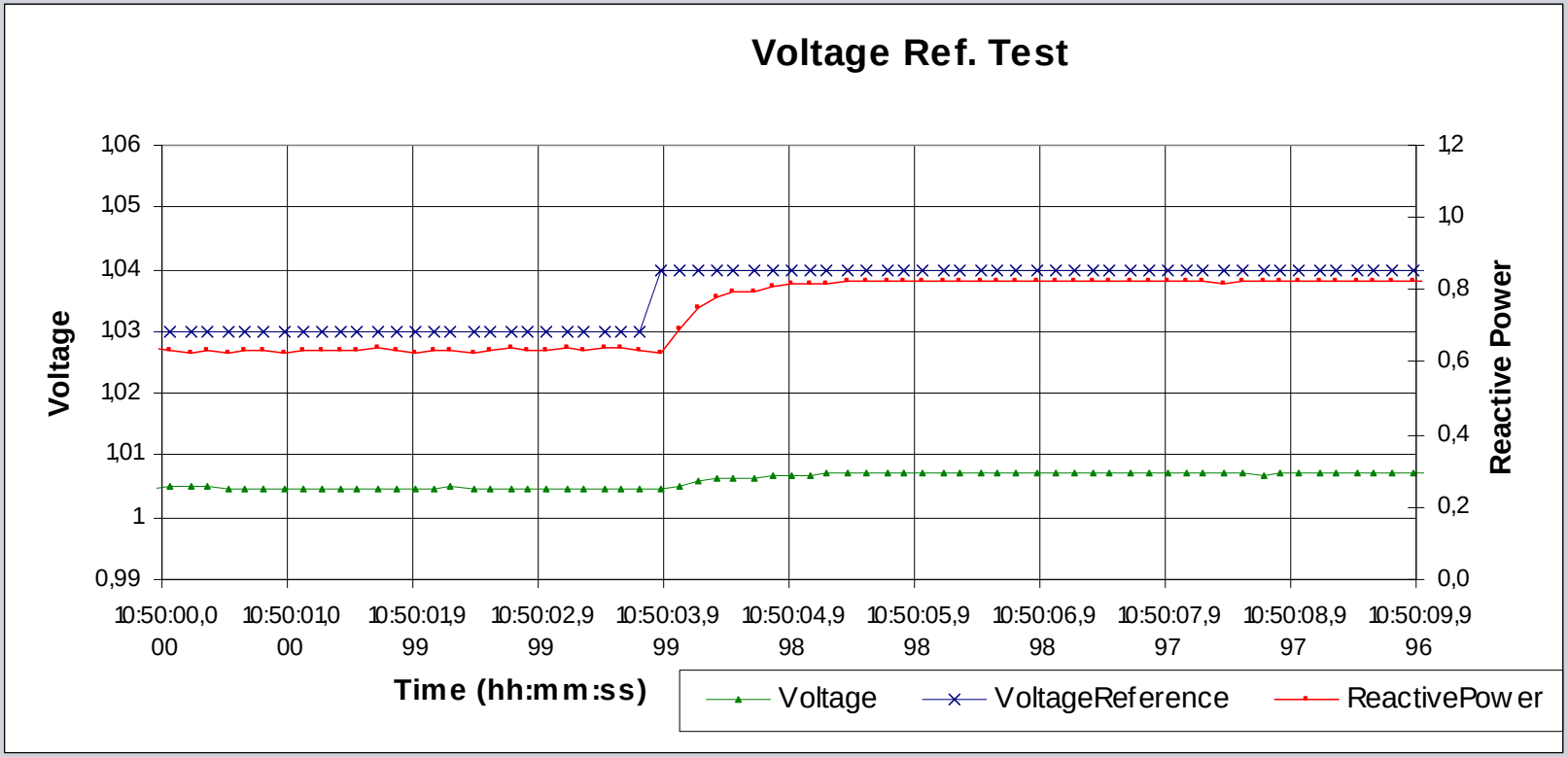
Reactive Power Control - Voltage Control

User Interface



Restricted Release / © All Rights Reserved 2009

Reactive Power Control - Voltage Control



Restricted Release / © All Rights Reserved 2009

SIEMENS

Conclusion

Restricted Release / © All Rights Reserved 2009

SIEMENS
Thank you for your attention
Restricted Release / © All Rights Reserved 2009