

# Siemens Experience with Validation of Different Types of Wind Turbine Models

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# IEC 61400-27 Electrical Sim. Models

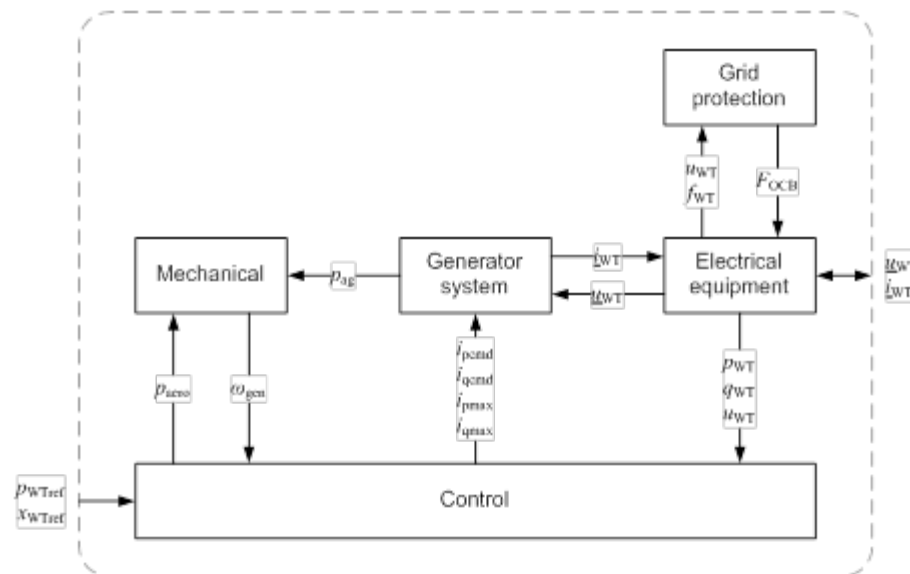
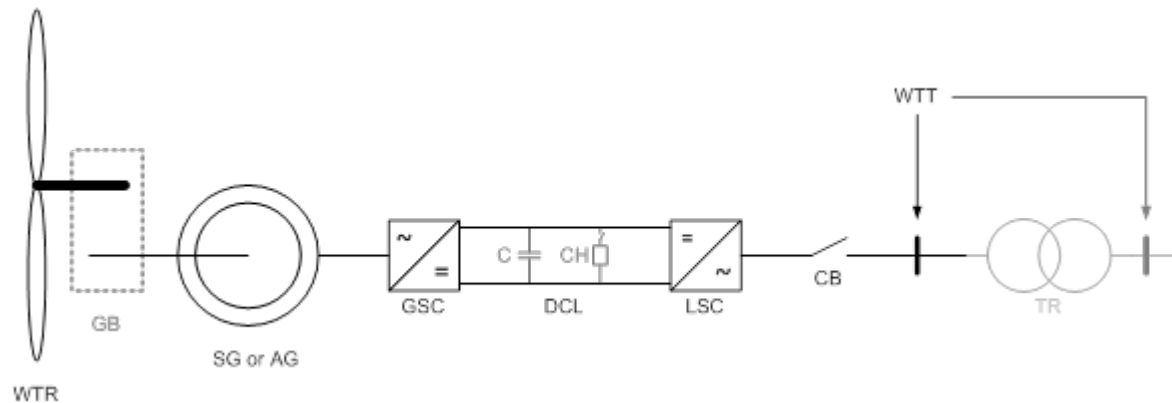
Standard in short:

- Standard is split into two parts - one for wind turbines (type 1-4) and one for wind power plants
- Working group consist of experts from utilities, academics, consultancy and other wind turbine manufactures
- Models are simple, modular and can overcome confidential issues
- Models are for fundamental frequency positive sequence response
- Standard is a model description – which is not simulation tool dependend
- Parameters set to be delivered

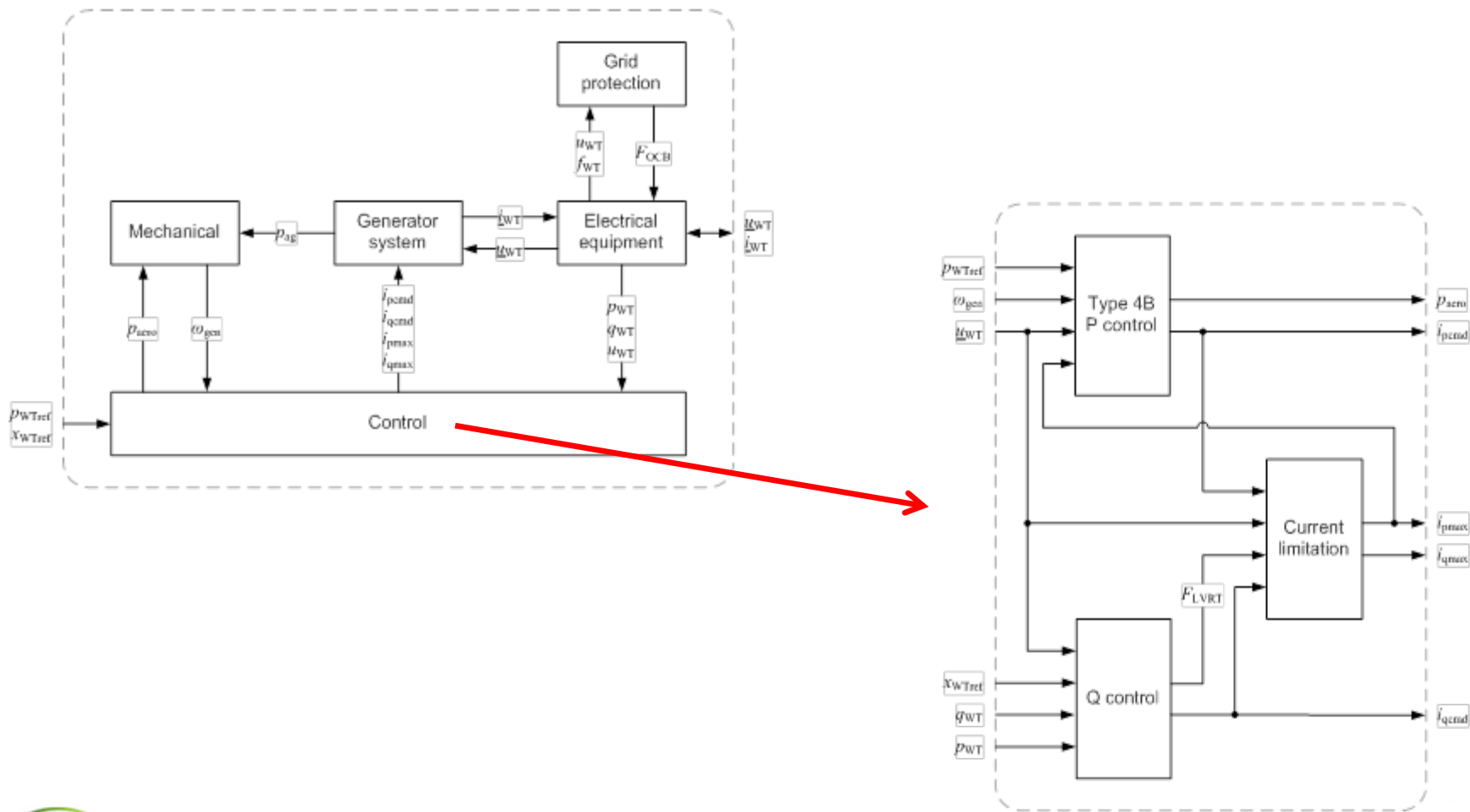
Stage for:

- Part 1 - wind turbine is FDIS (final draft international standard) – voting
- Part 2 - wind power plants is under development

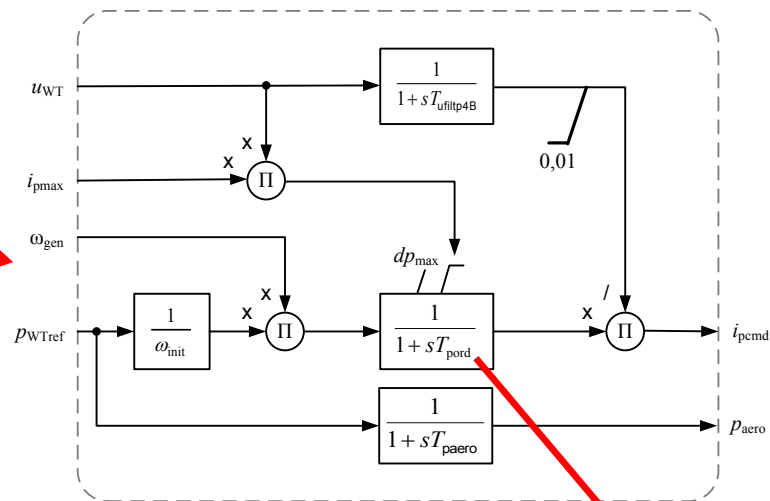
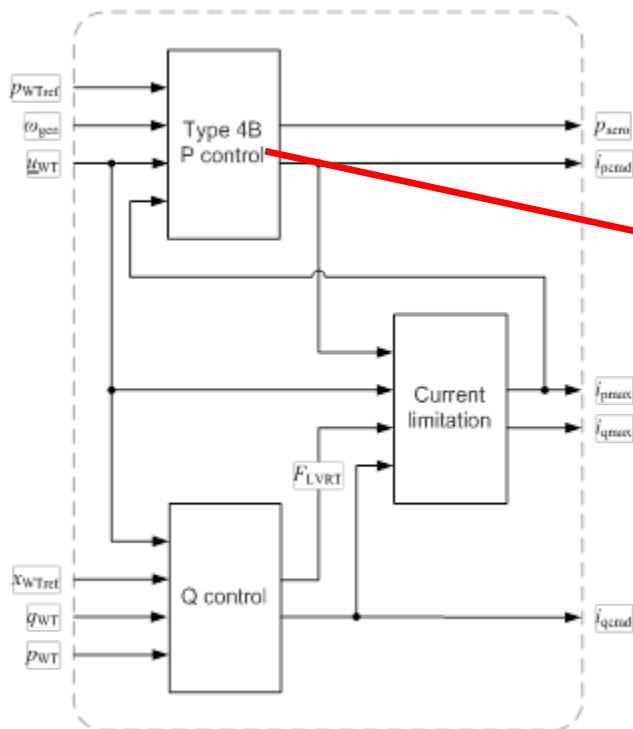
# IEC 61400-27-1 Type 4 Model



# IEC 61400-27-1 Sub-module

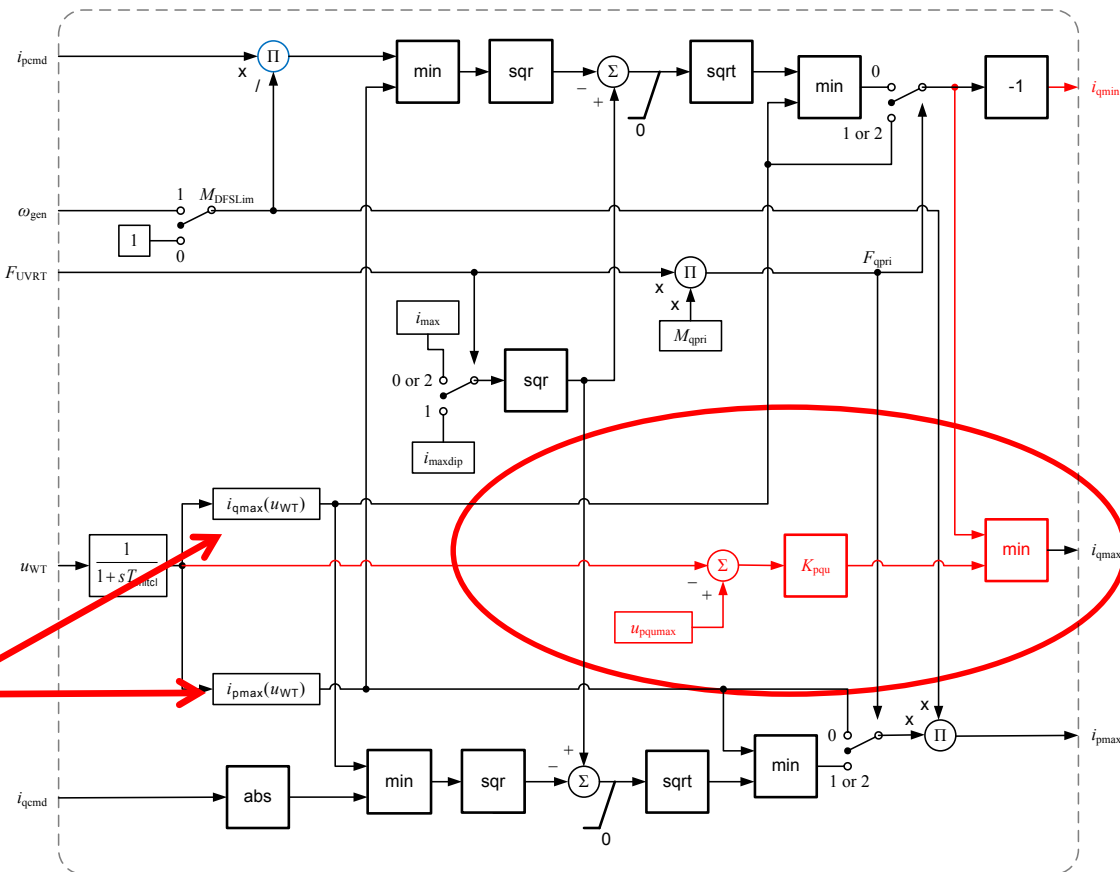
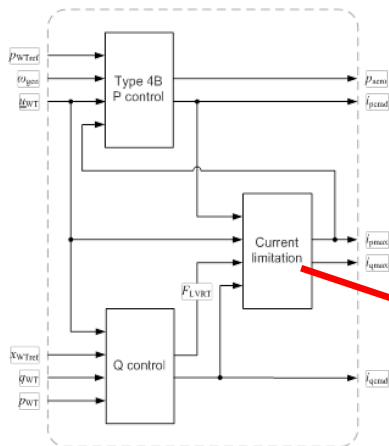


# Block diagram type 4B P ctrl model



Symbol	Base unit	Description	Category	Parameter value
Tufilt4B	s	Voltage measurement filter time constant	Type	
Tpord	s	Time constant in power order lag	Type	
Tpaero	s	Time constant in aerodynamic power response	Type	
Dpmax	PN/s	Maximum wind turbine power ramp rate	Project	

# Current limitation block



Voltage dependent reactive current limitation

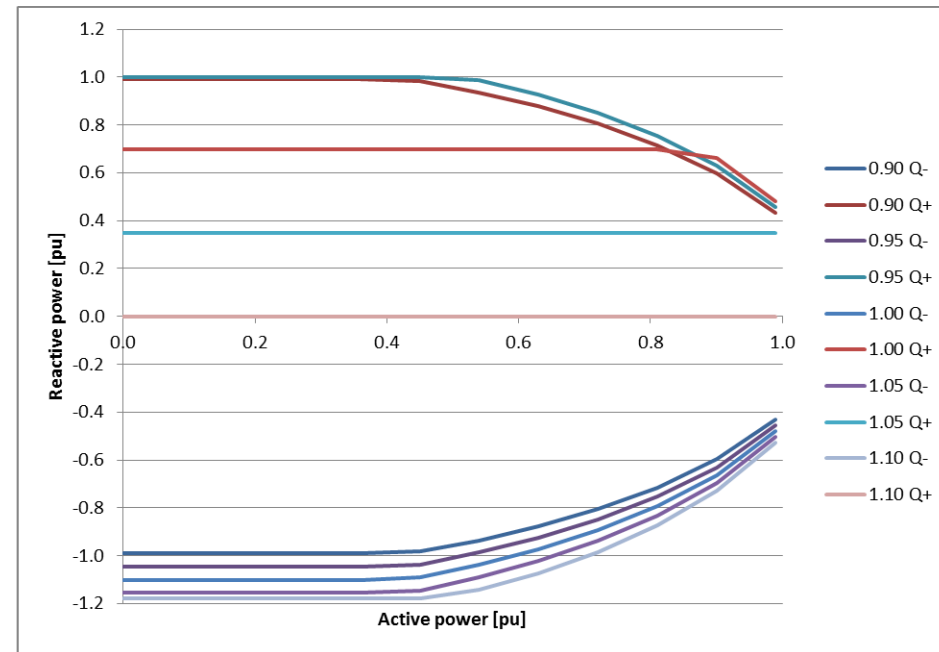
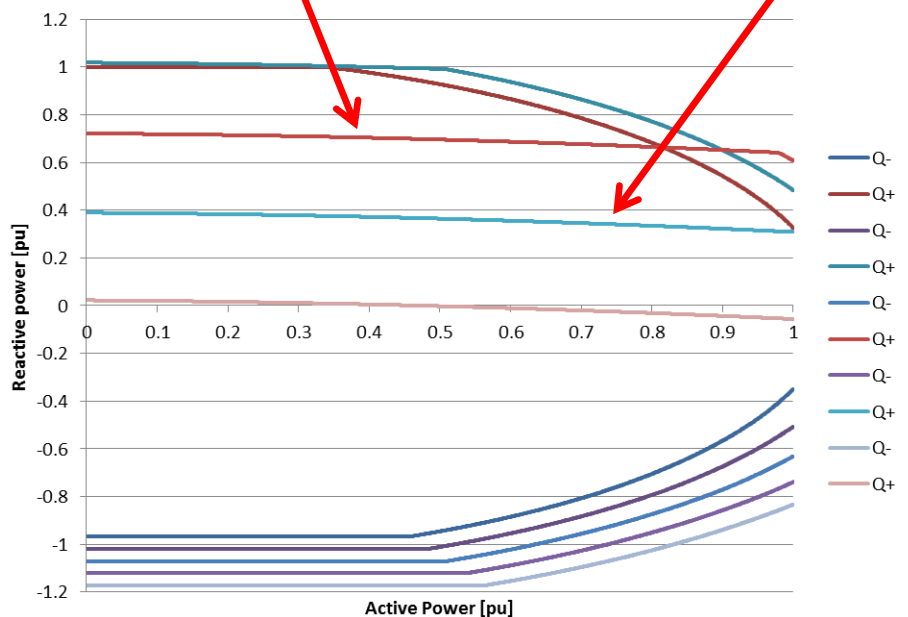
Current injection under fault in tabular form

# PQ chart – Voltage Dependend

Voltage = 1.00 pu

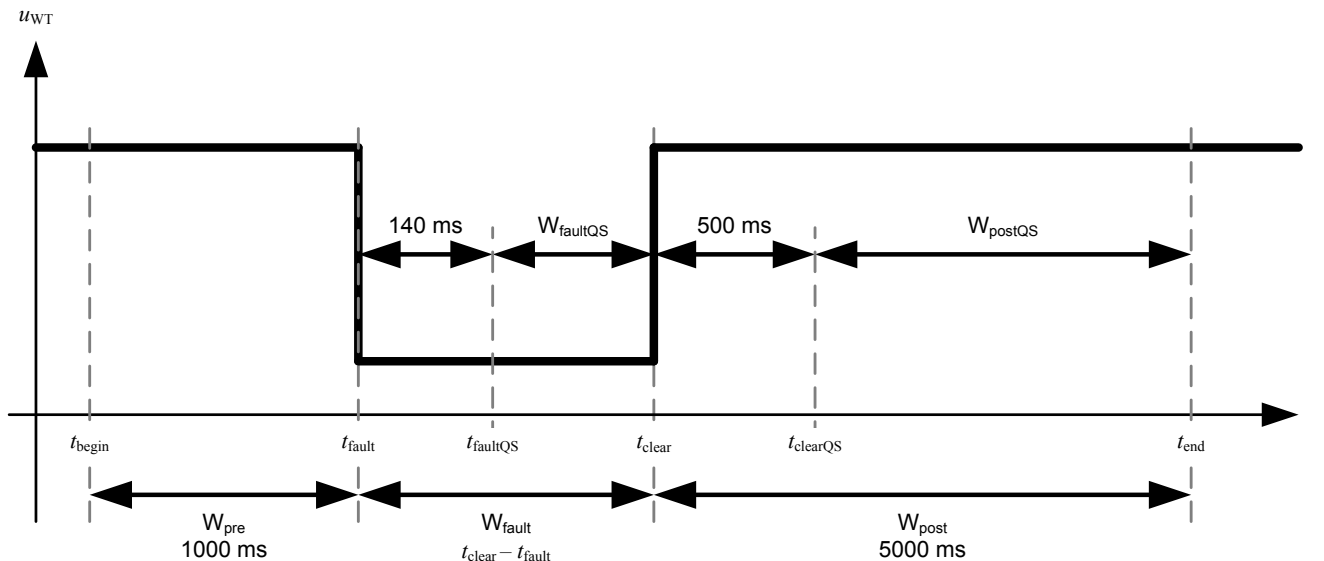
Voltage = 1.05 pu

Result of voltage dependency





# IEC 61400-27-1 Validation Method of FRT



Period	Maximum error	Mean error	Mean absolute error
Pre-fault	$W_{pre}$	$W_{pre}$	$W_{pre}$
Fault	$W_{faultQS\_a}$	$W_{fault}$	$W_{faultQS}$
Post fault	$W_{postQS}$	$W_{post}$	$W_{post}$

# Validation Examples

IEC type 4B model

- FRT test
- Post fault reactive power response

PowerFactory model implementation from DigSilent

IEC type 1 model

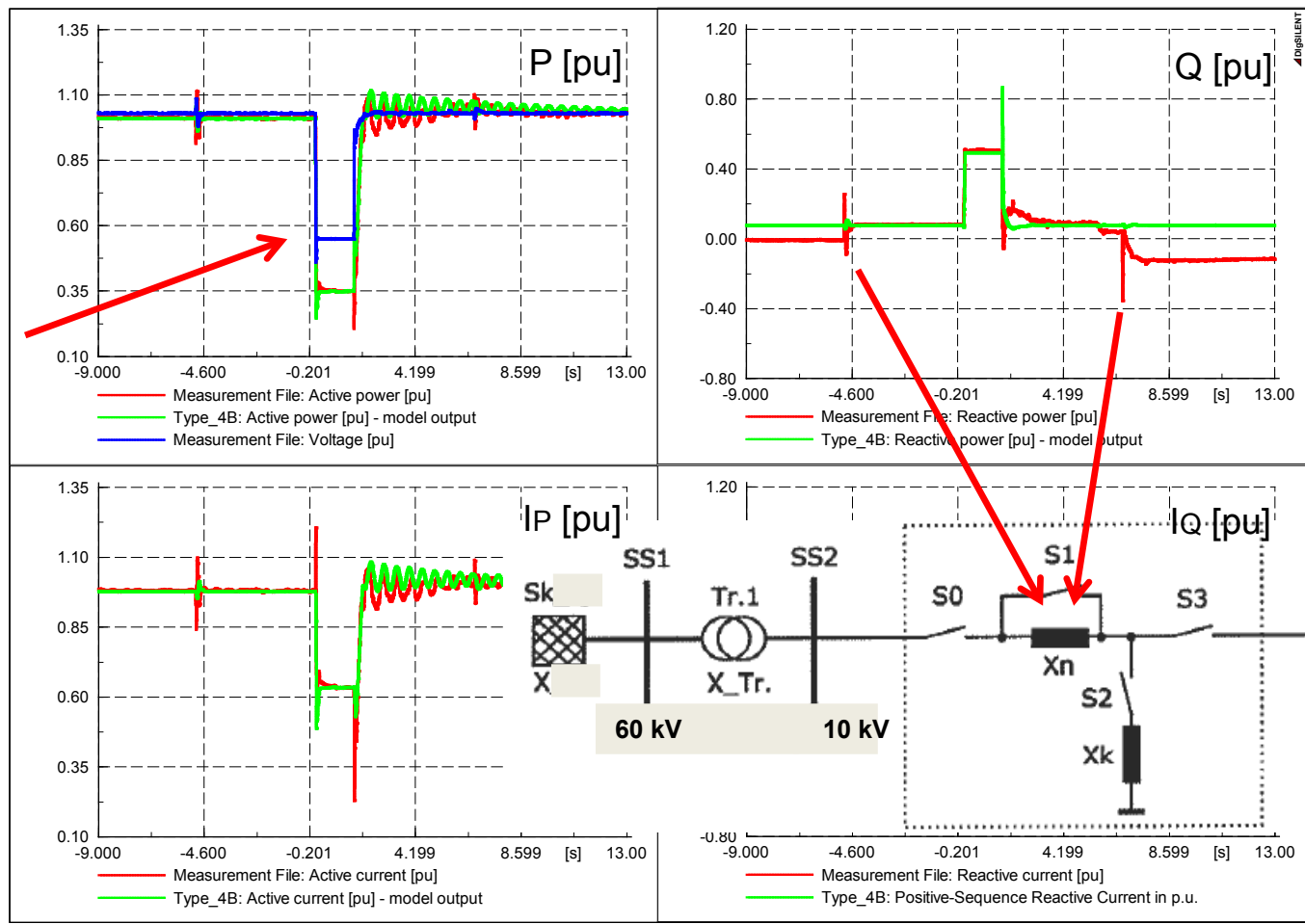
- FRT test

PowerFactory model implementation from DTU

# FRT Test

Voltage  
Measured  
Simulated

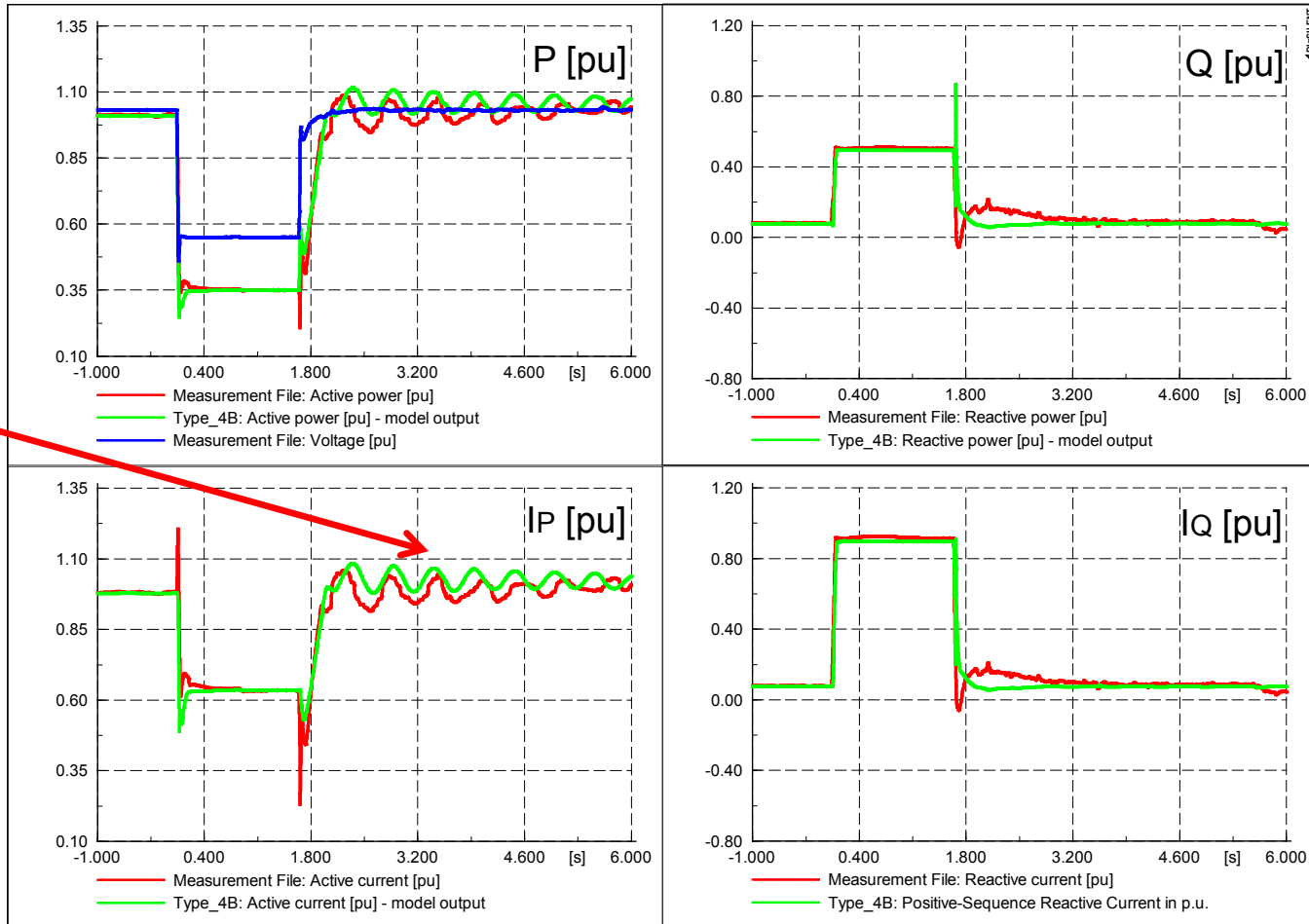
0.55 pu  
in 1.6s



# FRT Test

Voltage  
Measured  
Simulated

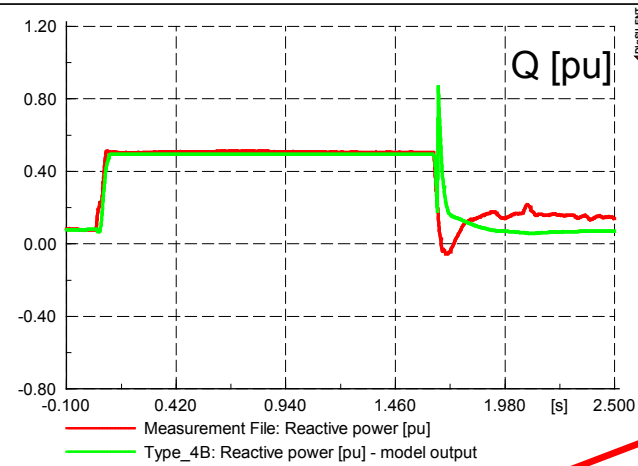
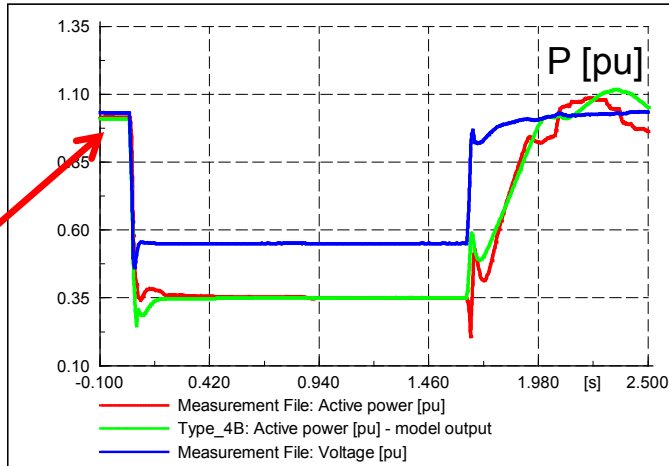
Wind is  
not  
constant



# FRT Test

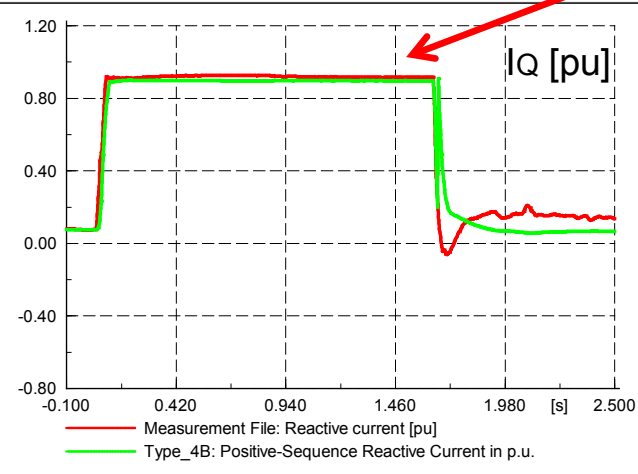
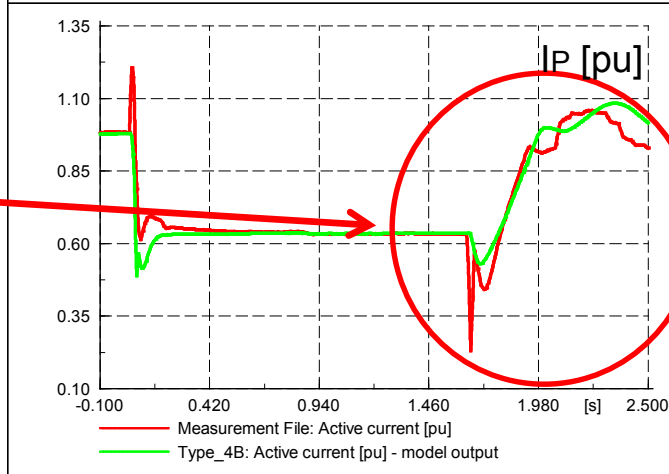
Voltage  
Measured  
Simulated

Initial  
values  
the same



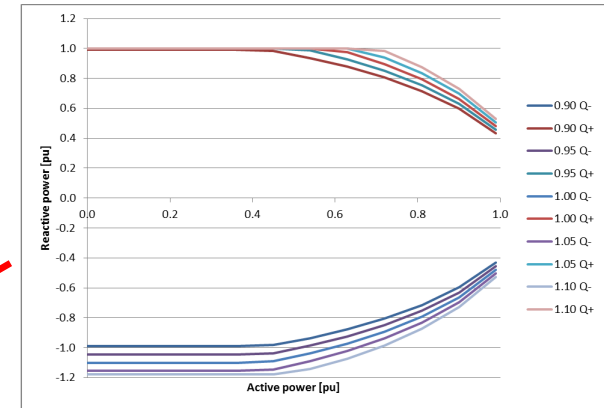
Reactive  
current  
support

Post-fault  
ramping

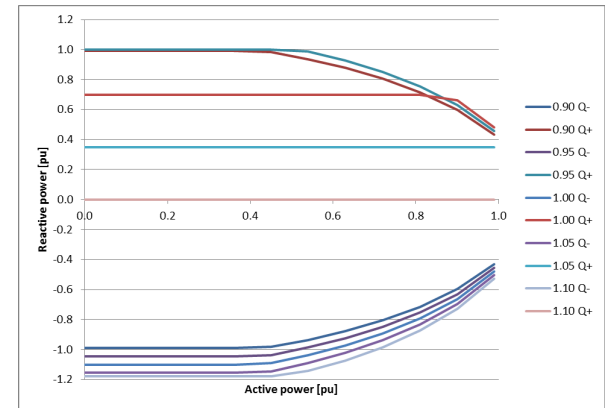


# Post Fault Reactive Power Response

PQ

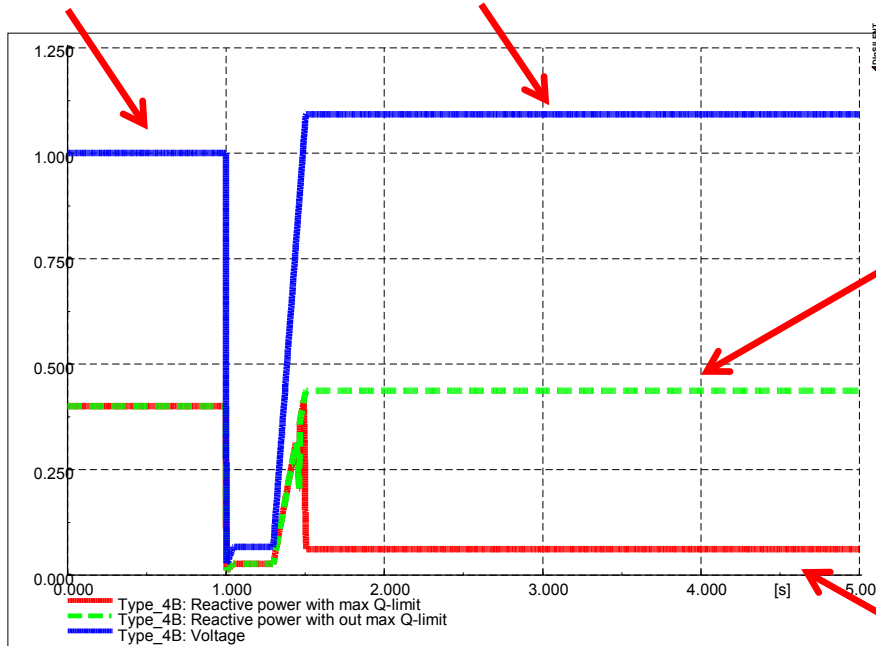


PQ(voltage)

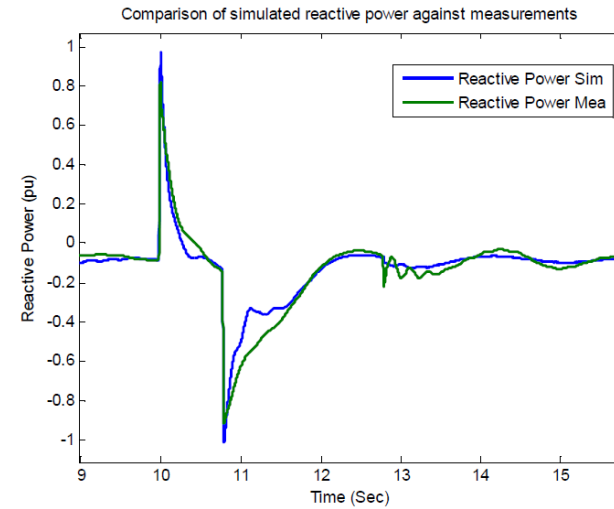
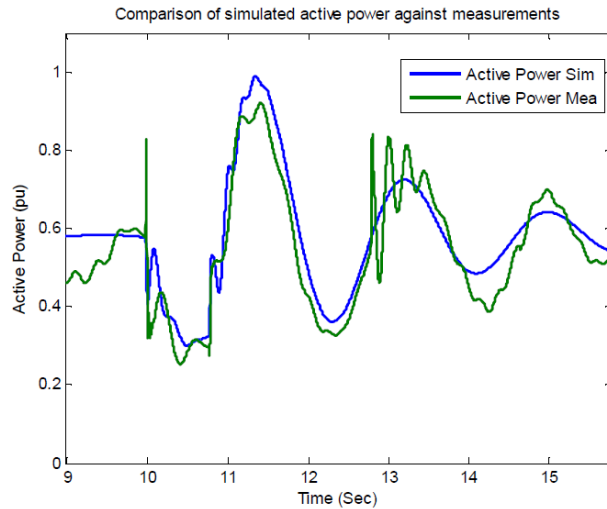
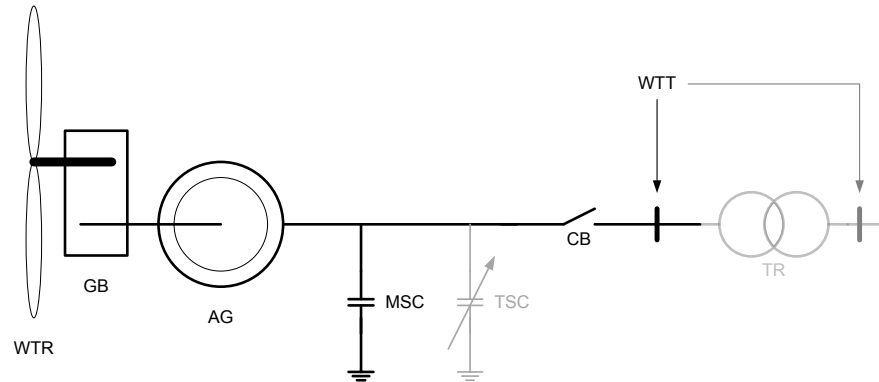


Difference  
appr. 0.4 pu

Initial voltage 1.0 pu    Postfault voltage 1.09 pu



# Type 1 - Validation



Ref.: Implementation and Validation of IEC Generic Type 1A Wind Turbine Generator Model, International transactions on electrical power systems, H. Zhao<sup>1,4</sup>, Q. Wu<sup>1,4</sup>, I. Margaritis<sup>2</sup>, J. Bech<sup>3</sup>, P. Sørensen<sup>2</sup> and B. Andresen<sup>3</sup>

1 Centre for Electric Power and Energy (CEE), Department of Electrical Engineering, Technical University of Denmark (DTU), Denmark, 2 Wind Energy Systems, Department of Wind Energy, Technical University of Denmark (DTU), Denmark, 3 Siemens Wind Power A/S, Denmark, 4 Sino-Danish Center for Education and Research, Aarhus, 8000 Denmark

# Summary

- IEC 61400-27 Electrical Simulation Models – model description
- Simple models – only parameters are different
- Validation examples show that a simple generic model can give a decent performance
- Voltage dependend PQ chart can be implemented by simple blocks
- If more precise models are needed – manufacture models are needed. Probably under NDA.