AWEA Windpower 2011

Wind Turbine Grid Integration Challenge

In booth theater presentations
Wind Turbine Grid Integration Challenge

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- Speaker title: Design manager - Simulations, Grid codes
- Company name: ABB, Drives, Wind AC

Grid Integration Challenges

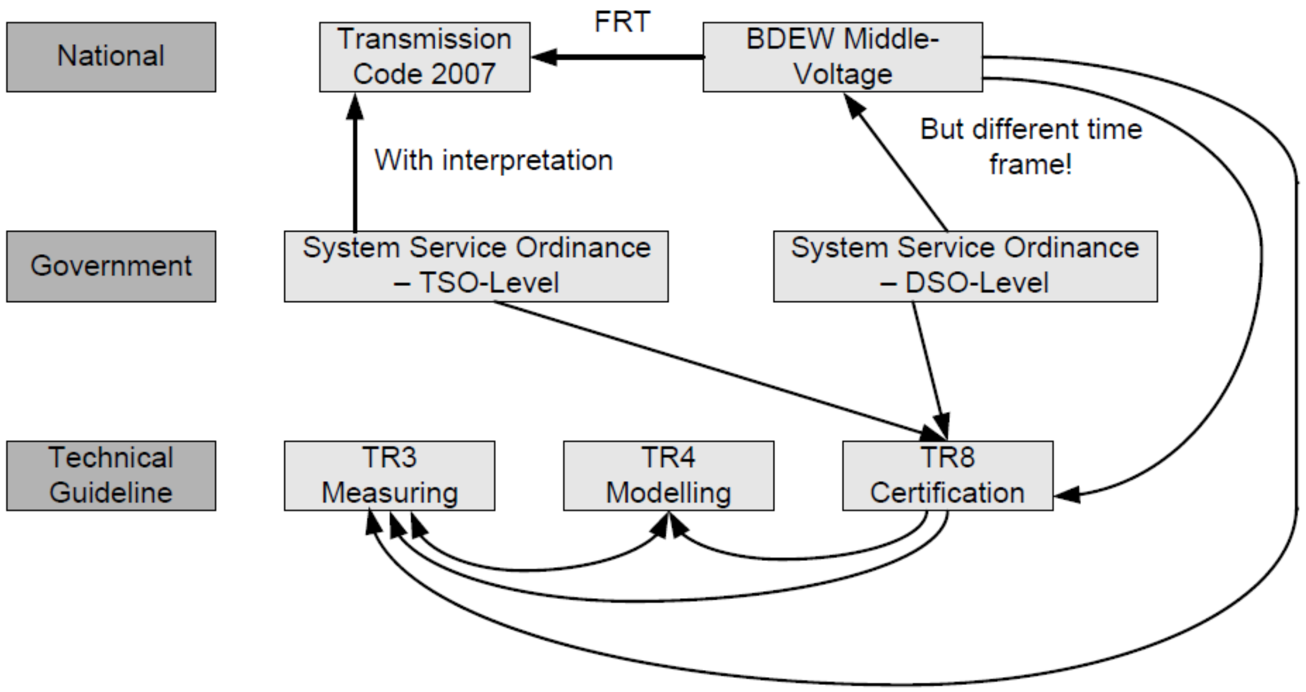
- # 1: Grid integration requirements – What, Where and How ?
- # 2: Fault Ride Through (FRT) – How to support the grid during fault conditions
- # 3: Quick Response - Fast acting voltage control and reactive current during fault
- # 4: Advanced simulation models – Important tool for compliance validation
- # 5: Series compensated lines & DFIG wind farm

Grid Integration Challenge #1

What are the requirements?

- Requirements of the local grid codes are different between countries/regions.
- Today's grid codes are very diverse and contain many technical “gray areas” (historical reasons, new generation).
- Common specification language, as required for global standardization, does not exist.
- Grid codes are continually changing.

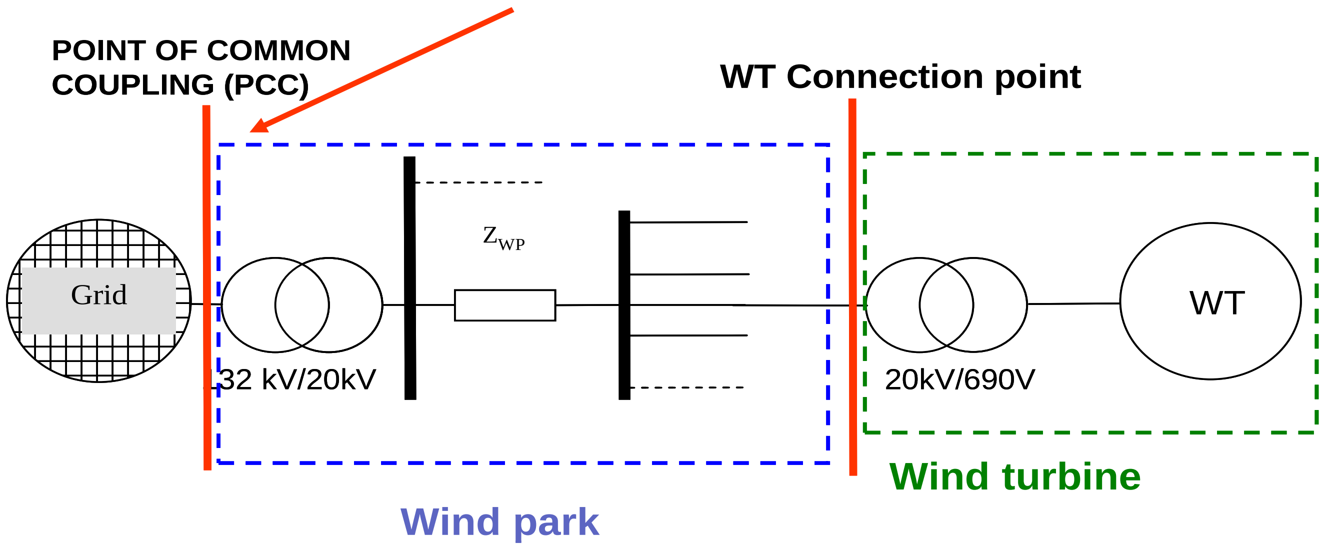
EXAMPLE Germany (11 Grid codes and guidelines):



Code	Short term interuption (disconnect.)	Fault type FRT	FRT reference voltage (V-profile)	Reactive current injection V-ref.
TC 2007	Not defined but allowed	Symmetric Unsymmetric?	Largest L-L	Voltage – effective value
MV 2008	Not defined but allowed	Symmetric Unsymmetric	Lowest L-L	Undefined (U limited to 1.1.p.u)
SDL Wind V	Not defined	Symmetric Unsymmetric	Positive seq. voltage	Positive seq. voltage (U limited to 1.1.p.u)
Transpower 2009	Defined	Symmetric Unsymmetric	Highest L-L Pos. Seq.	V-effective value(?unsym)

Grid Integration Challenge #1

Usually defined at PPC



Where to Comply

- Defines what the performance requirement is for power plants connected to power system
- Grid code reflects the structure and status of transmission system
- The content of grid code depends on the region
- US FERC Order 661
- E.ON 2006, German
- R.E.E 12.3. Spain

Grid Integration Challenge #1

How to validate compliance

- Type test of a single wind turbine – typically performed by so-called “container test”.
- Wind power plant compliance assessment – performed by simulation.

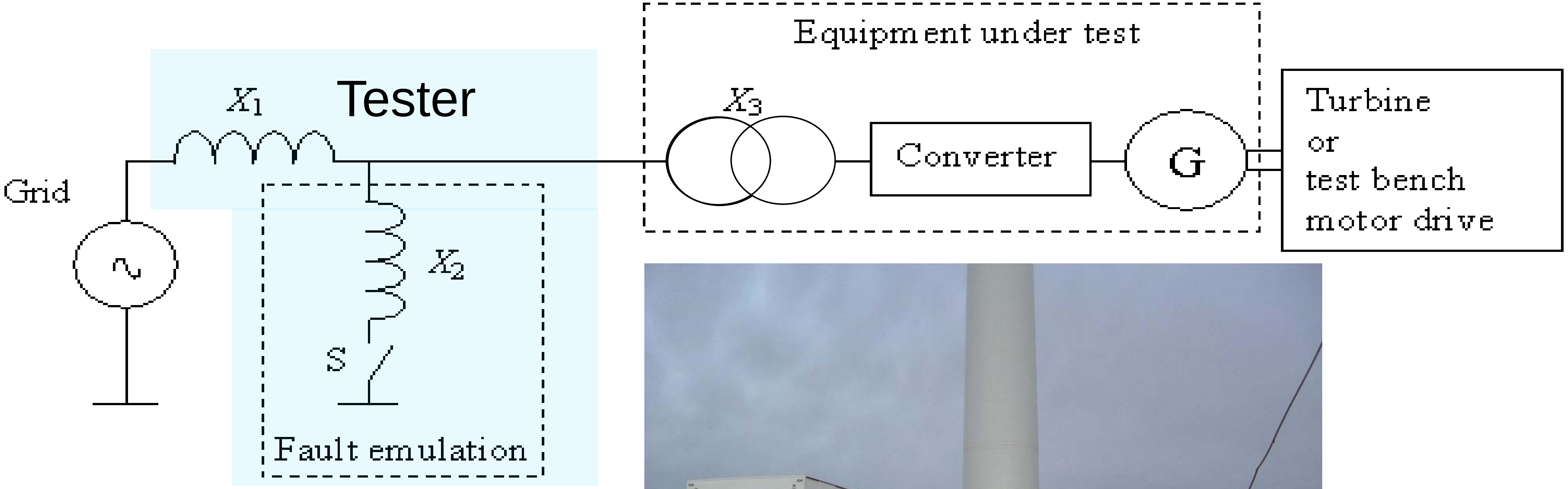
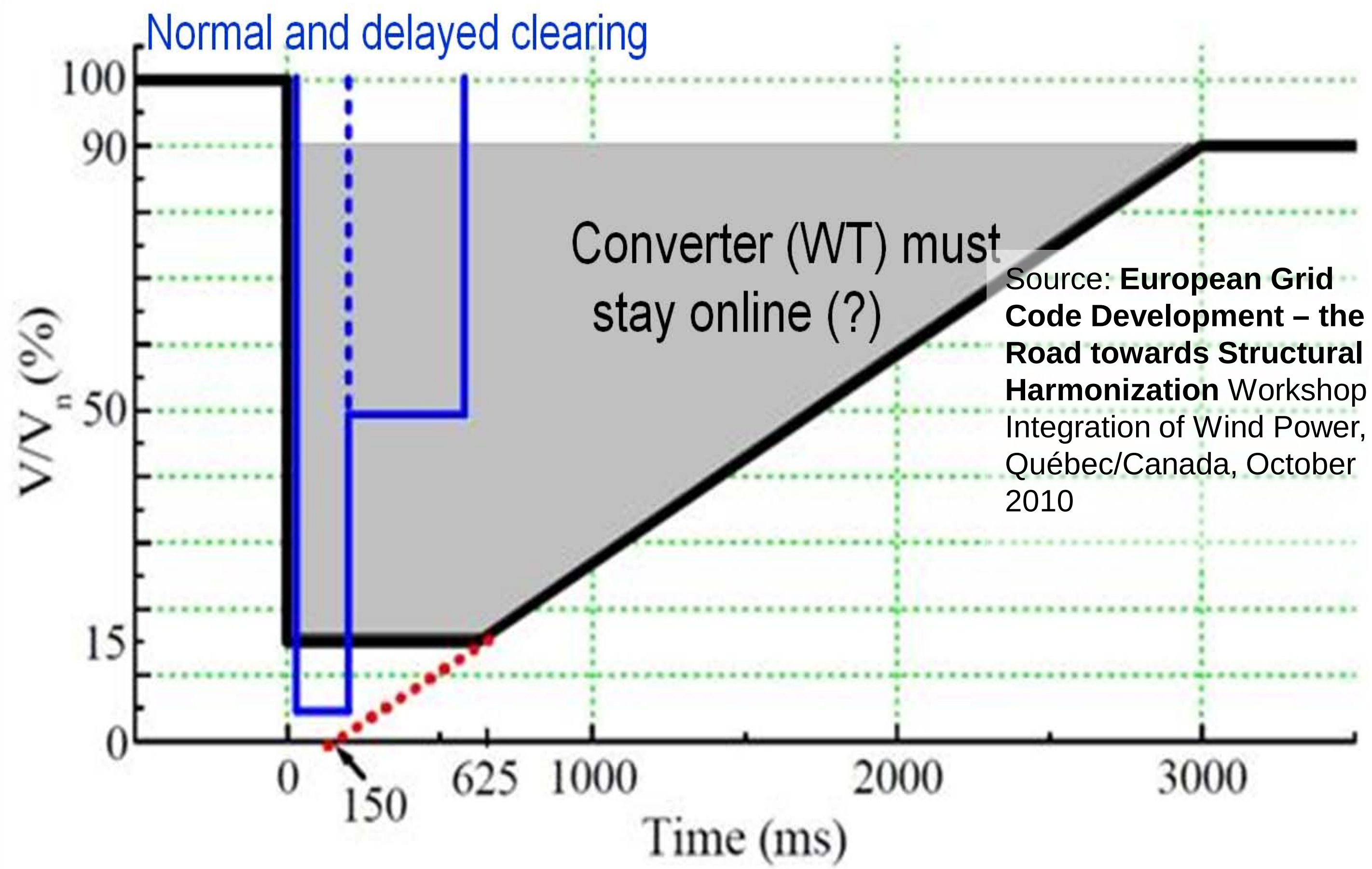


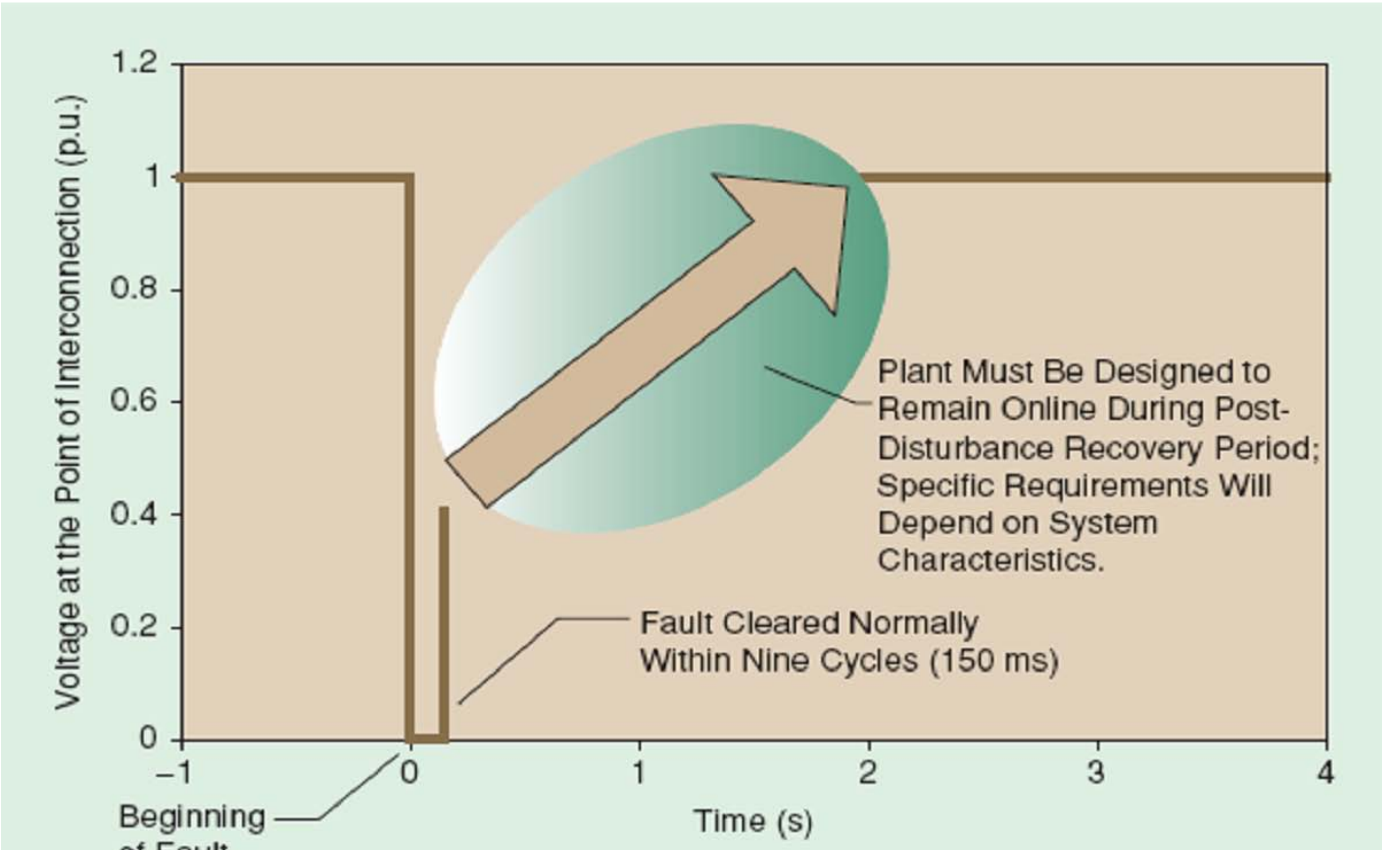

Photo: E2Q

Challenge #2: Fault Ride Through (FRT)



Source: **European Grid Code Development – the Road towards Structural Harmonization** Workshop on Integration of Wind Power, Québec/Canada, October 2010

Typical FRT curve - not full consistency on how FRT profiles are to be understood and applied



Source: IEEE power and energy magazine November/December 2007

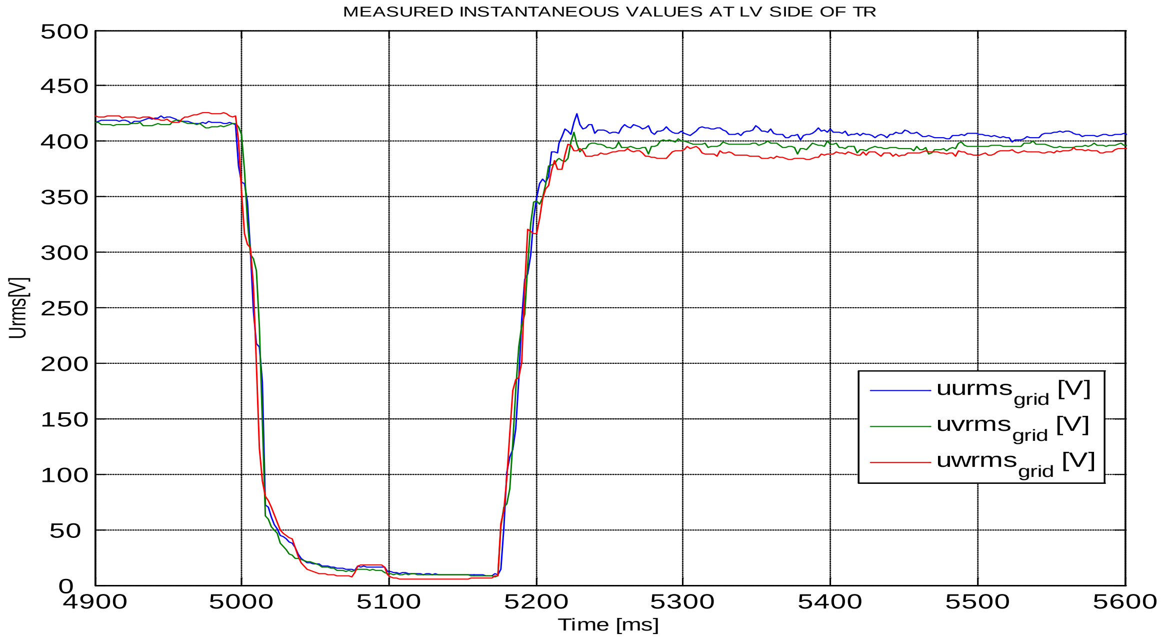
FERC Order 661- LVRT requirements defined at HV side of the plant step-up TR. Wind generation facility remains online during:

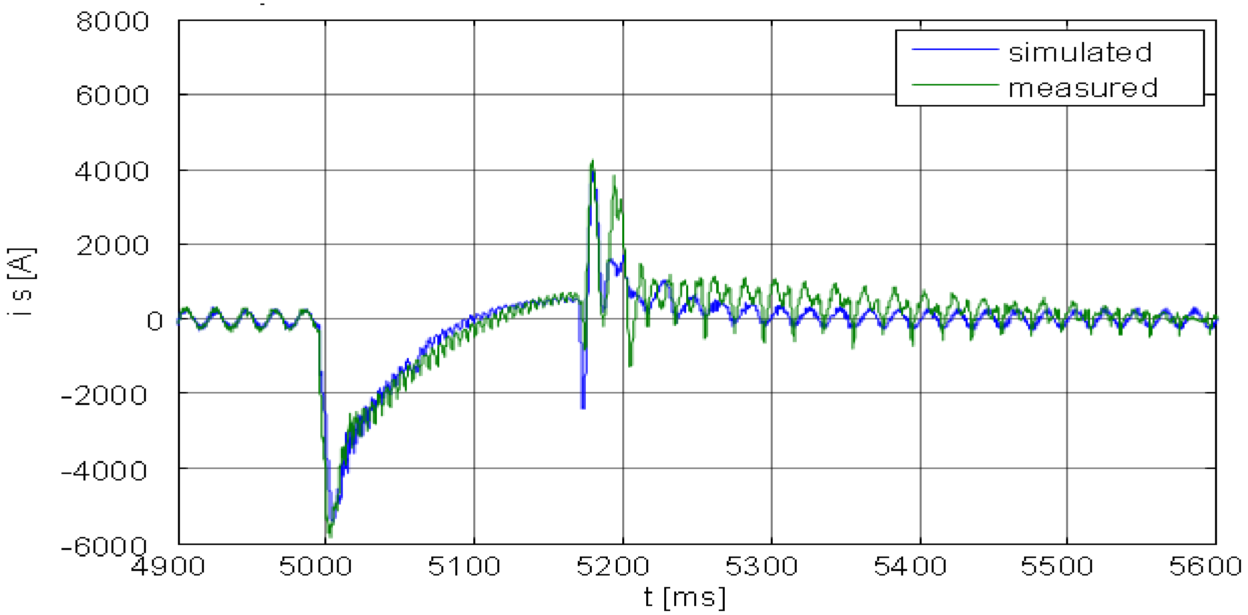
3-phase fault with normal clearing

1-phase to ground fault with delayed clearing

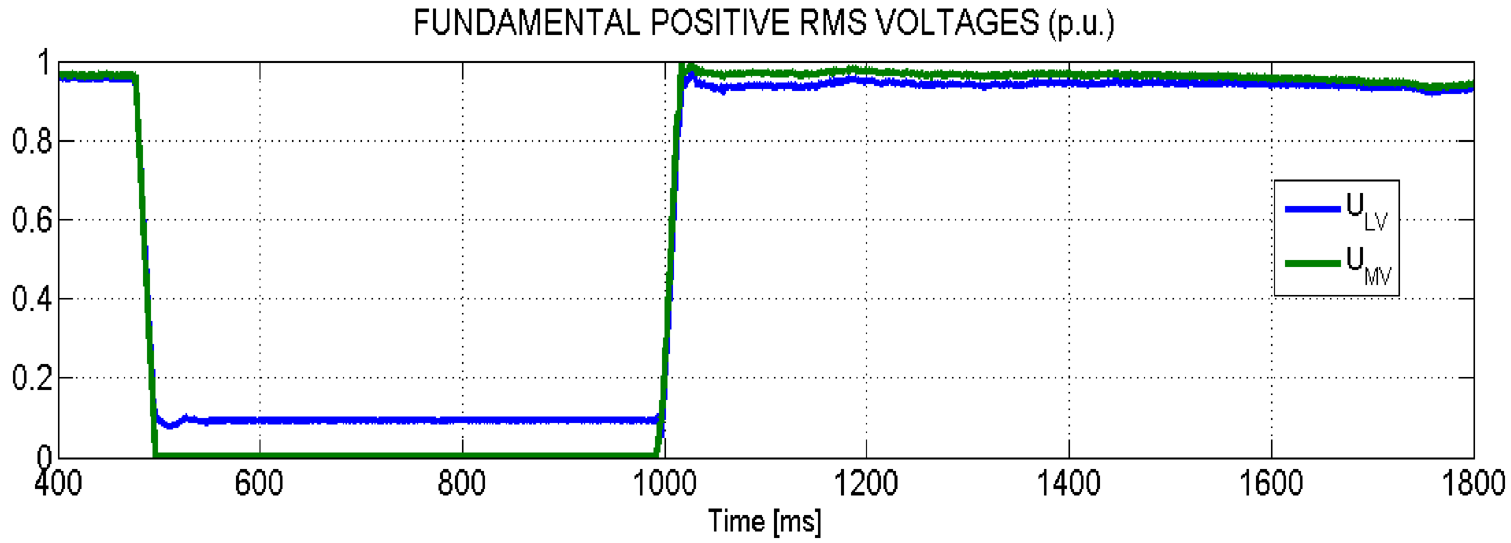
Challenge #2: FRT – Example of Dynamic Performance

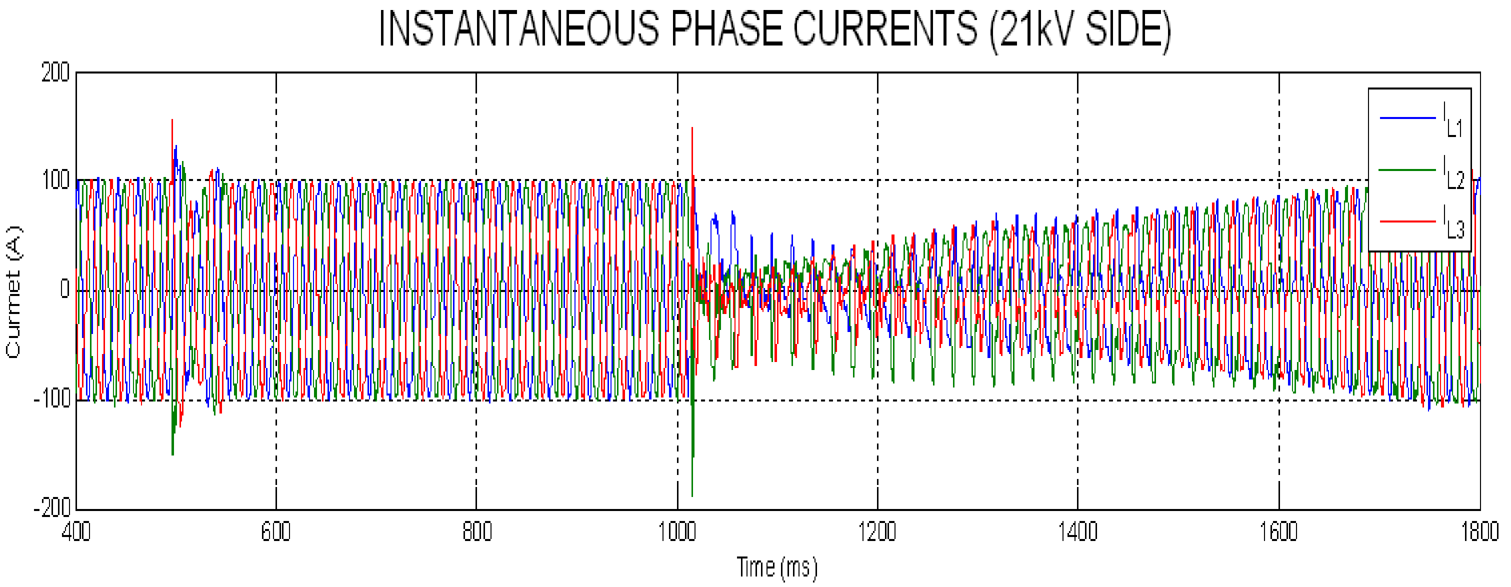
FRT 0% Un, 180 ms – DFIG (Type 3) - LV side



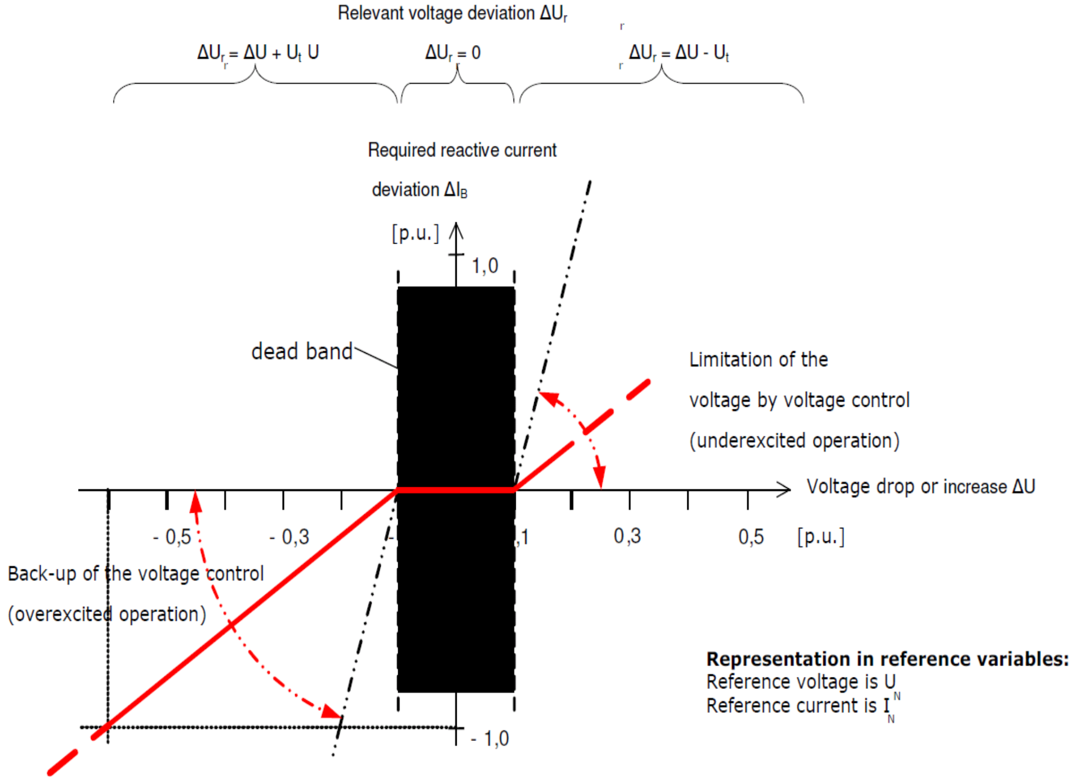


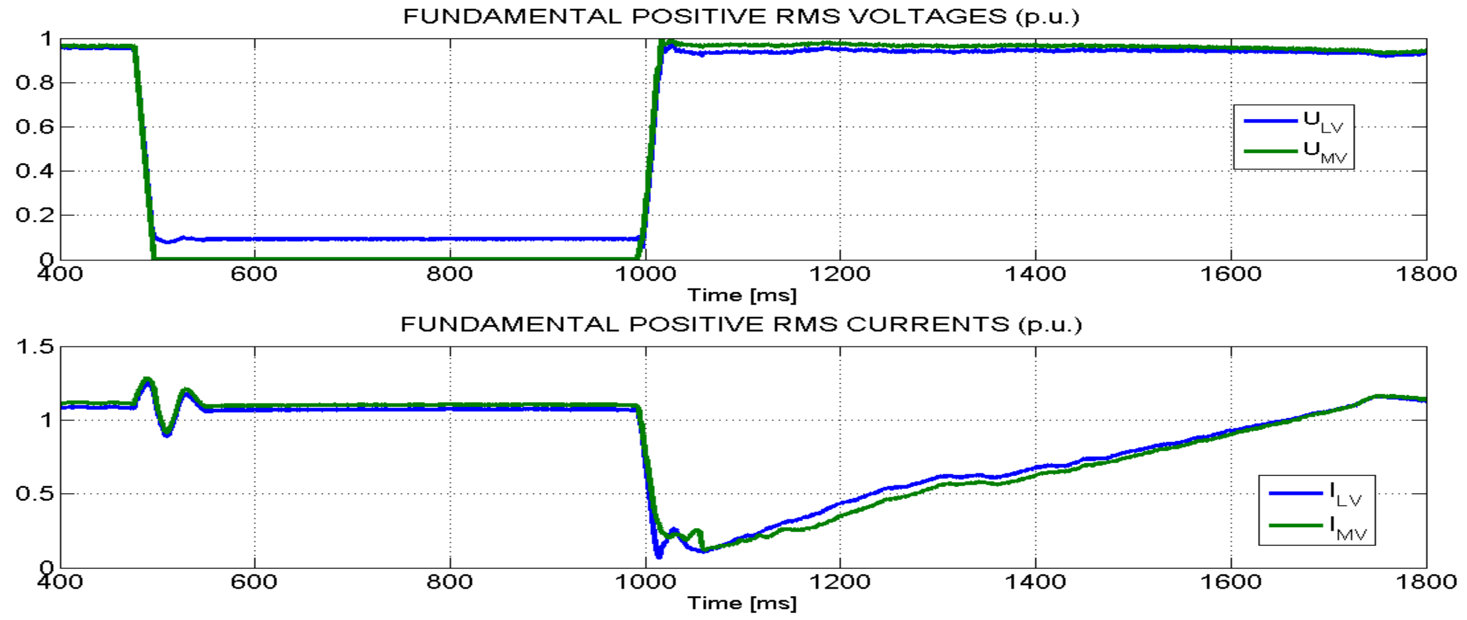
FRT 0% Un, 500 ms – Full Converter (Type 4) – MV/LV side

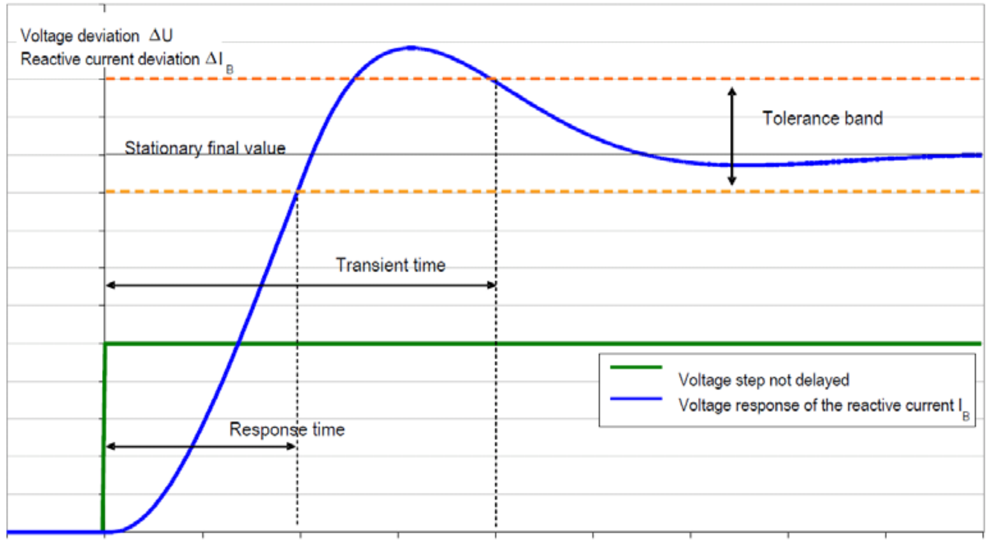


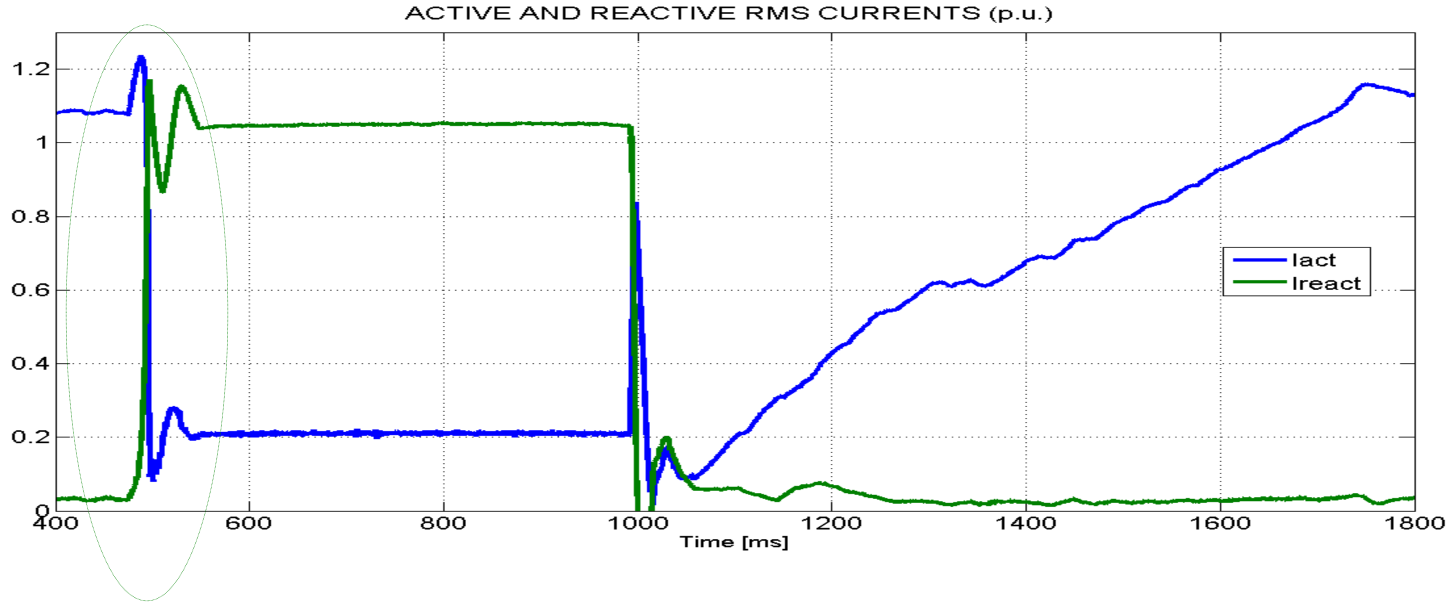


Challenge #3: Quick Response to Grid Faults/Voltage Support









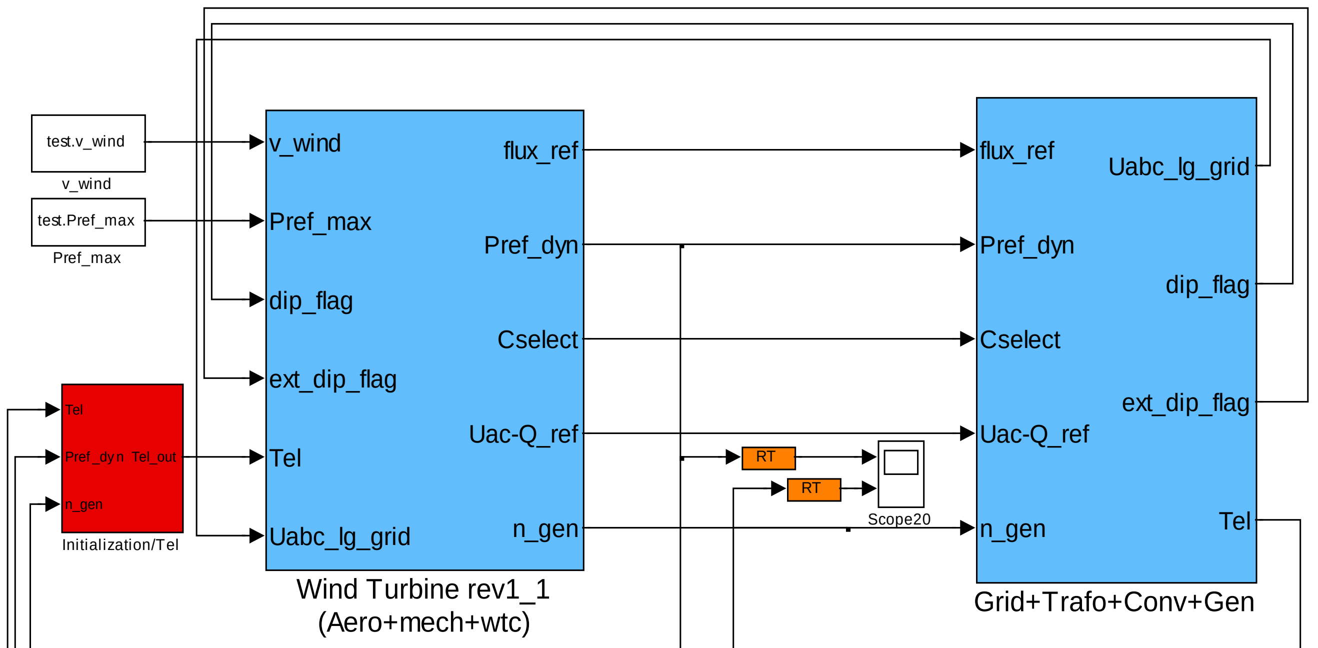
Reactive Current (<100%In) injected within 30 ms during ZVRT

FRT – Converter Supports Wind Turbine

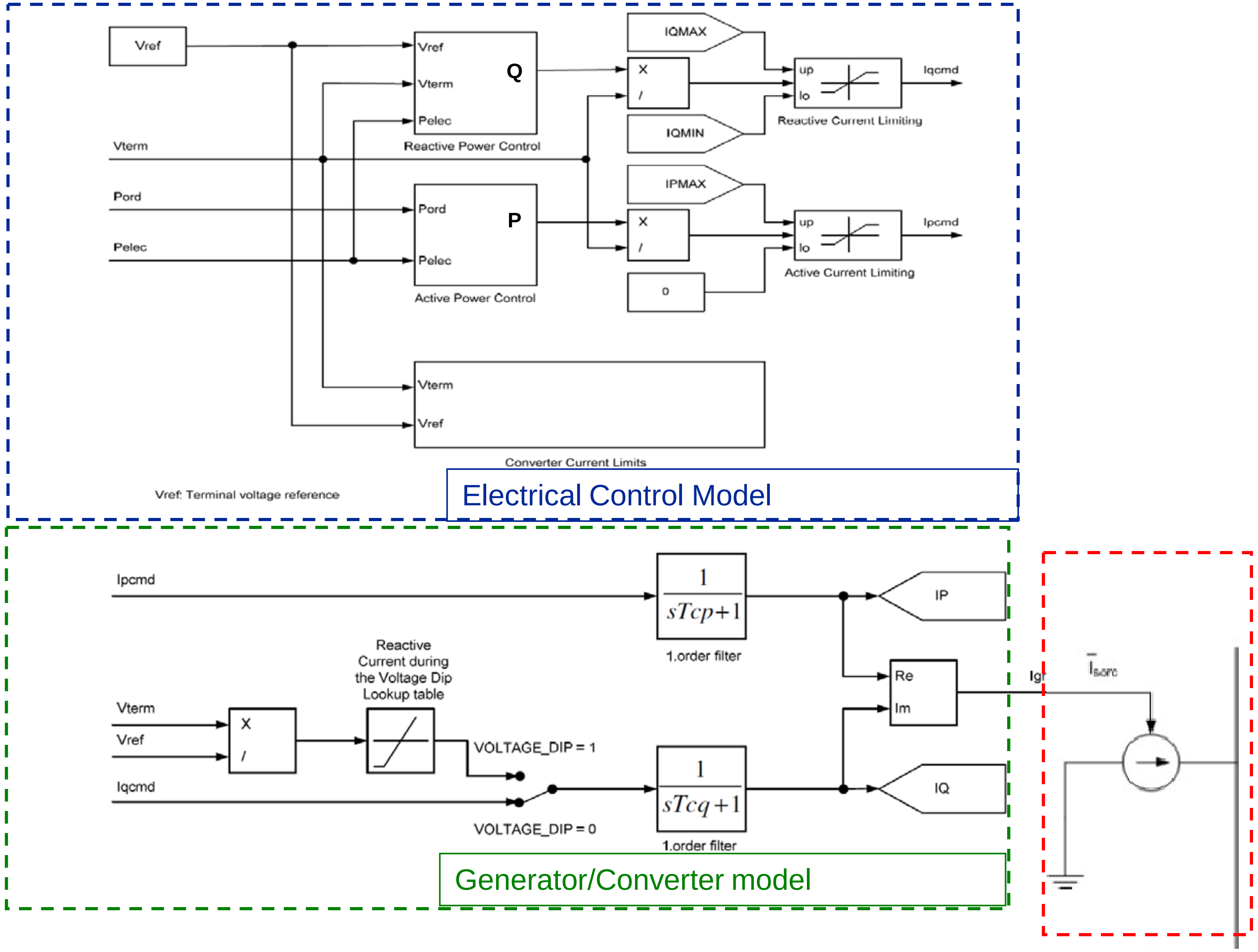
Fault Condition	Double Fed Induction (DFIG) with ABB ACS800-67(LC) *	Full Power Converter (FPC) with ABB ACS800-77/87(LC)
LVRT - Symmetrical Fault	Down to V_{L-L} = 0% U_{Nom} at MV side	Down to V_{L-L} (rms) = 0% U_{Nom} at MV side
LVRT-Unsymmetrical Fault	Down to V_{L-L} = 0% U_{Nom} at MV side (limited time duration)	Down to V_{L-L} (rms) = 0% U_{Nom} at MV side
Reactive Current Support – Symmetrical Fault	I_Q = 100% I_{Nom} within 50-150ms (depending on severity) Down to approx V_{L-L} = 15% U_{nom} (MV side)	I_Q = 110% I_{Nom} within 30-40ms, down to V_{L-L} = 0% U_{nom} (MV side)
Reactive Current Support – Unsymmetrical Fault	I_Q =possible down to V_{L-L} = 20% U_{nom}	I_Q = 100% I_{Nom} within 50ms, down to V_{L-L} = 0% U_{nom} (MV side)

Challenge #4: Advanced Simulation Models

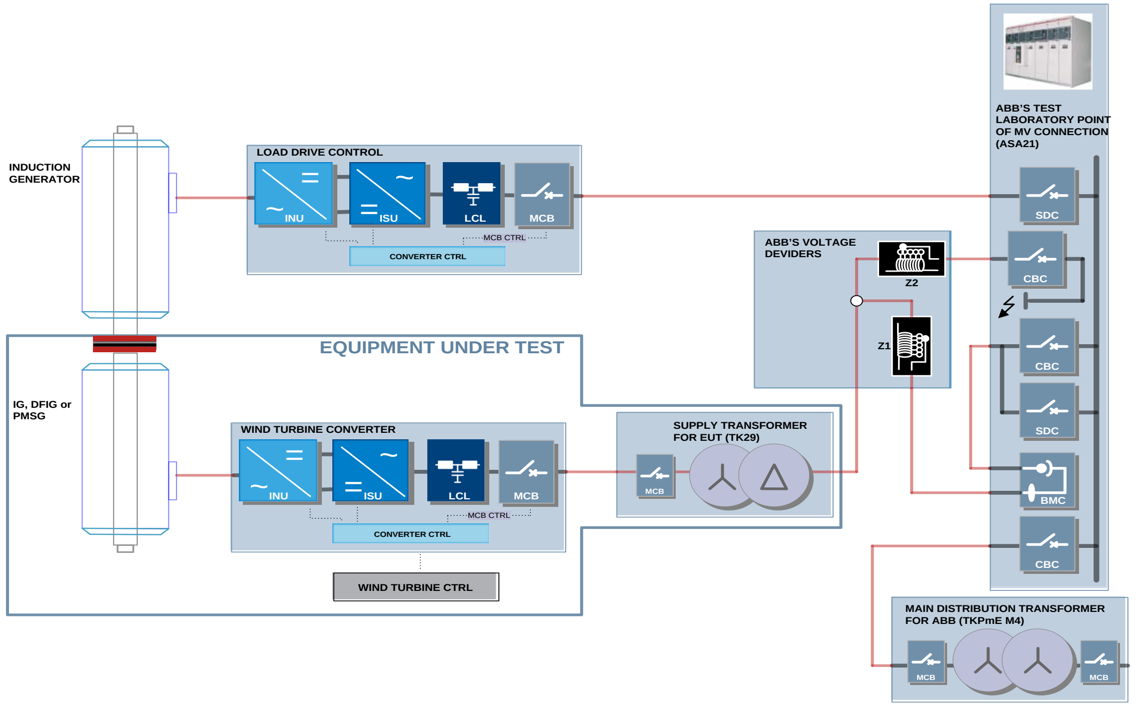
Detailed model "black box" (EMT) of WT 4 type model – Full power converter

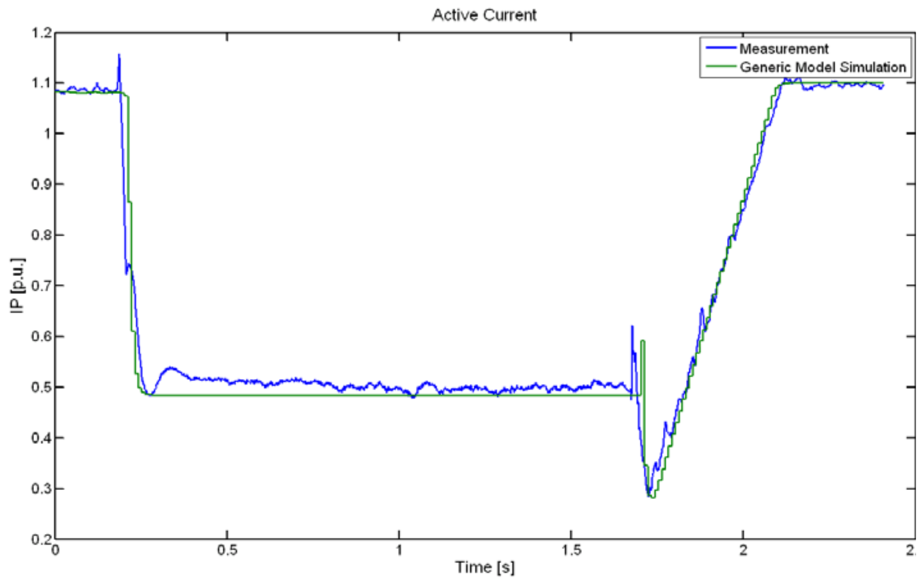


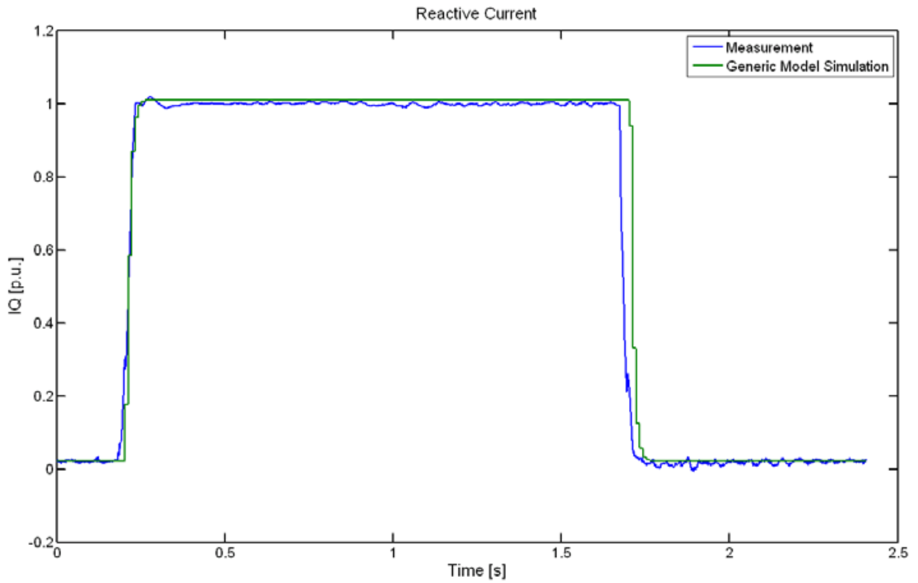
Generic model "open source" (RMS) of WT 4 type model – Full power converter

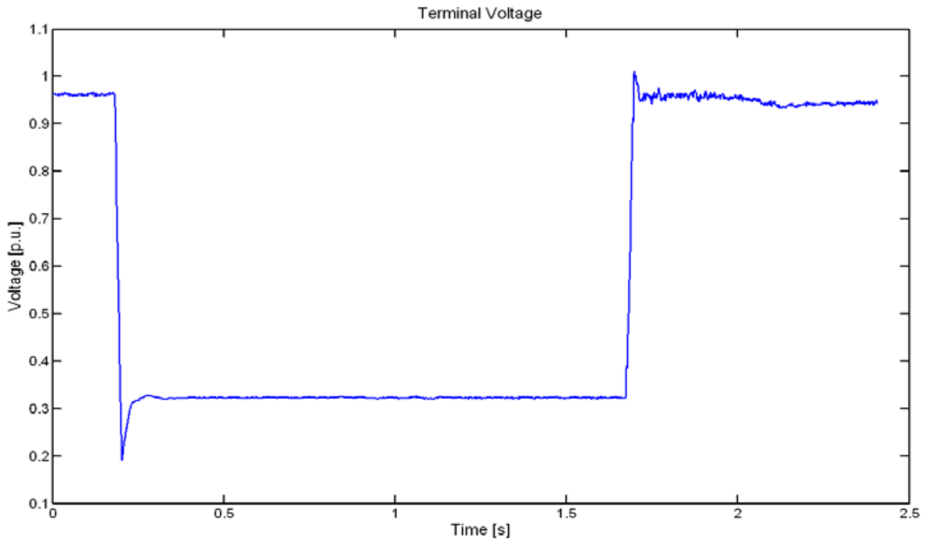


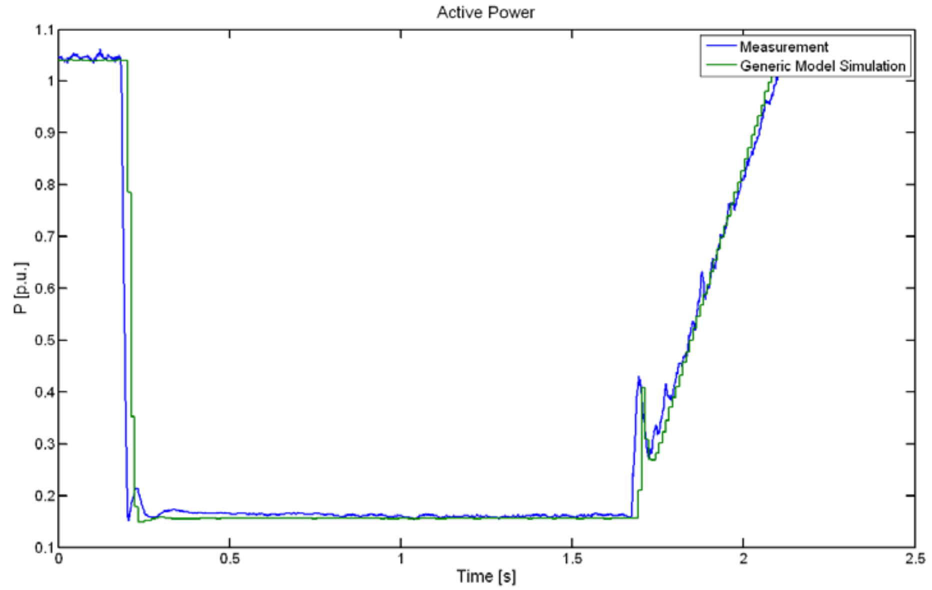
Challenge #4: Advanced Simulation Models – Validation

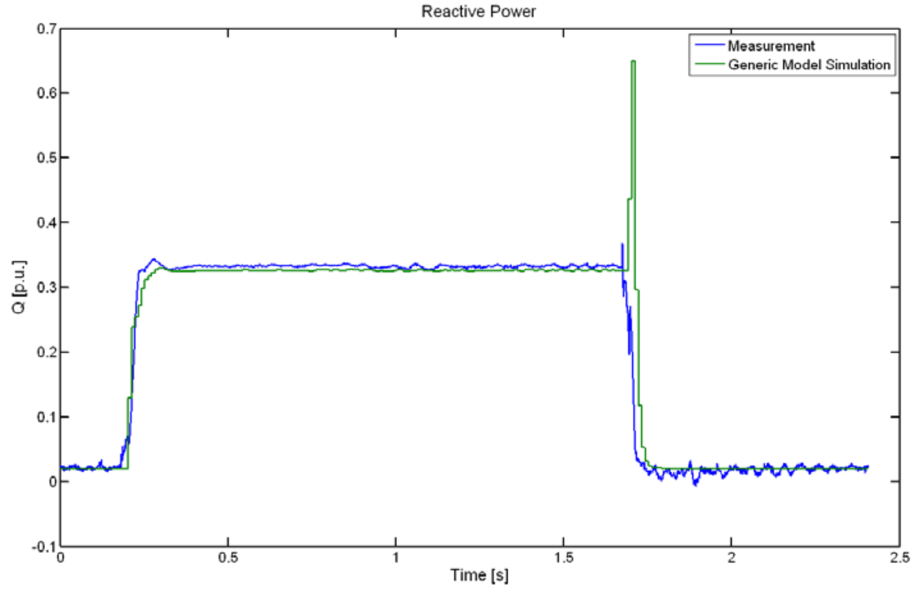








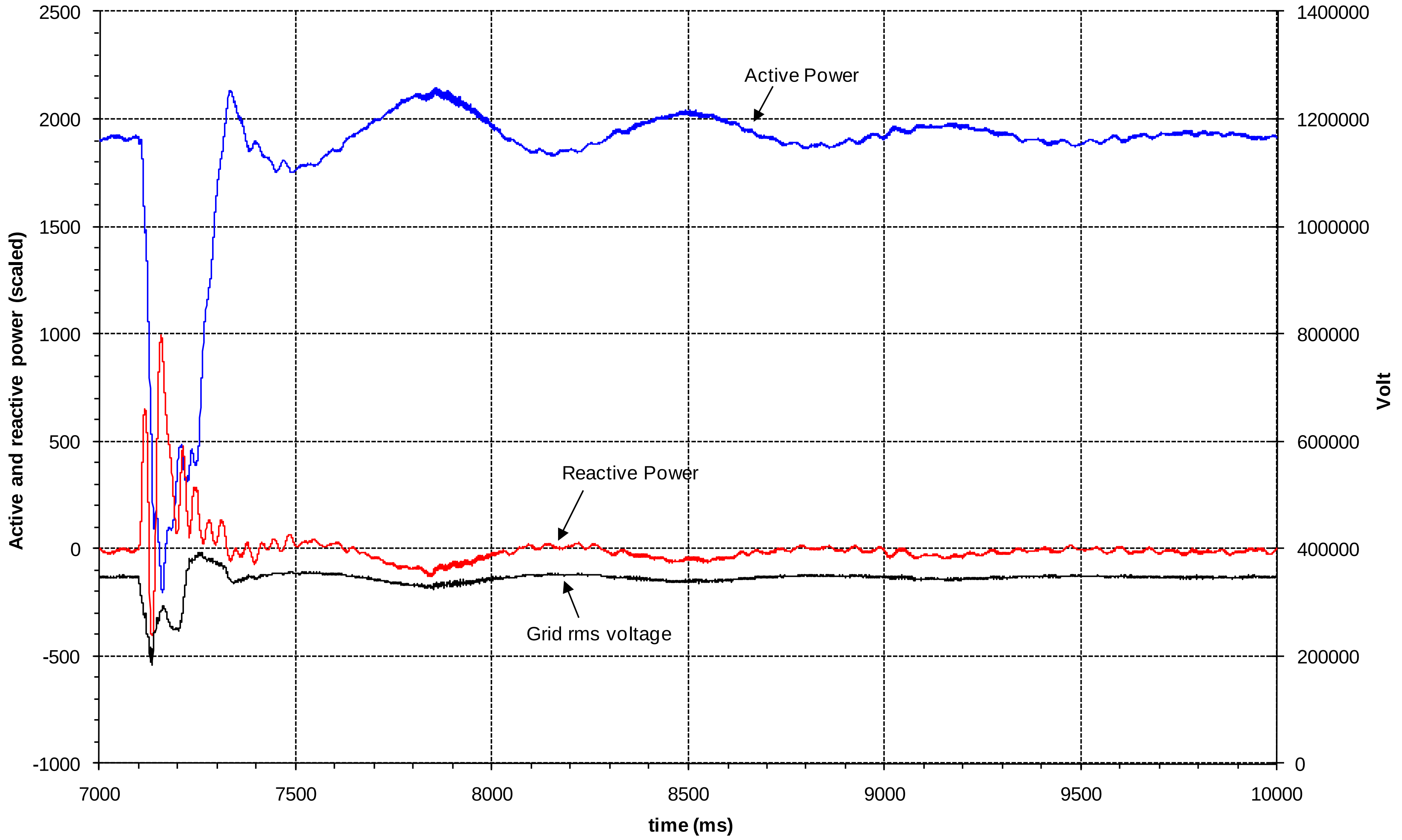




WT 4 model against full power test - 2,5 MW, Full converter under 3-ph dip , Generic model Ts = 5 ms

Challenge #5: Series compensated lines & DFIG wind farm

Voltage dip, 55 % compensated line, R_{SC} about 1.6 at the point of connection



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