

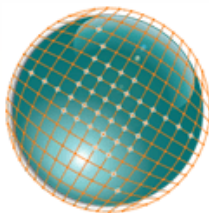
Active Distribution Network (ADINE) Modeling and real-time simulation

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**Integration of
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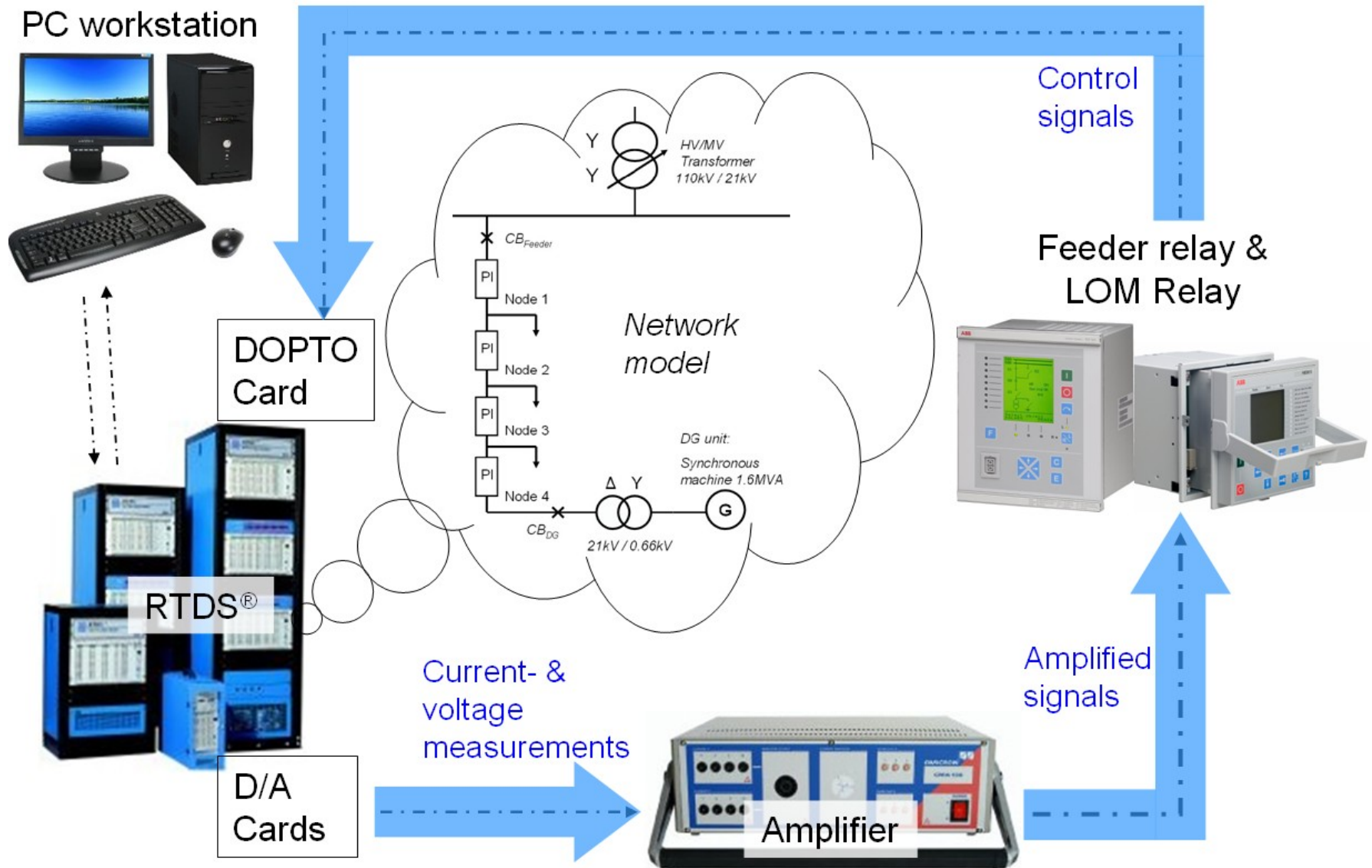
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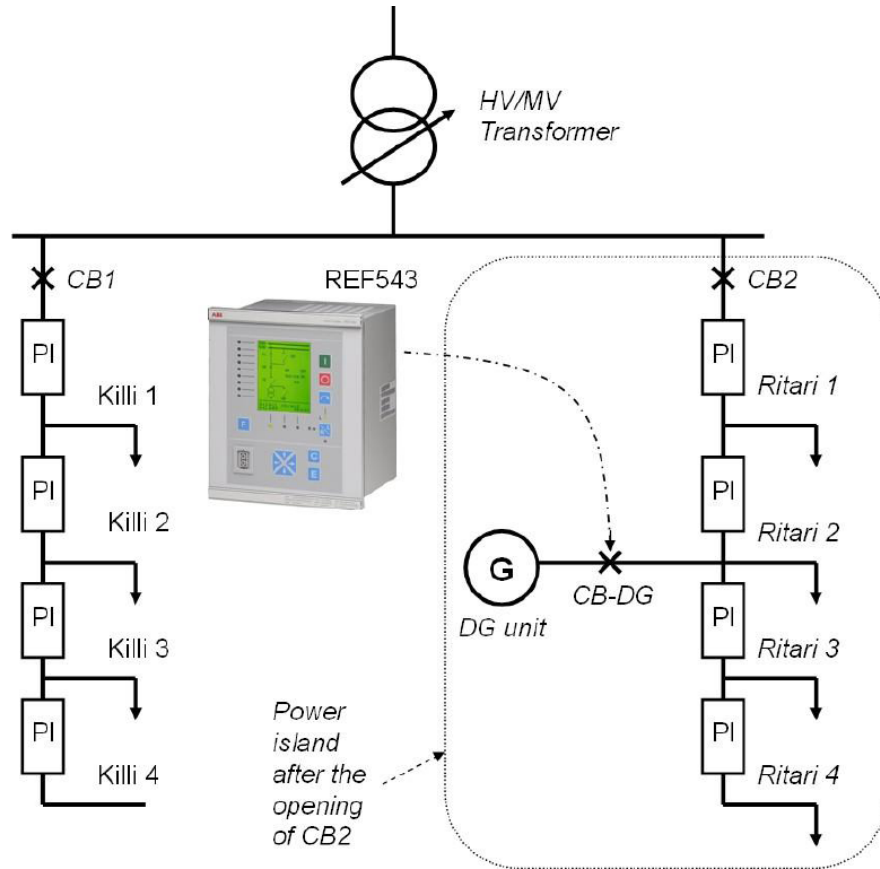
Contents

- Real-time digital simulations with RTDS
- Combination of RTDS and dSPACE simulations
- Example of “ideal” simulation sequence
- Interaction simulation

Hardware in loop testing



Non-detection zone of LOM

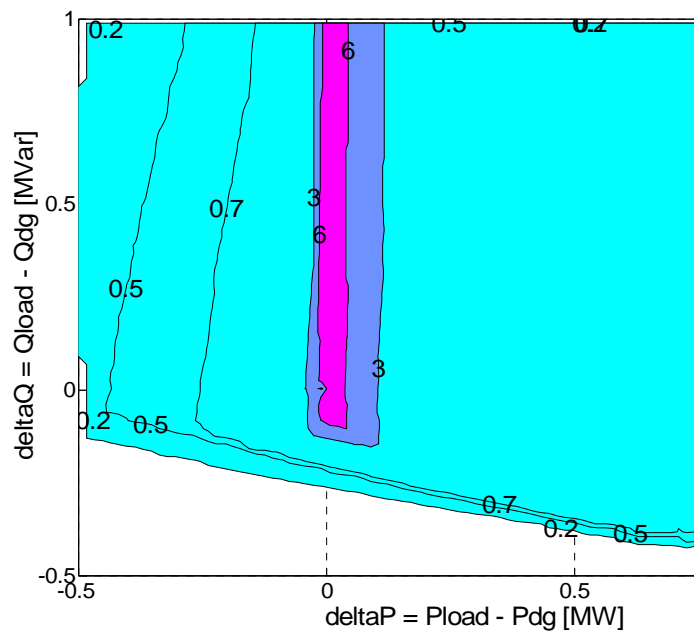


	Operation limit	Delay [s]
$f <$	47 Hz	0.2
$f >$	51 Hz	0.2
$U <$	90 %	10
$U >$	106 %	10
$U \ll$	50 %	0.1
$U \gg$	110 %	0.05

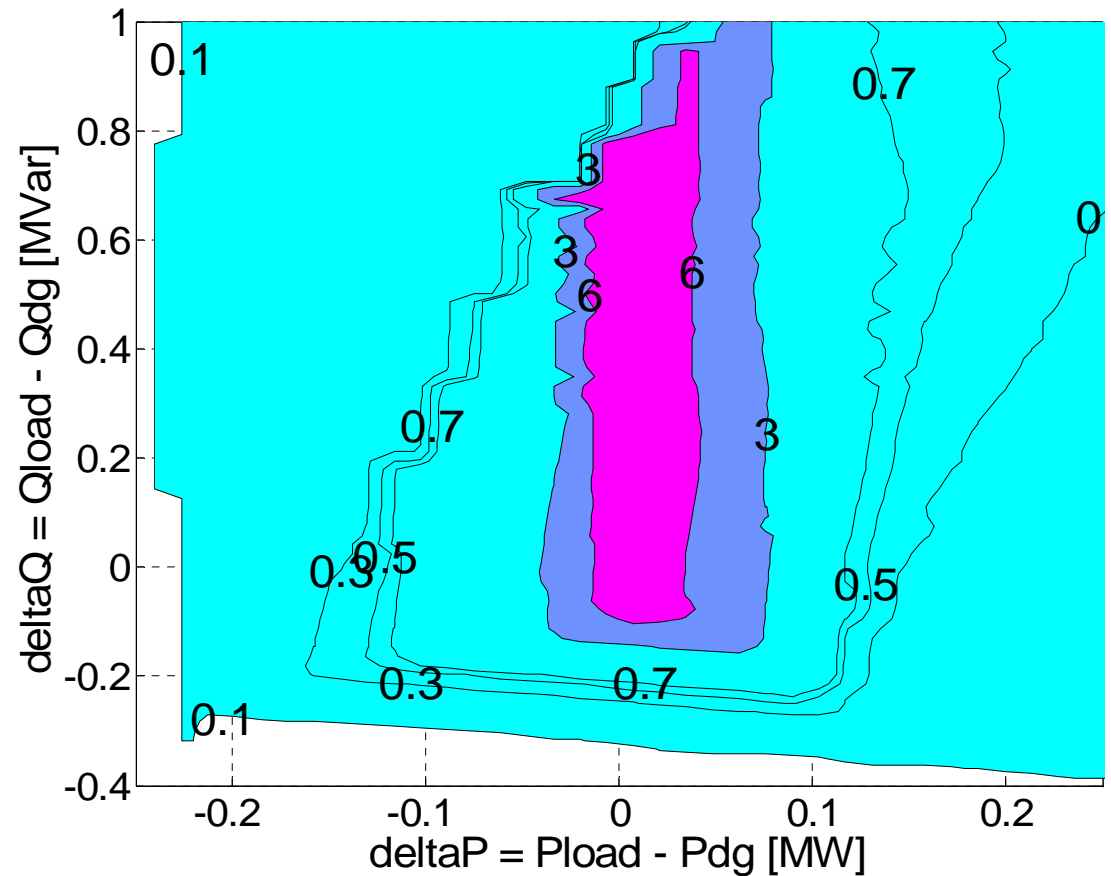
1.6 MVA hydro power unit, Synchronous generator
 Exciter + AVR (IEEE AC8B) and Q controller (IEEE Var Type 2)
 No turbine or governor controller

Non-detection zone of LOM

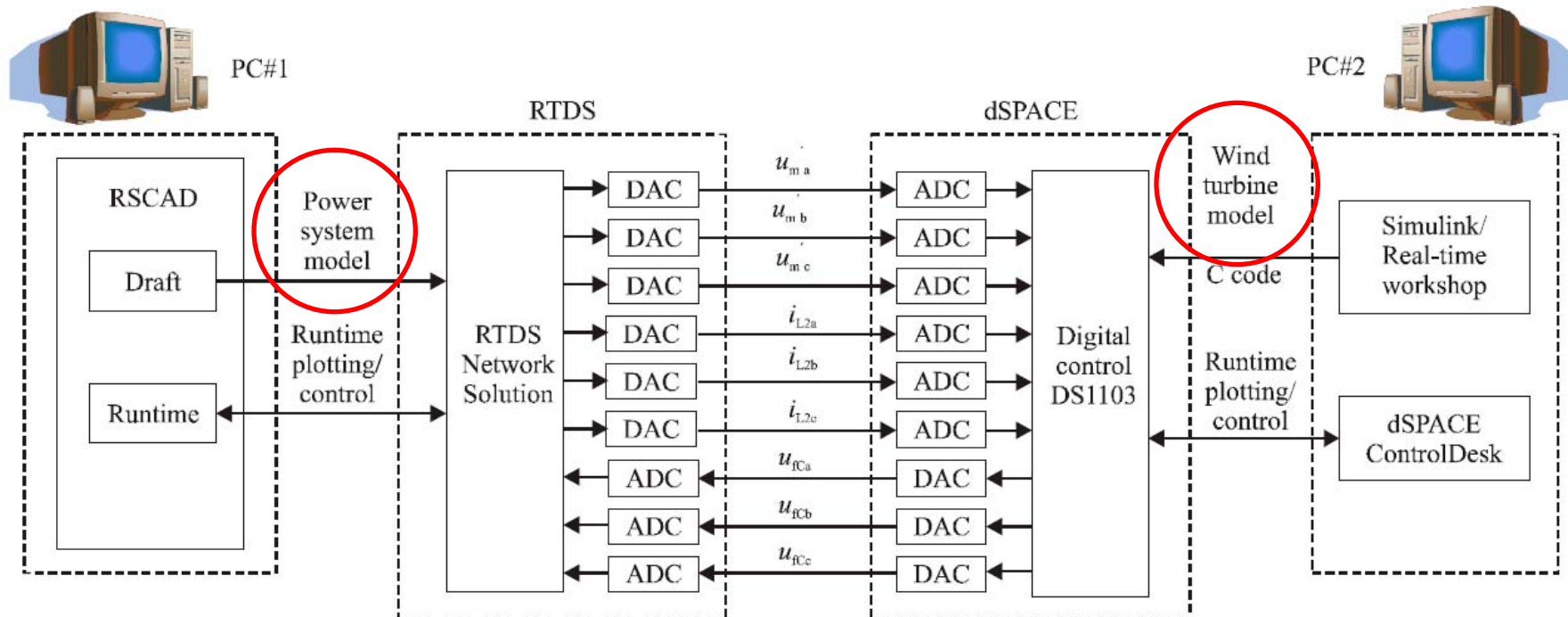
Frequency and voltage functions



Frequency and voltage Functions + ROCOF

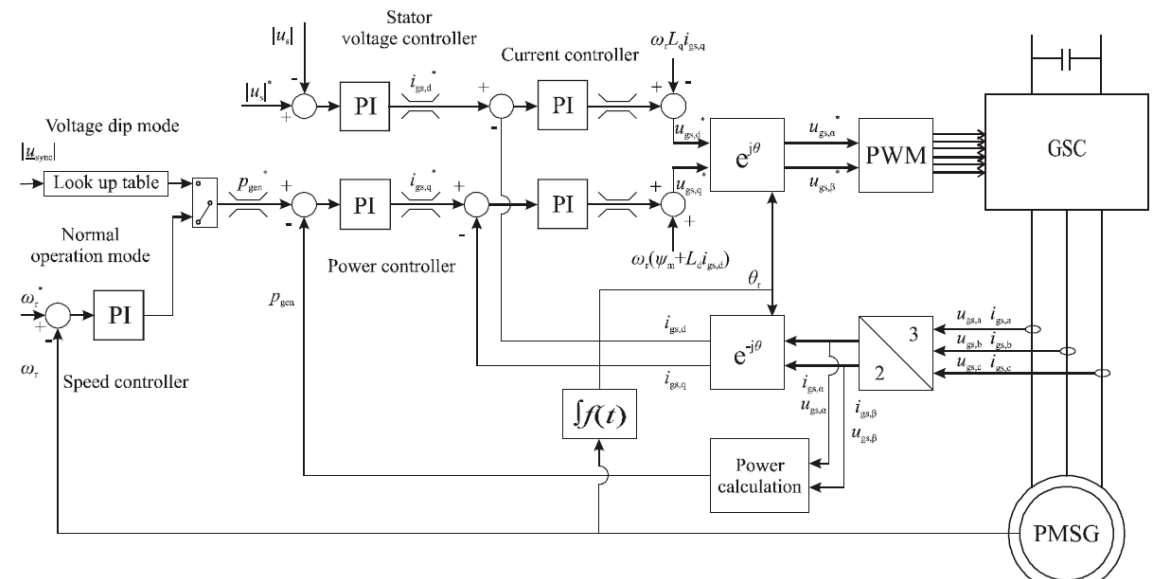
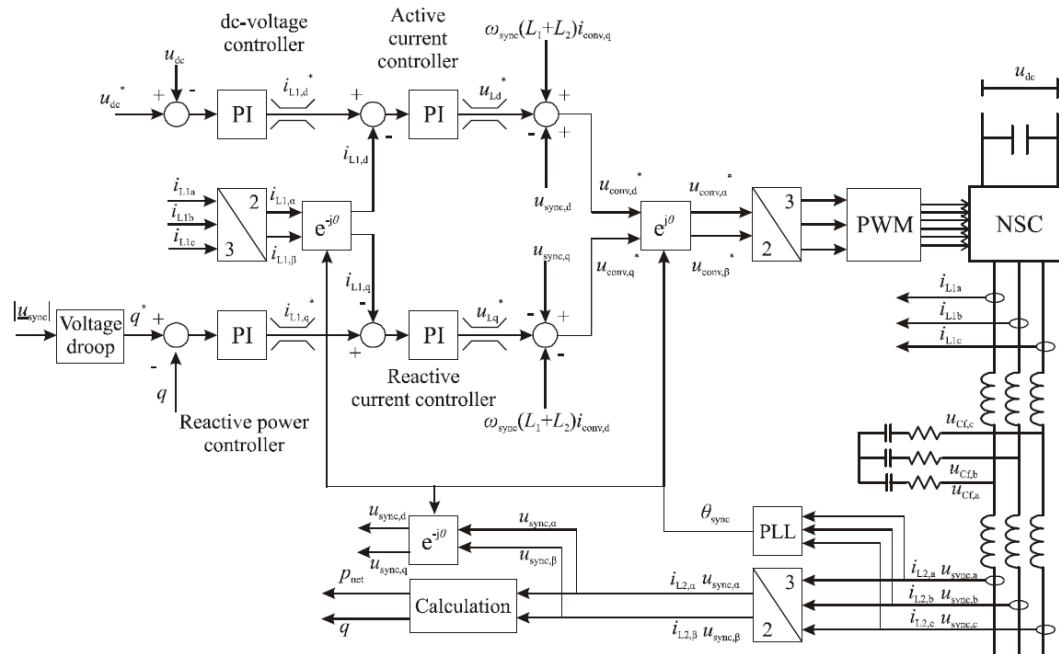


Combination of RTDS and dSPACE



dSPACE is real-time simulator for control systems
(we use dSPACE to model power electronics and its control)

Full power converter models



Example of full power converter FRT simulations

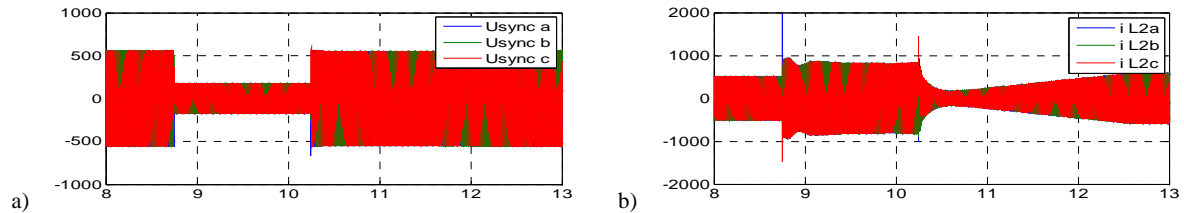


Fig. 4.4. a) Connection point voltage, b) Connection point current.

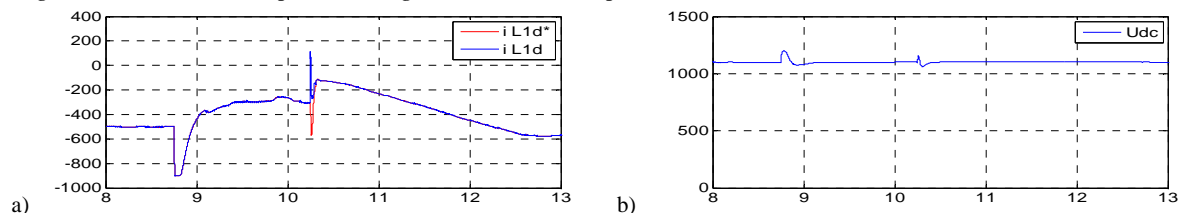


Fig. 4.5. a) d-component of the grid current and its reference, b) dc-link voltage and chopper current during the fault.

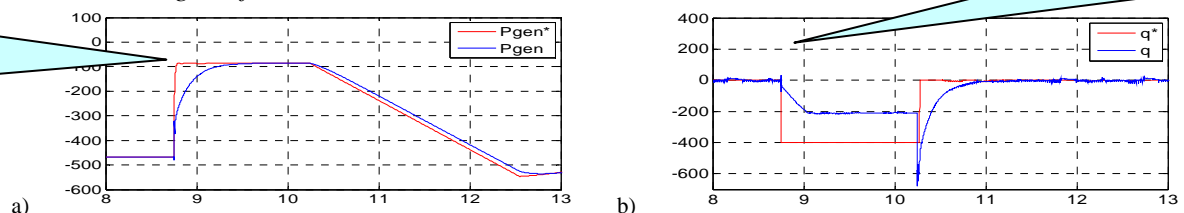


Fig. 4.6. a) Instantaneous active power of the generator and its reference, b) Connection point instantaneous reactive power and its reference.

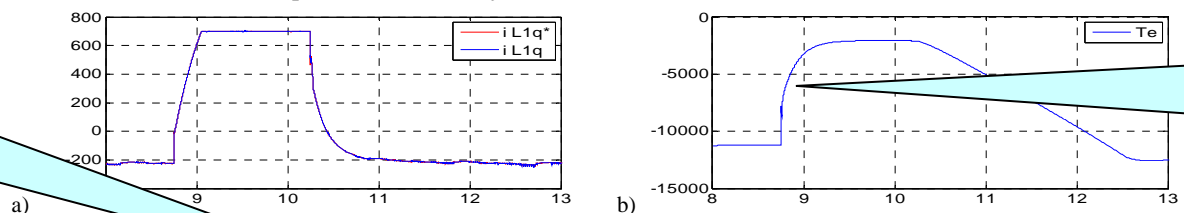


Fig. 4.7. a) q-component of the NSC current and its reference. b) Electrical torque of the generator.

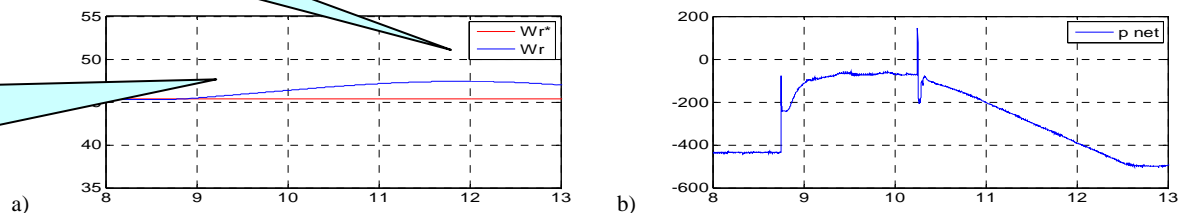


Fig. 4.8. a) Rotational speed of the turbine and its reference, b) Instantaneous active power in the network.

Output power reduction

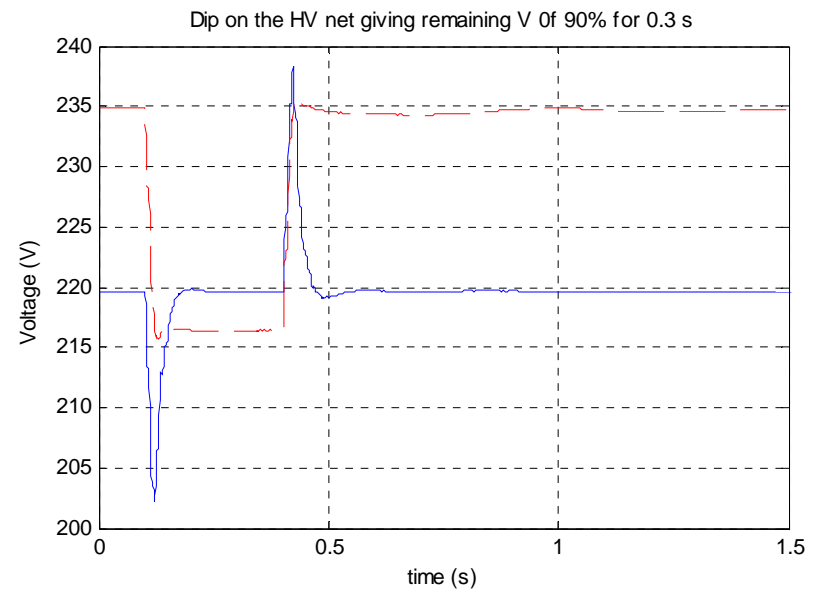
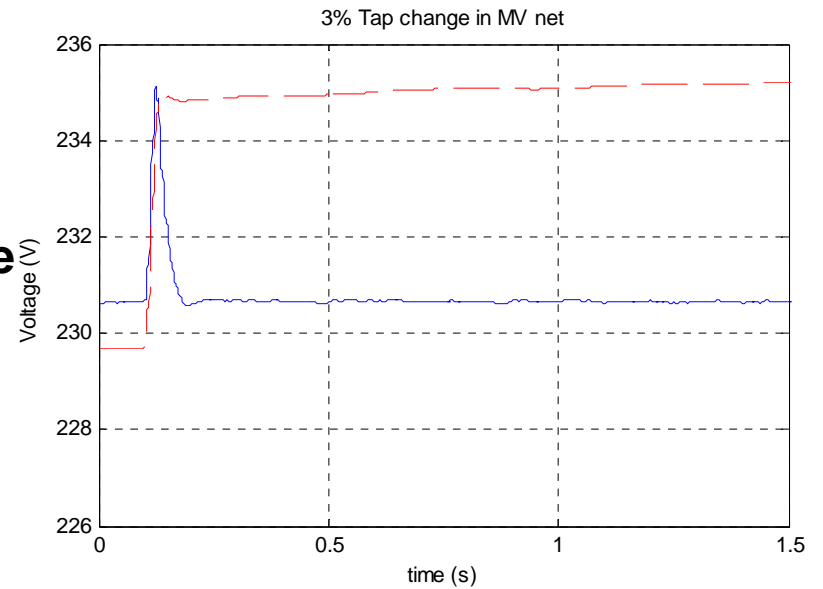
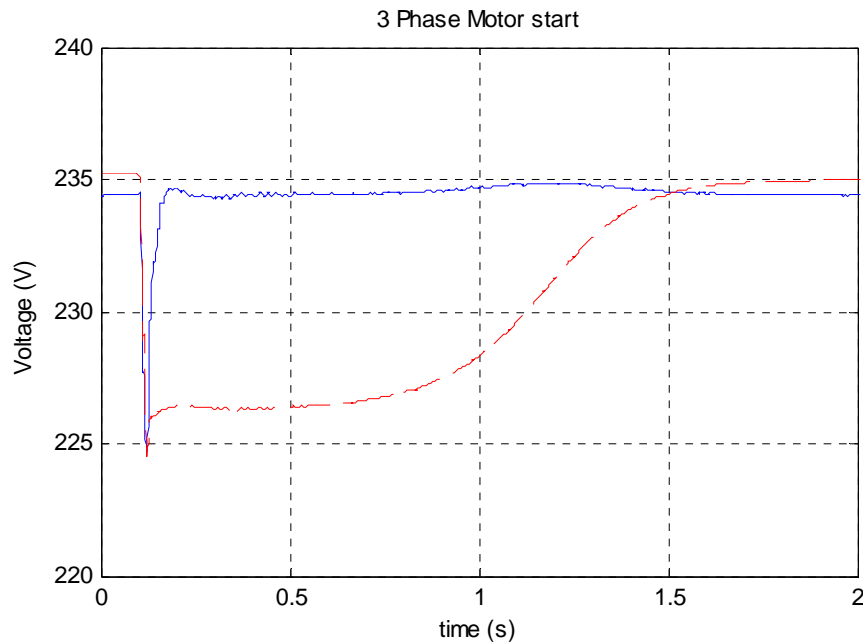
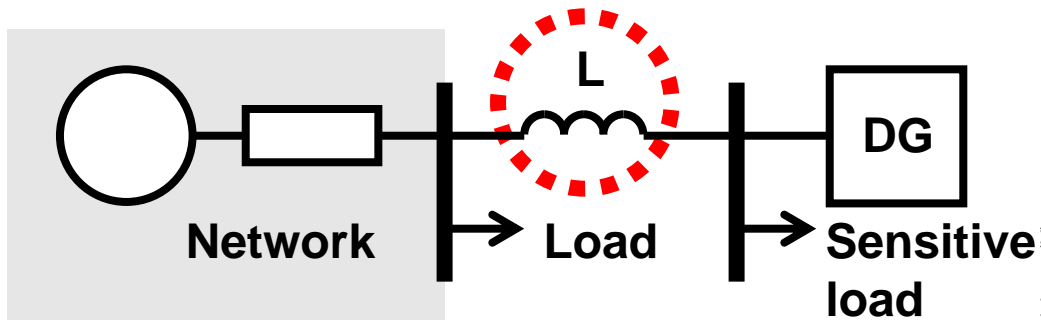
Reactive power support

Pitch control activated

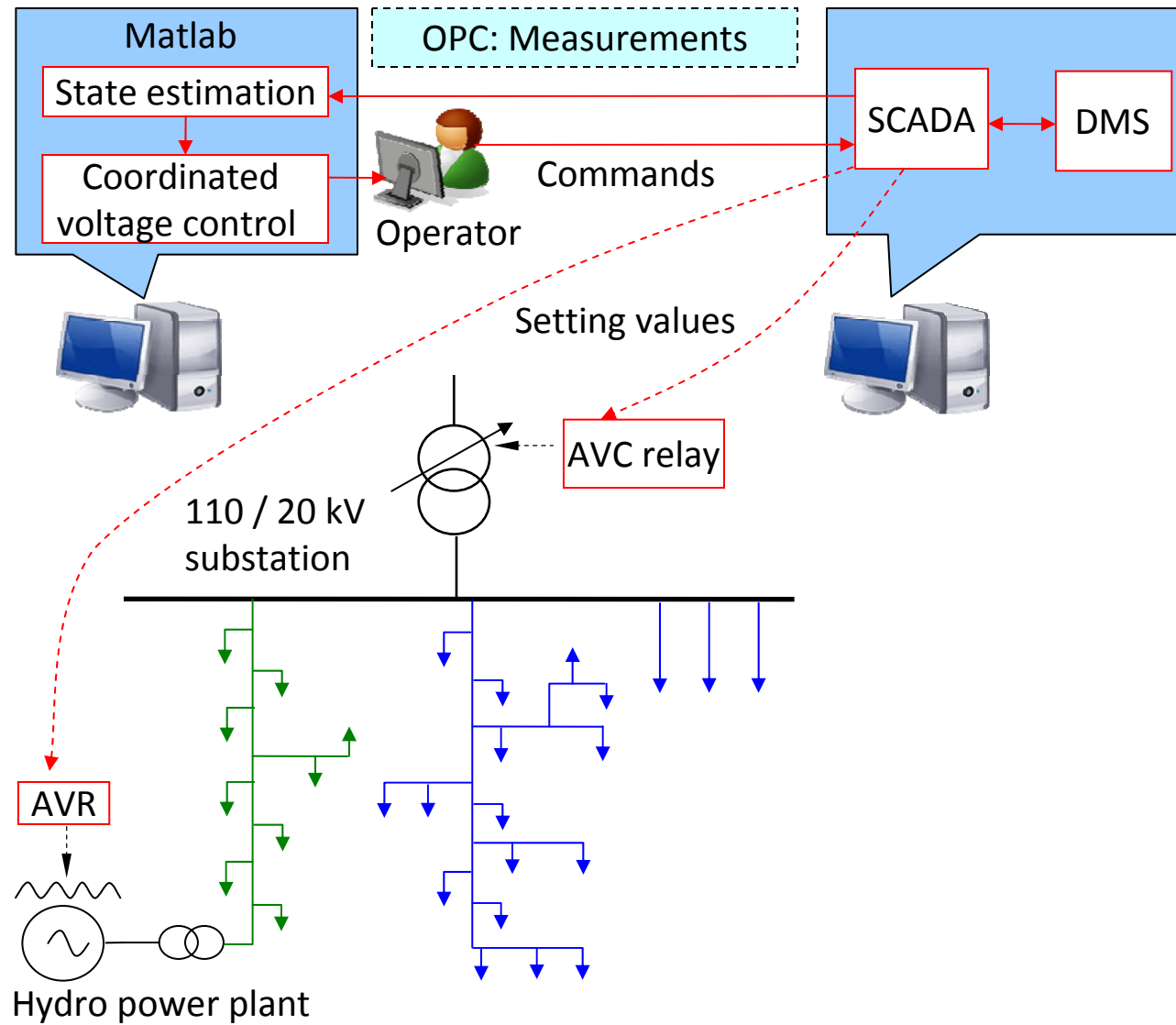
Reducing electrical torque

Kinetic energy increases

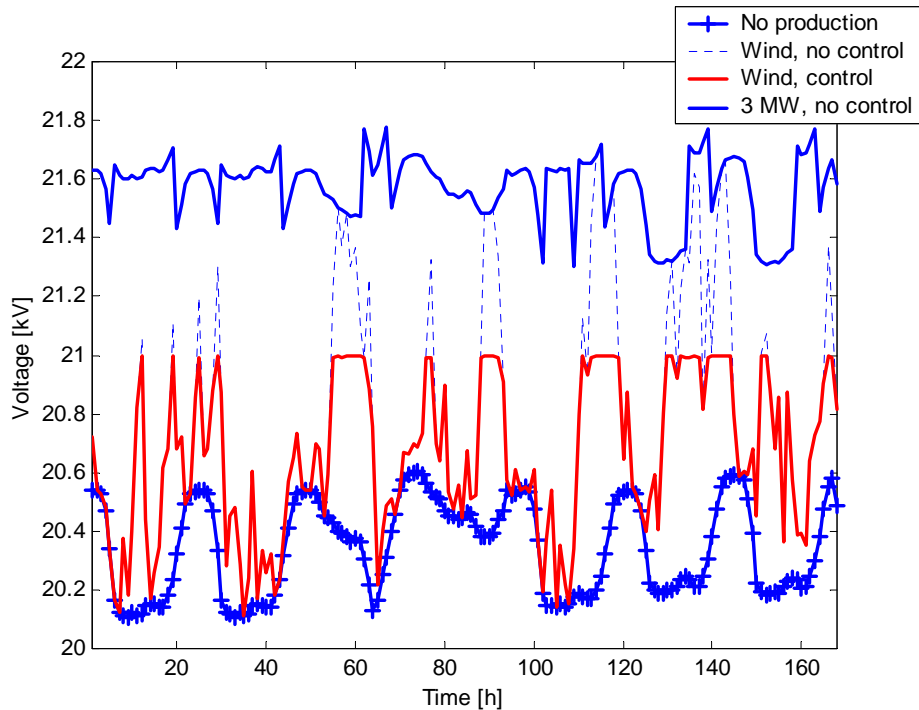
Microturbine LV network simulations



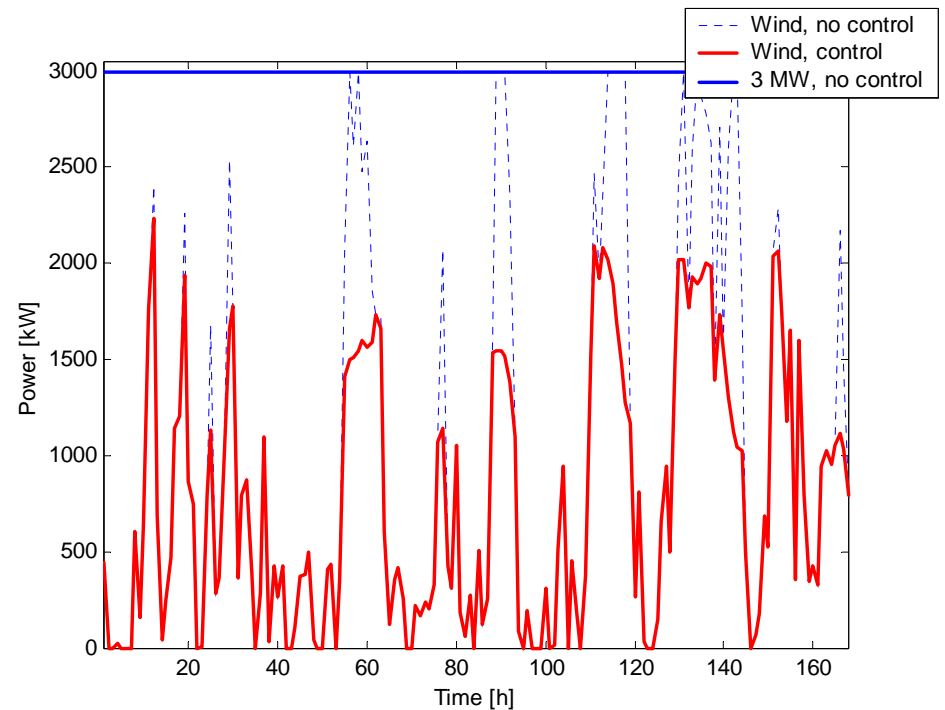
Co-ordinated voltage control



Loadflow studies

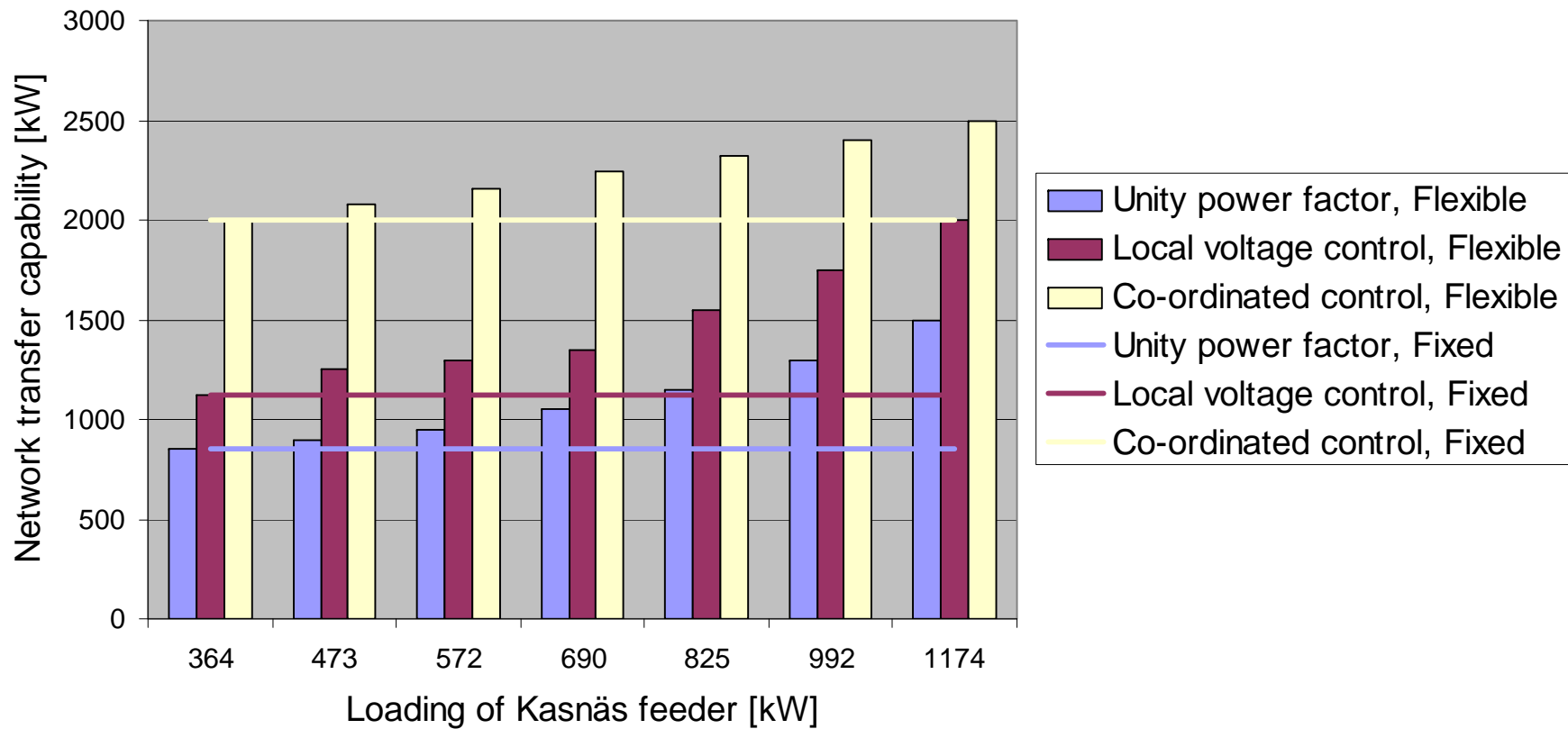


Voltage at wind farm connection point

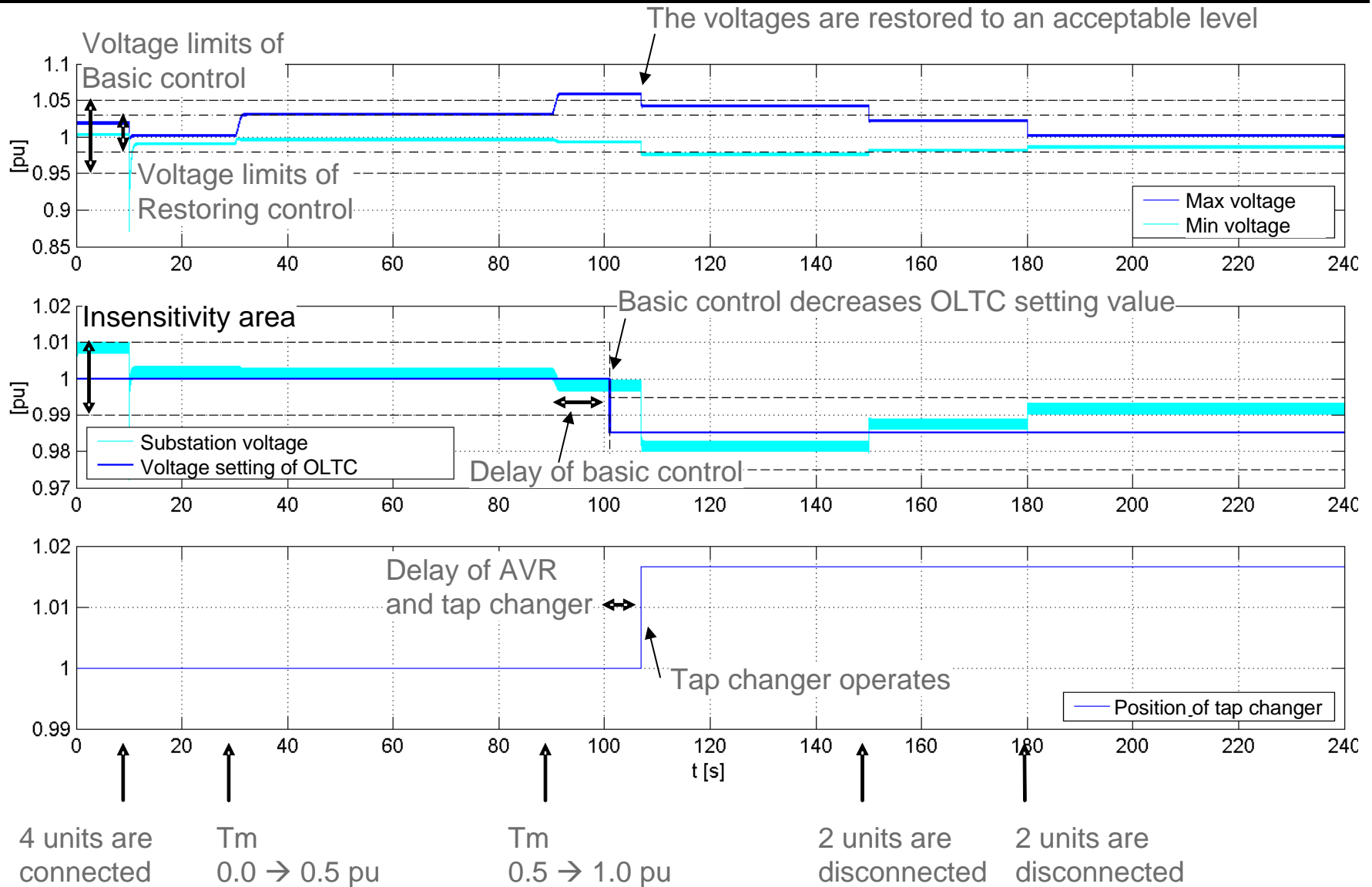


Wind power production

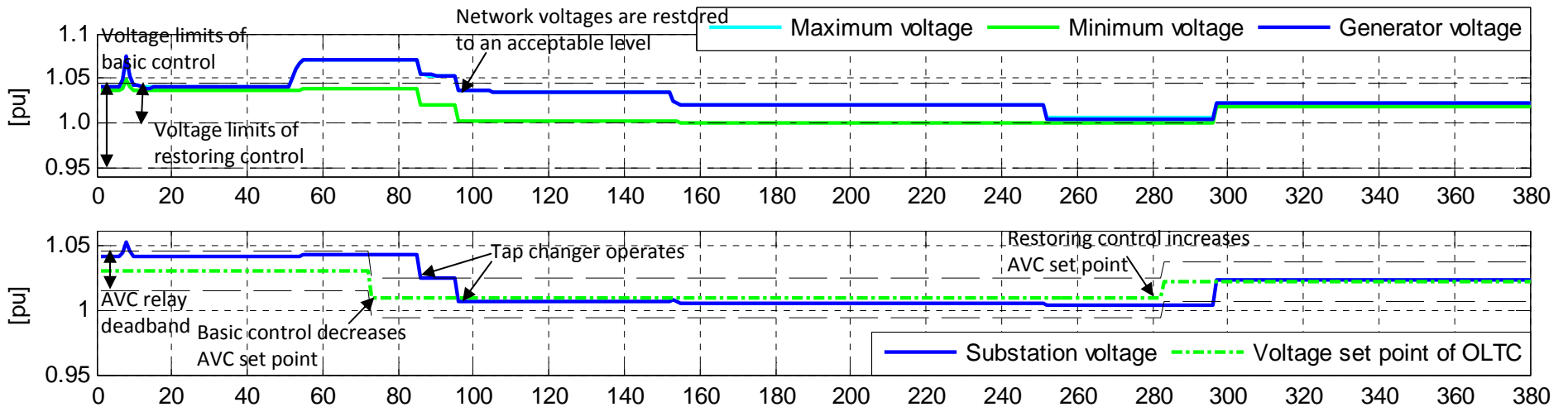
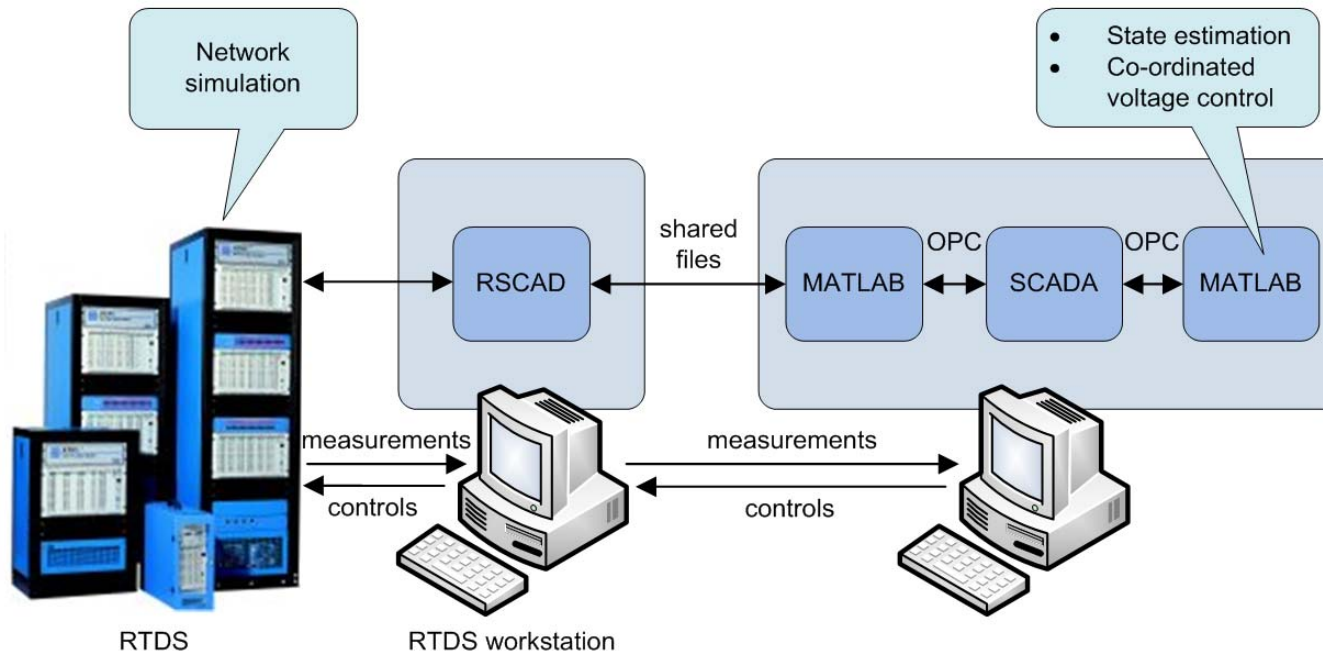
Benefits of co-ordination



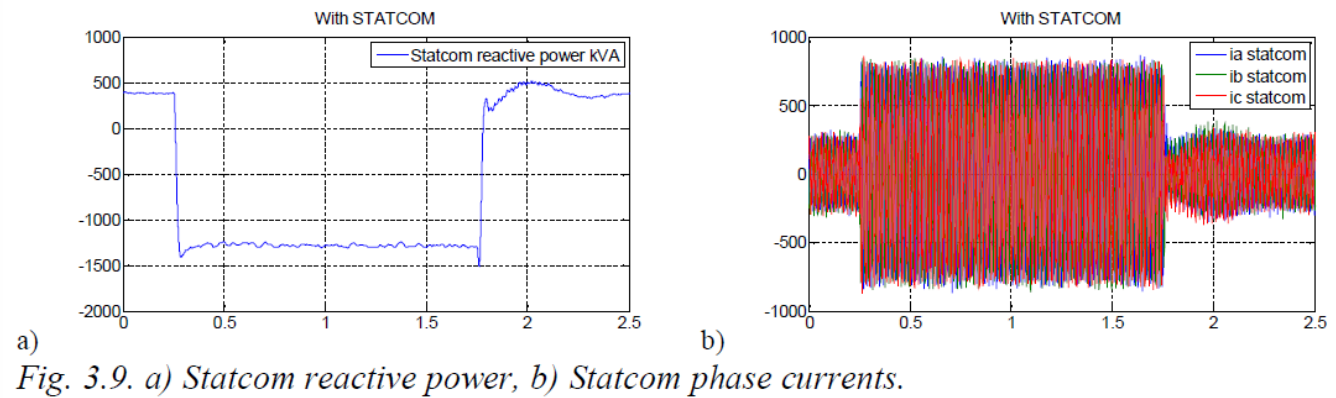
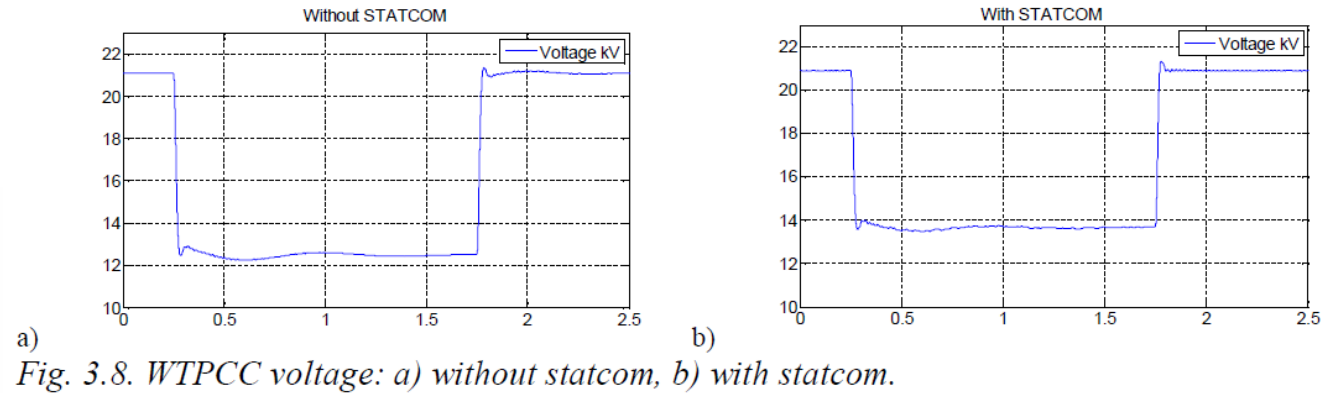
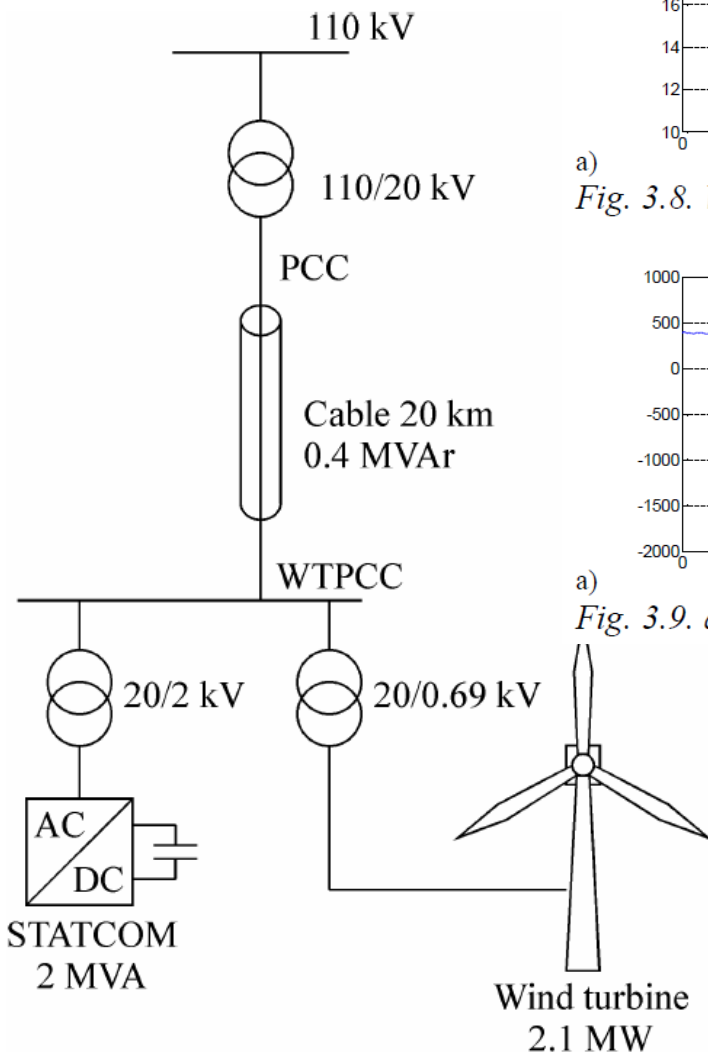
Time domain performance in PSCAD

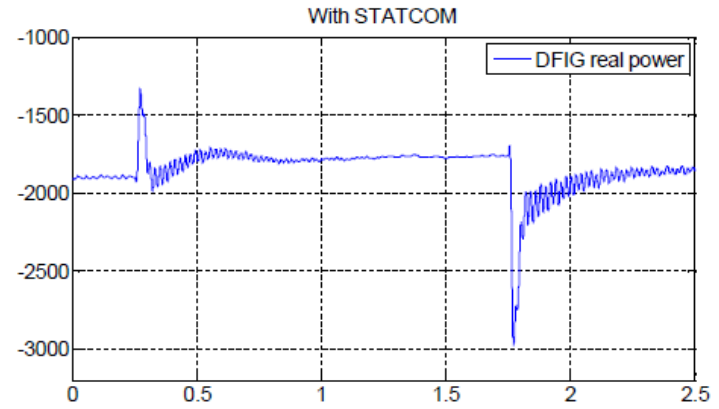
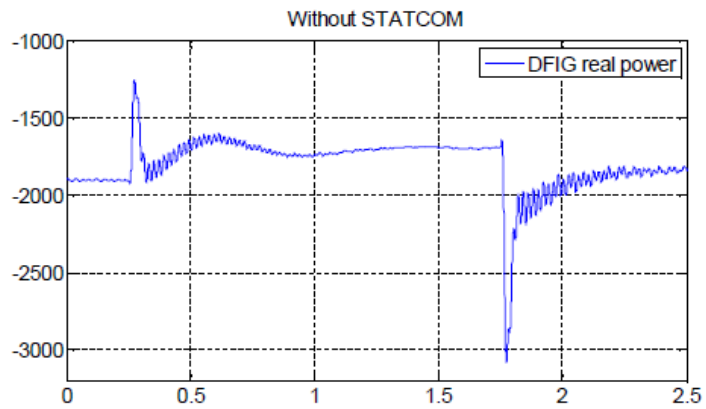


RTDS testing of control algorithm



Interactions of STATCOM and DFIG wind turbine

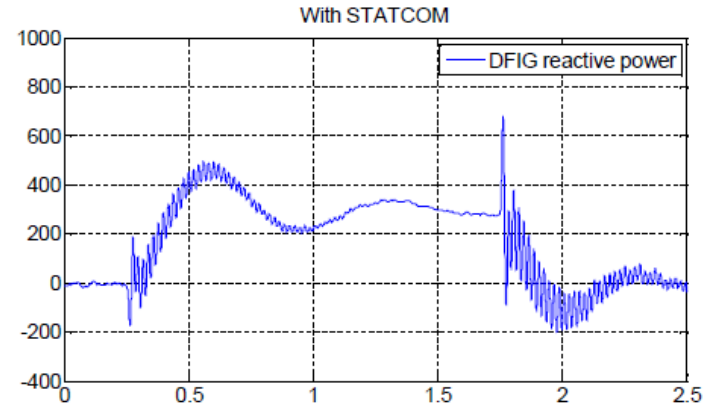
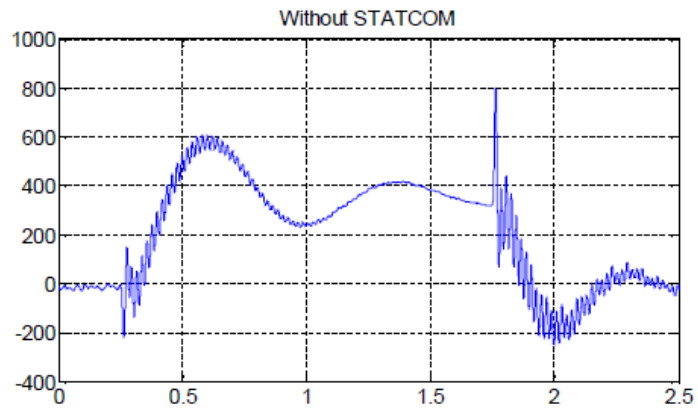




a)

b)

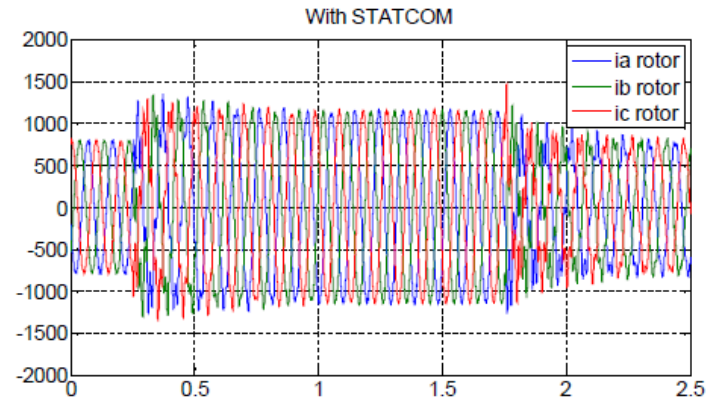
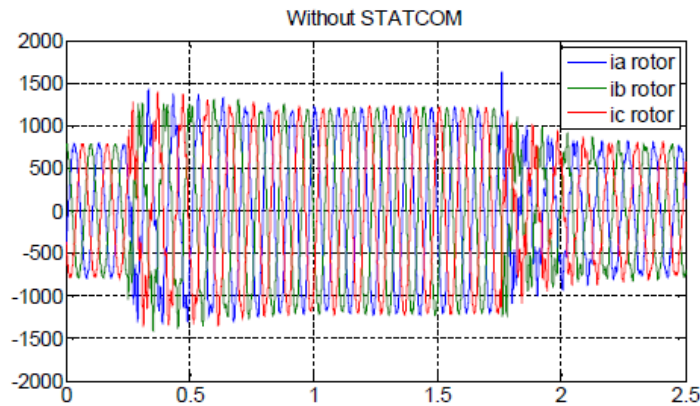
Fig. 3.10. Real power of DFIG: a) without statcom, b) with statcom.



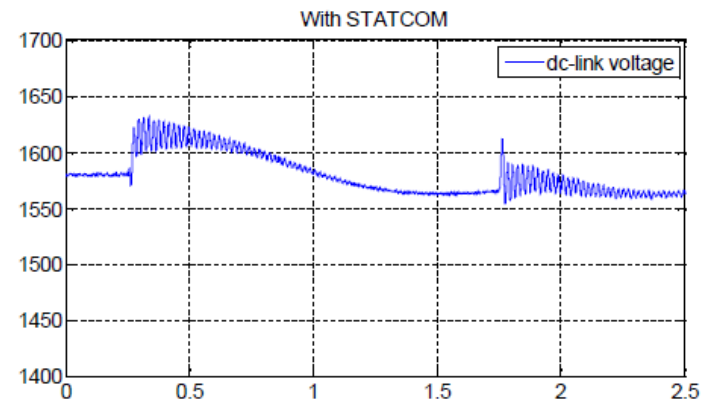
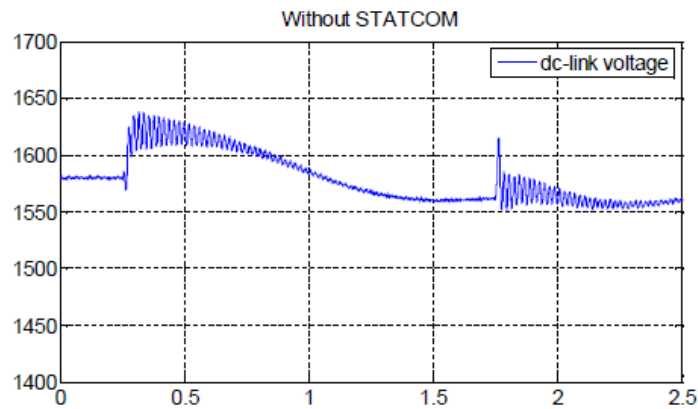
a)

b)

Fig. 3.11. Reactive power of DFIG: a) without statcom, b) with statcom.

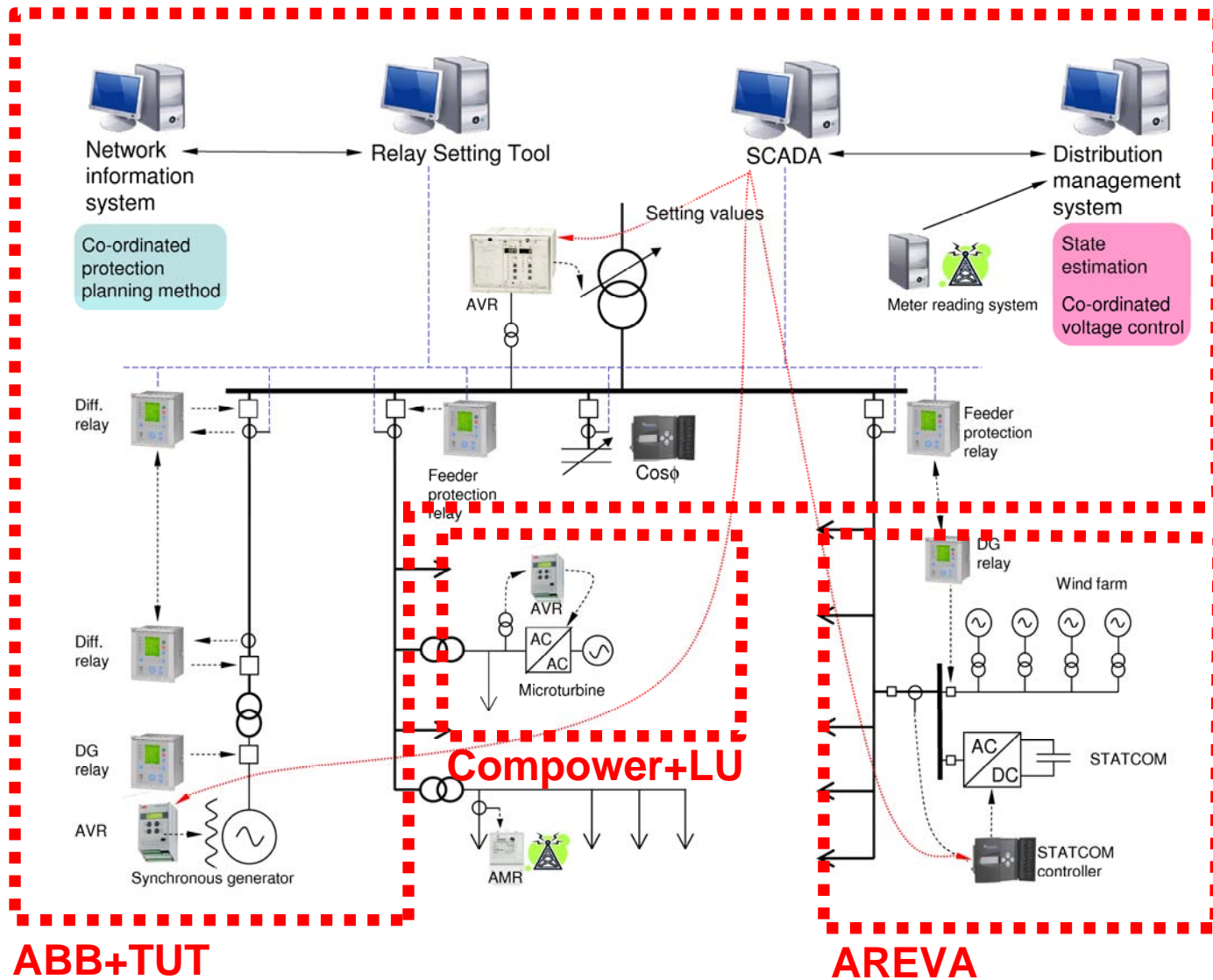


a) *Fig. 3.12. DFIG rotor current: a) without statcom, b) with statcom.*



a) *Fig. 3.13. dc-link voltage of the frequency converter: a) without statcom, b) with statcom.*

Test sites





ADINE is a project co-funded by the European Commission



Thank you!



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www.adine.fi



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Department of Electrical Energy Engineering