



Monitoring of Power System Dynamic Performance

Tutorial Part 2, Section 3:

Dynamic Modelling and Stability Calculations Approach

ETRANS, Laufenburg, Switzerland

Walter Sattinger
System Planning and Studies Dept.



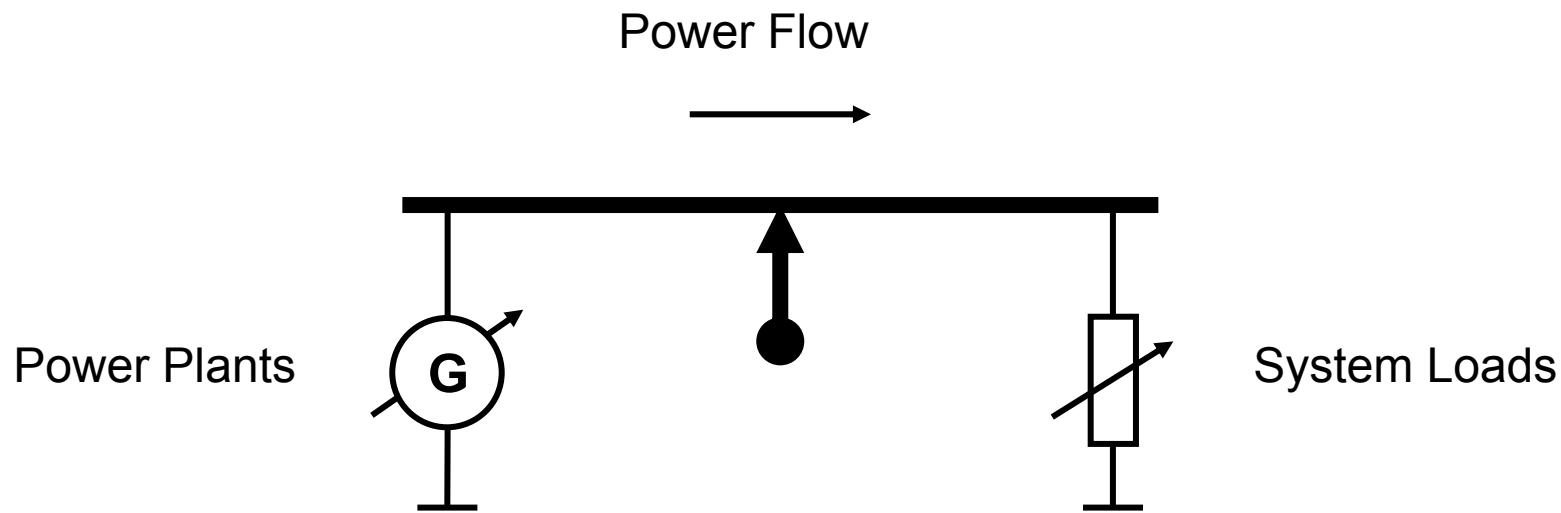


Content

- System power balance indices and control
- Time ranges and control schemes
- Dynamic system modelling
- Dynamic system parameter identification
- Application of dynamic system calculations



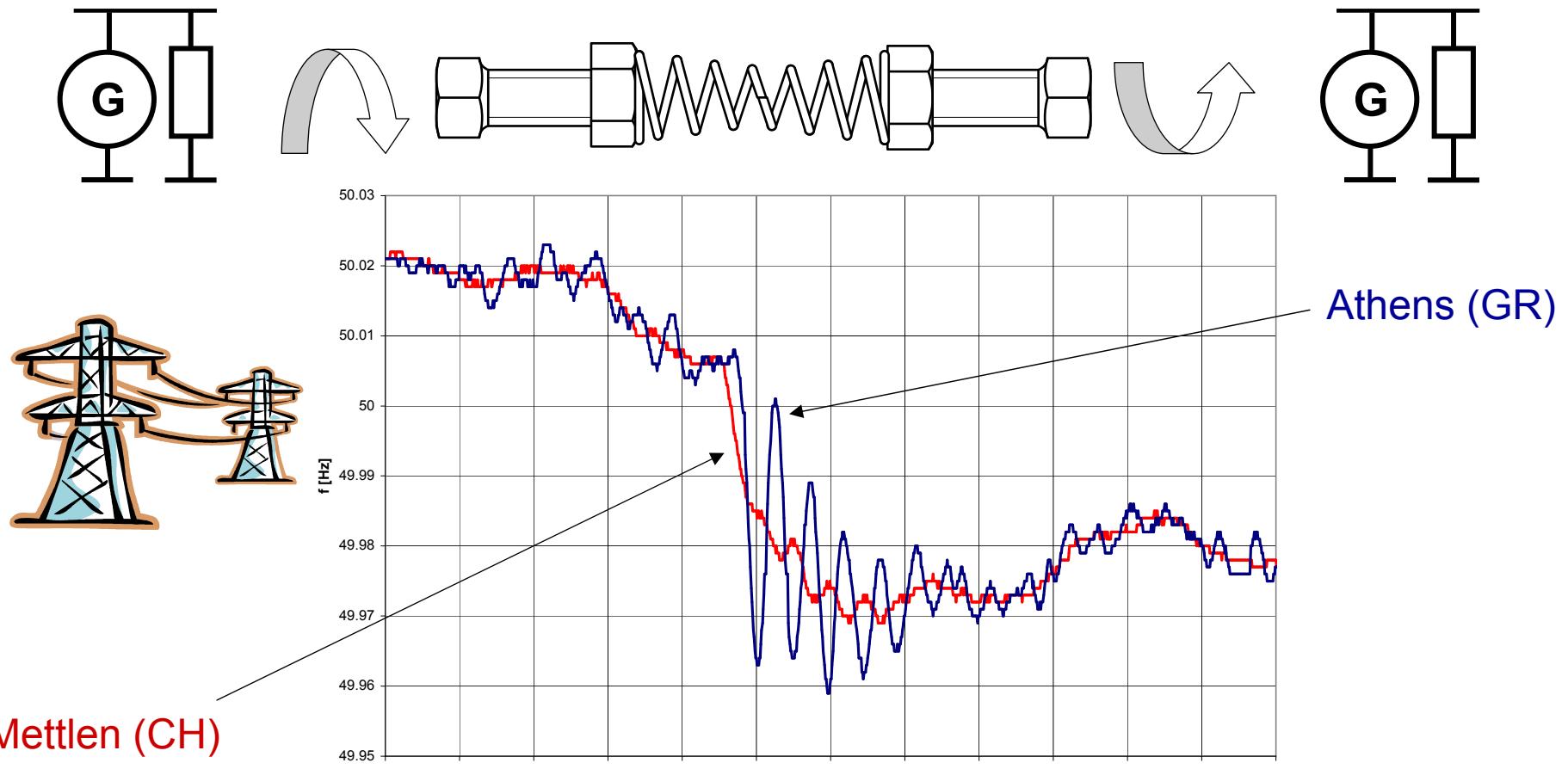
System Frequency = Balance between Generation and Consumption



Aktuelle Frequenzabweichung (mHz)	
-250	-200
-150	-100
-50	0
50	100
150	200
250	
Aktuelle Netzfrequenz	50.002 Hz
Aktuelle Zeitabweichung	12.010 Sec

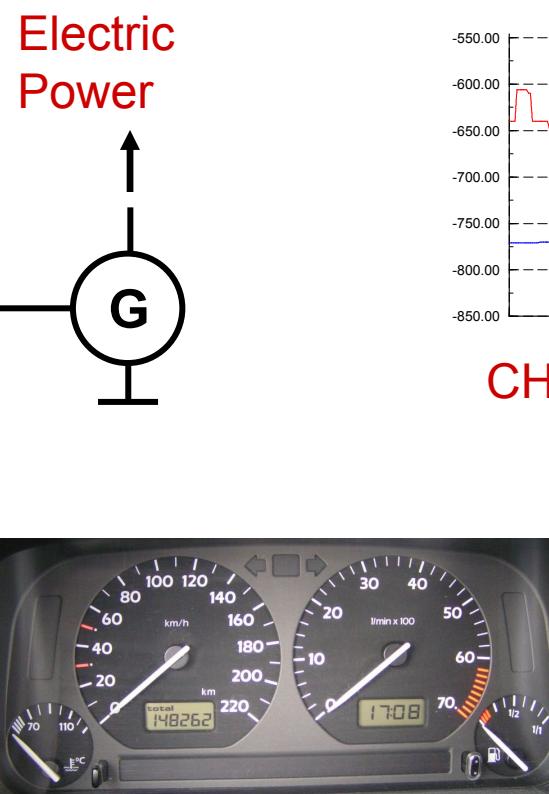
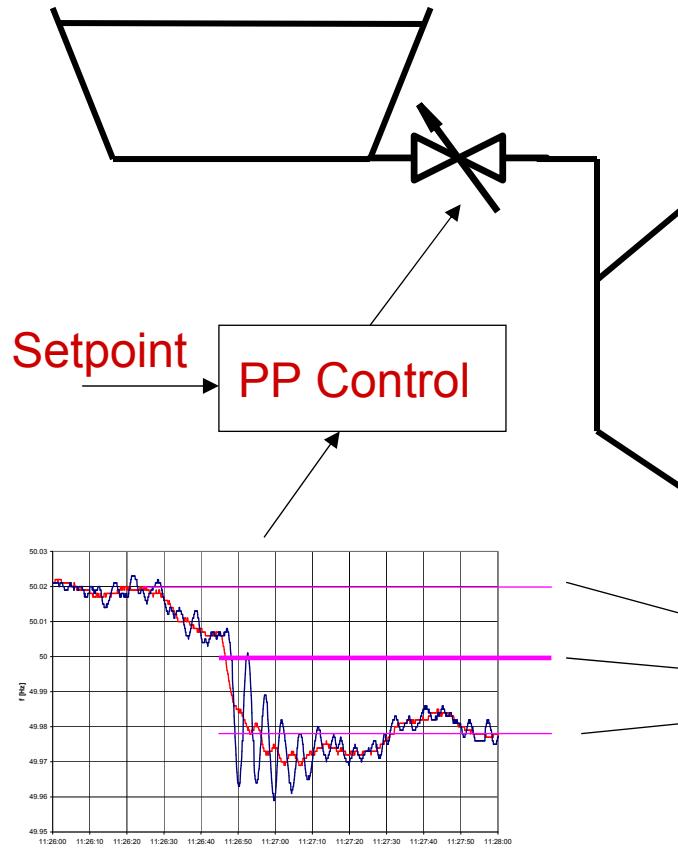
<http://www.etrans.ch/services/online/frequency/>

Transmission System = Elastic Shaft between Areas



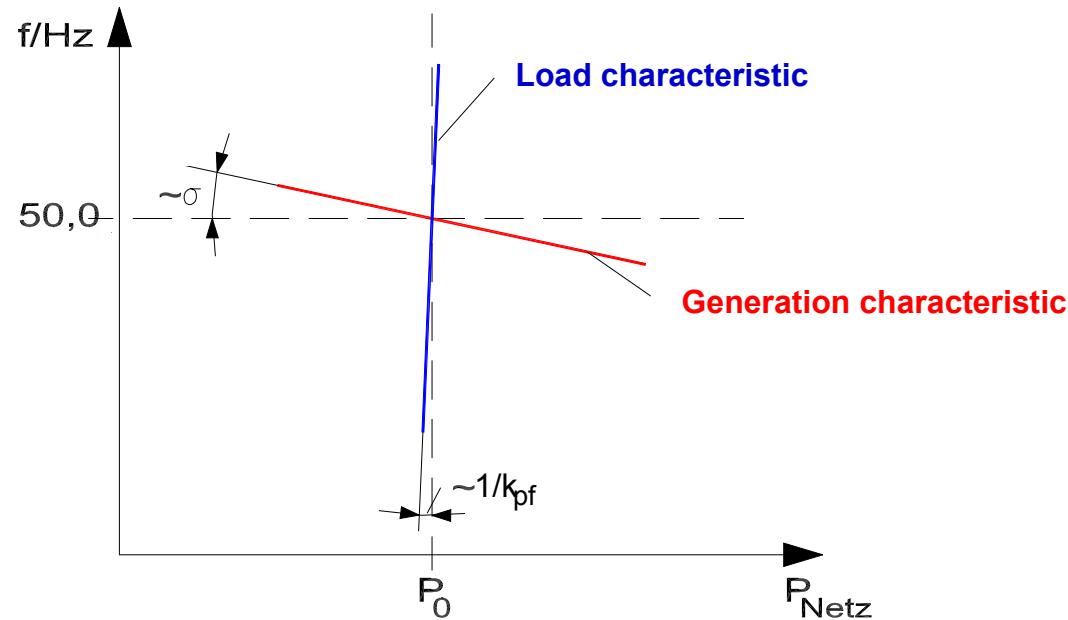
1200 MW PP Outage 09.02.06 in Spain

System Control = Automatic Speed Control





Generation and Load Characteristic

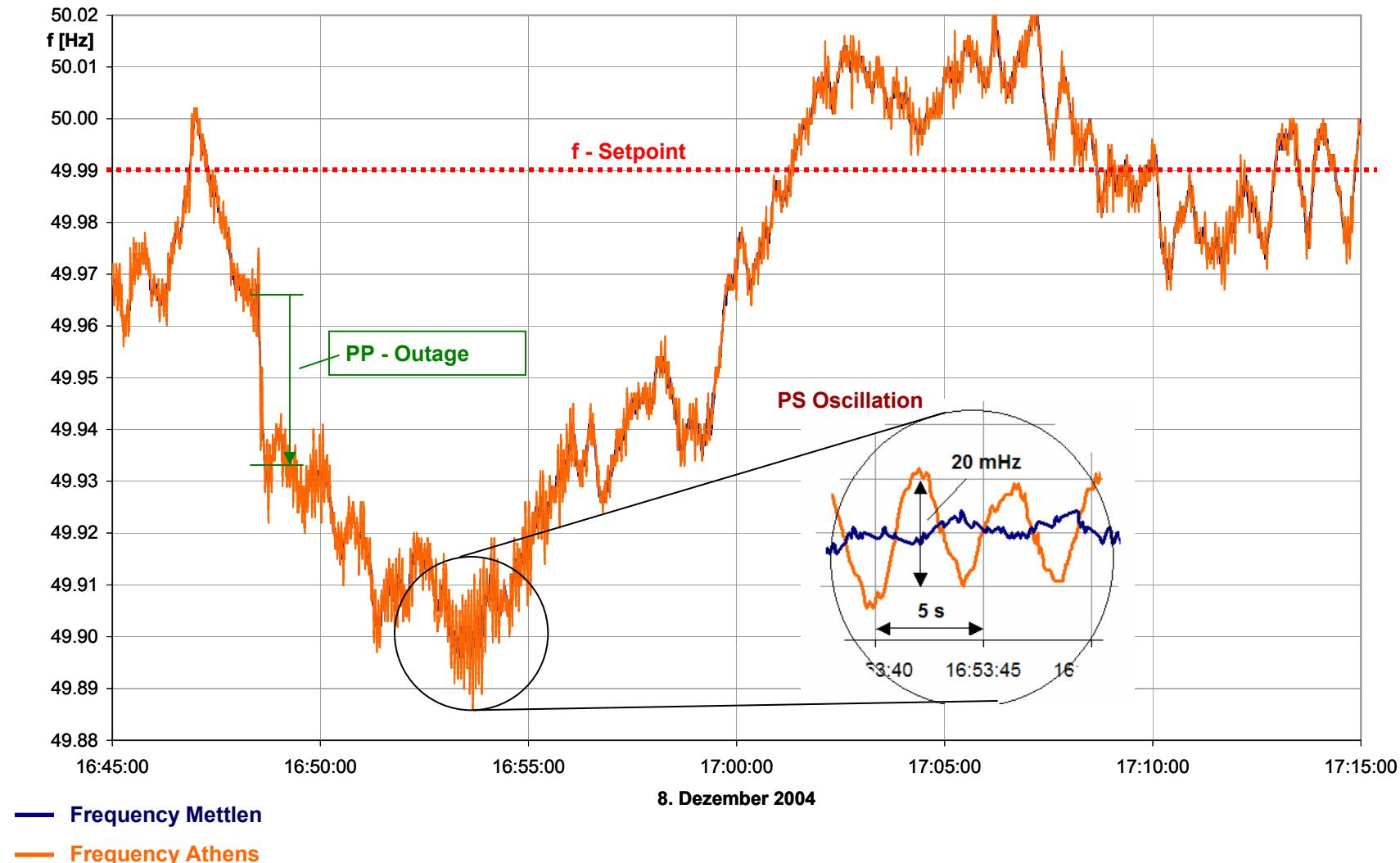




Time Ranges with Respect to System Stability

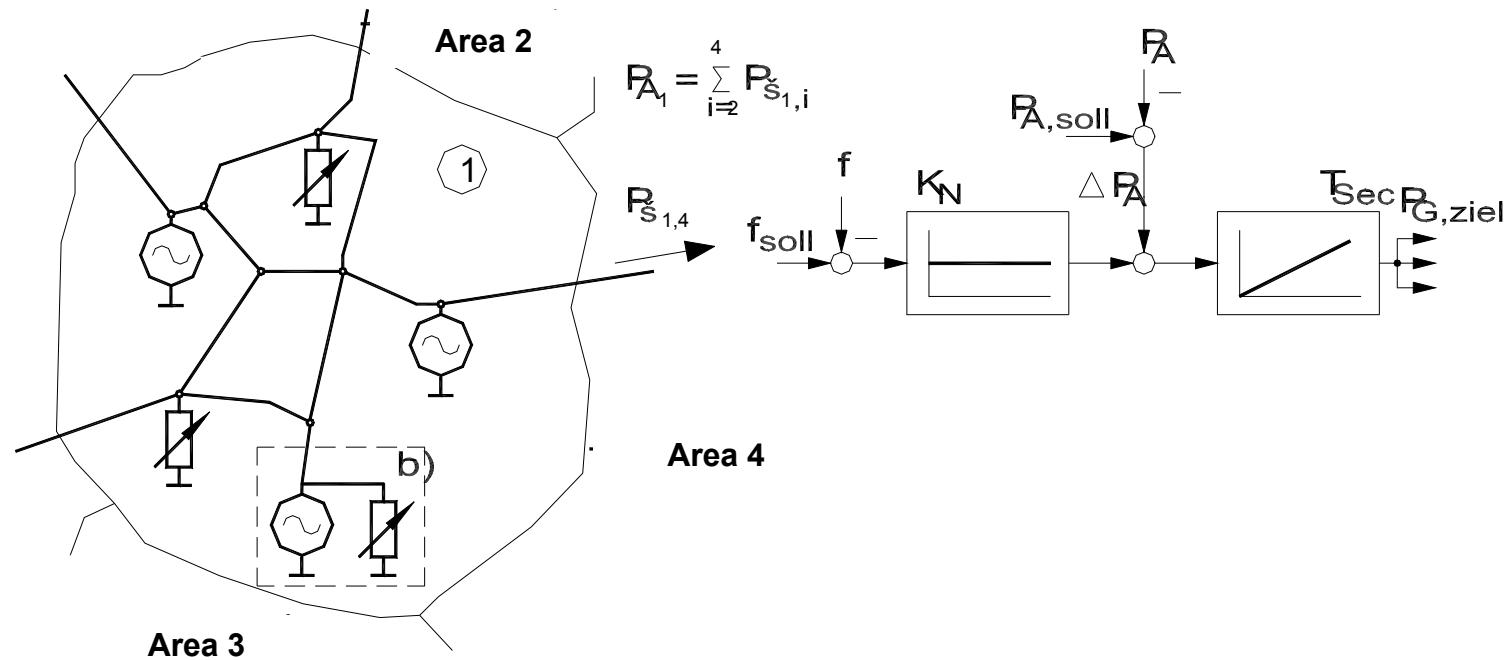
	Short-term	Mid-term	Long-term
Range	1 ms – 2 s	1 s – 2 min	1 min – 1h
Events	Faults Switching	Load shedding PP outage	Schedule change PP dynamics
Impact	Electromagnetic transients near the event location Voltage controller (AVR)	Primary control Dynamic load behaviour	Secondary control (AGC)

Frequency – Mirror of System Behaviour

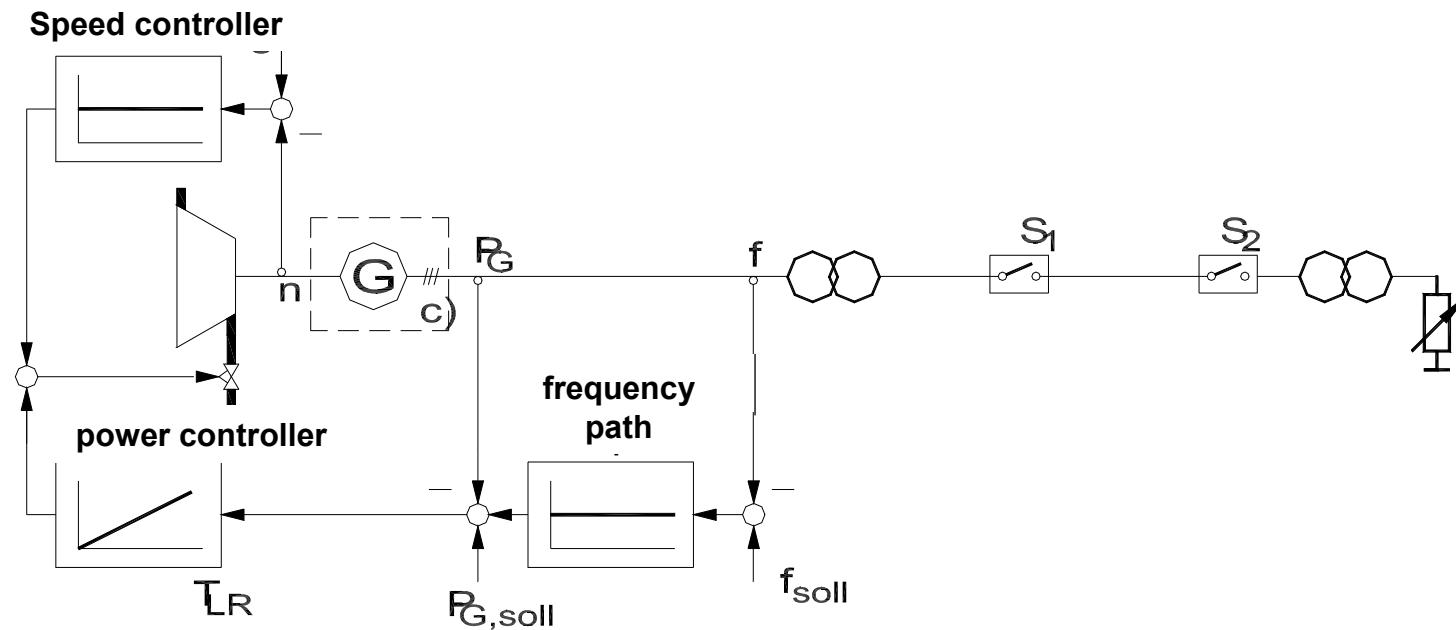




Secondary Control (AGC)

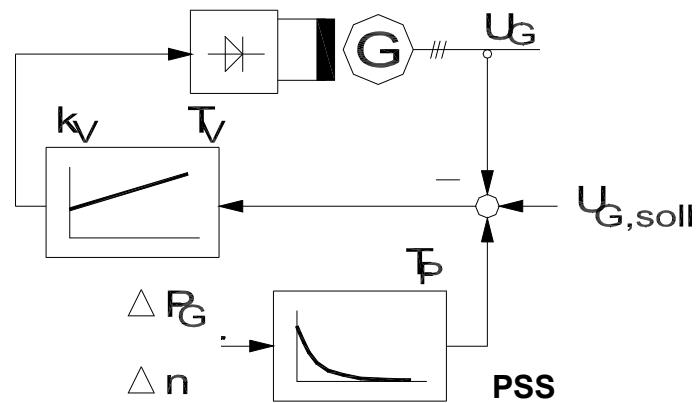


Primary Control / Governor / Turbine Control



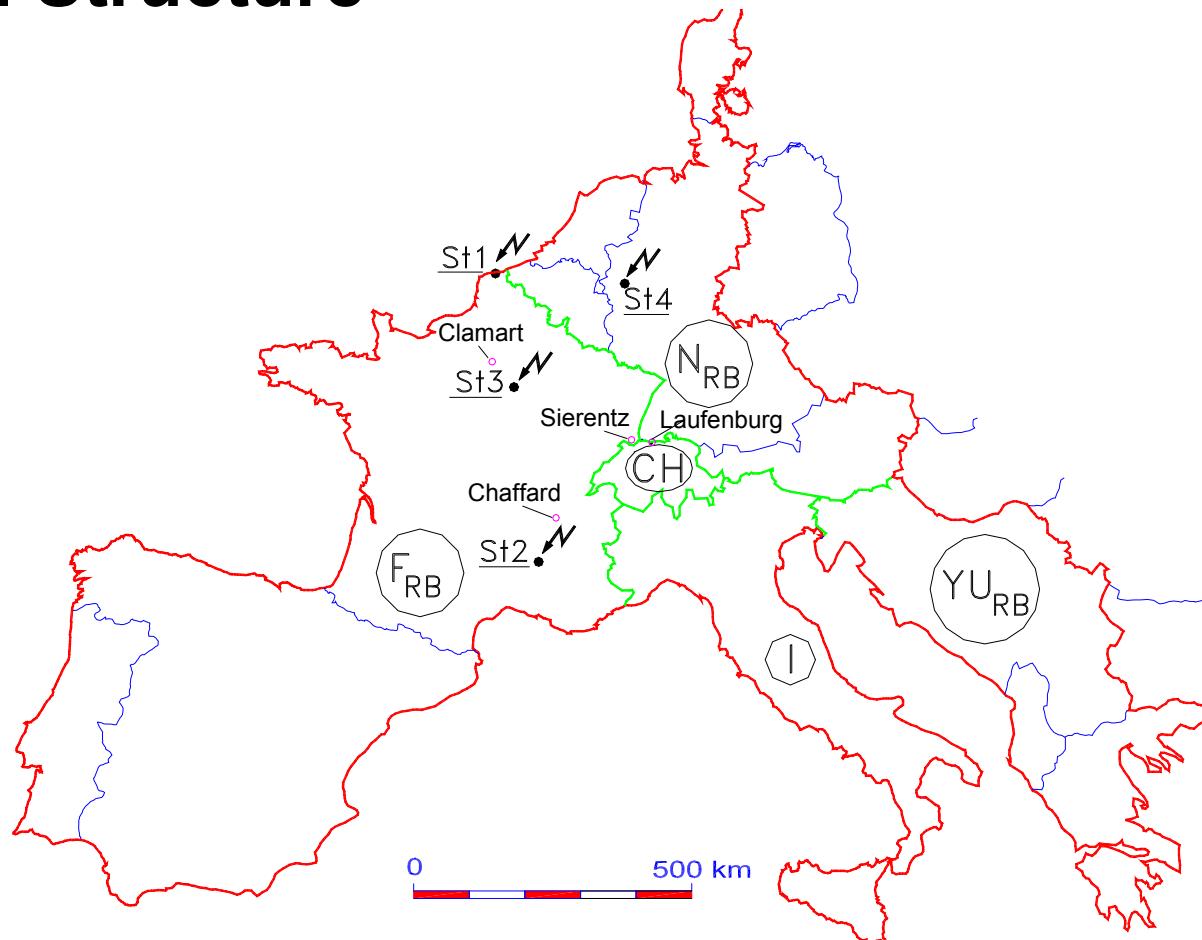


Automatic Voltage Controller (AVR)





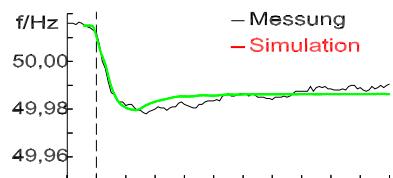
Model Structure



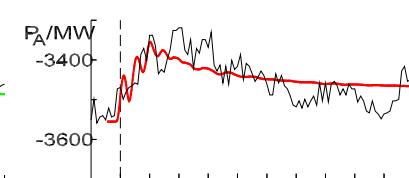


Model Calibration – Time Domain Calculations

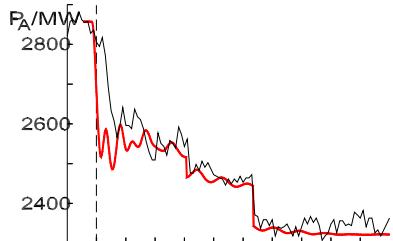
a) Frequenz in Laufenburg



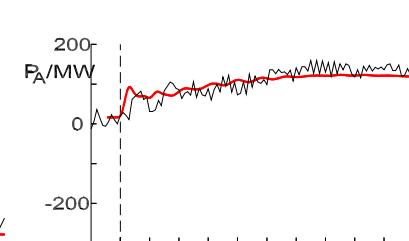
d) Austauschleistung ENEL



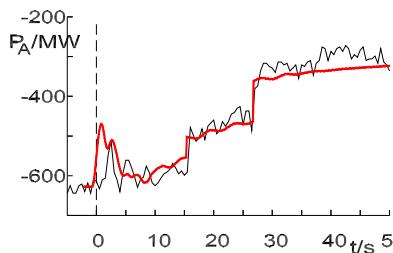
b) Austauschleistung französischer Regelblock



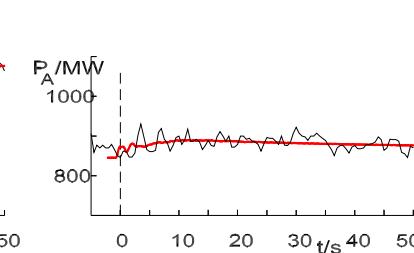
e) Austauschleistung JUGEL



c) Austauschleistung nördlicher Regelblock



f) Austauschleistung Schweiz

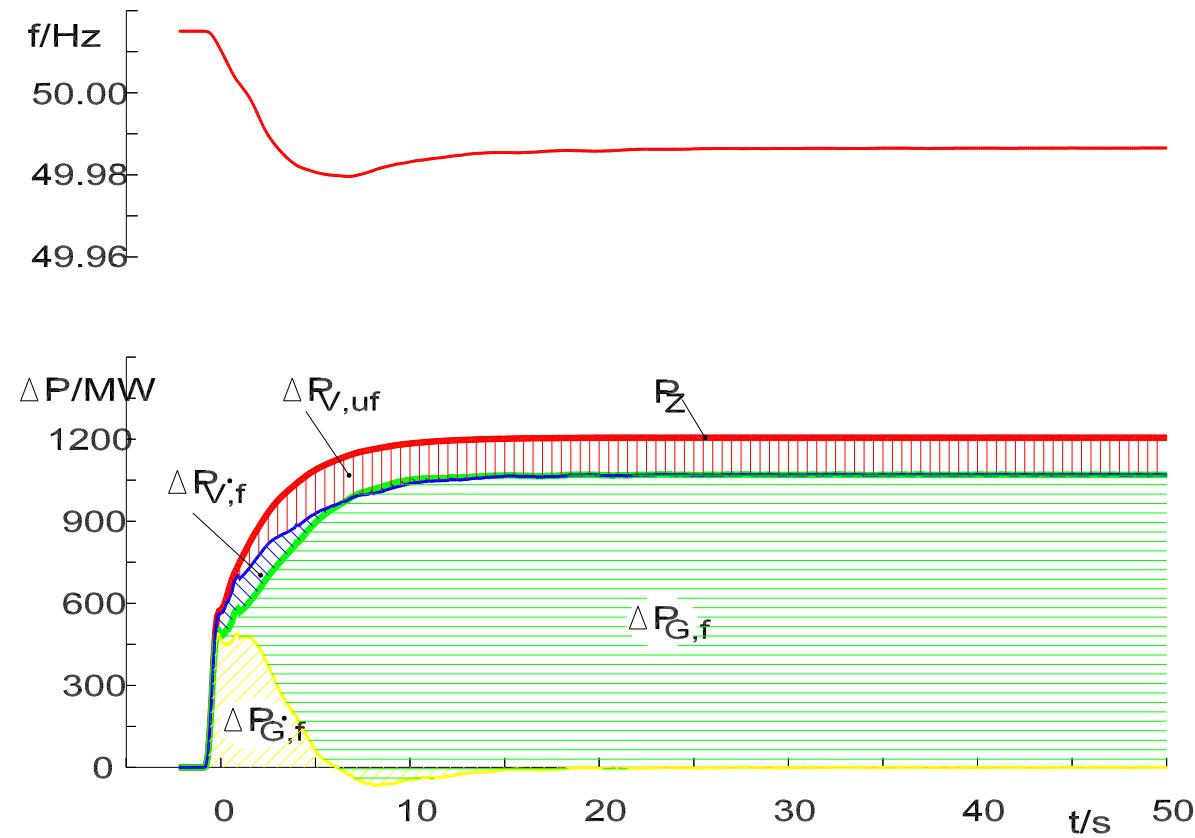


**Simulation of Outage of
Nogent PP 1200 MW
6.02.1991, 21:49**

**Comparison Measurement –
Dynamic Model Calculation**

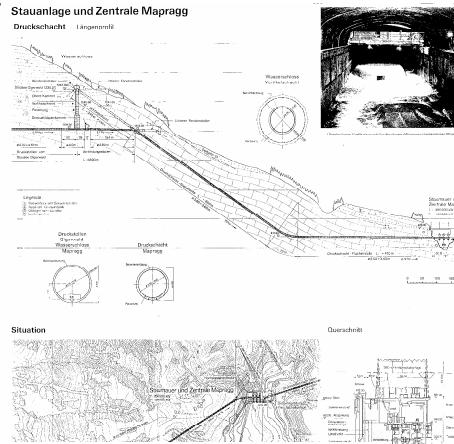


Phenomena Description / Active Power Components



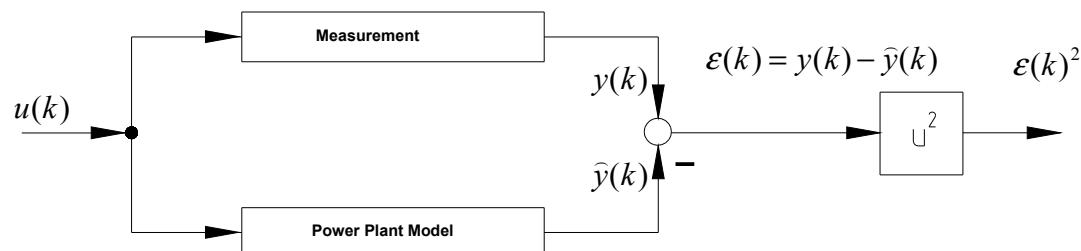
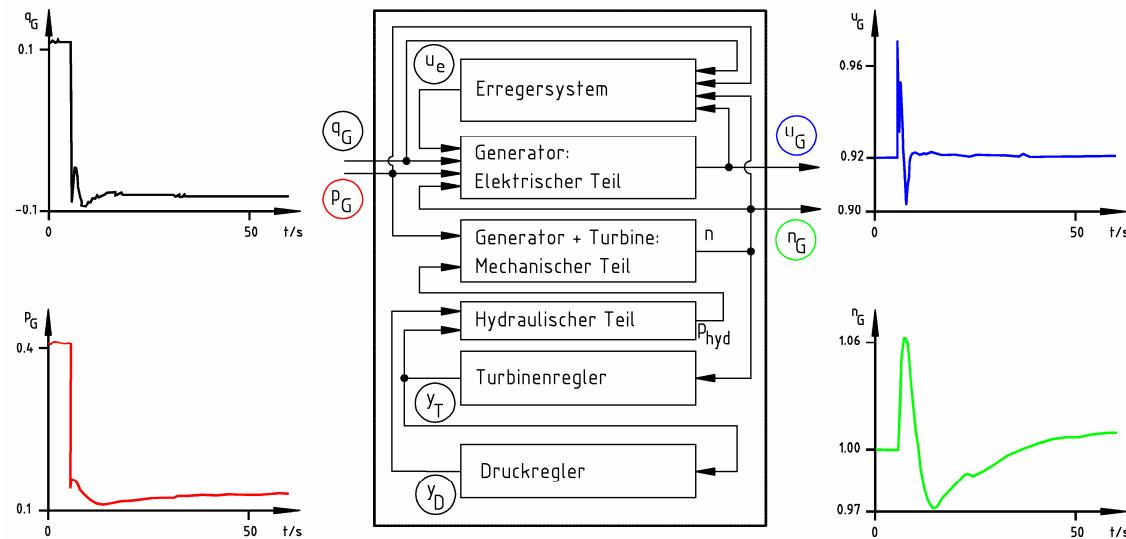


Documents + Measurement = Dynamic Model



Anlage 1620		Reihen Sektor:	Indikatoren Sektoren 1 und 2	Werte / Zeiteinheit
8.5 Speisewasserstrom: 2500				Wert 2 / Zeit
Volumenstrom: 8000 m³/s				Wert 256/16/3
Strom: 50000				Wert 256/16/3
cosφ: 0,94				
U ₁ : 11000		± 5%		
U ₂ : 24500				
U ₃ : 12500				
U ₄ : 13500				
U ₅ : 14500				
U ₆ : 15500				
U ₇ : 16500				
U ₈ : 17500				
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U ₁₈₇ : 196500				
U ₁₈₈ : 197500				
U ₁₈₉ : 198500				
U ₁₉₀ : 199500				
U ₁₉₁ : 200500				

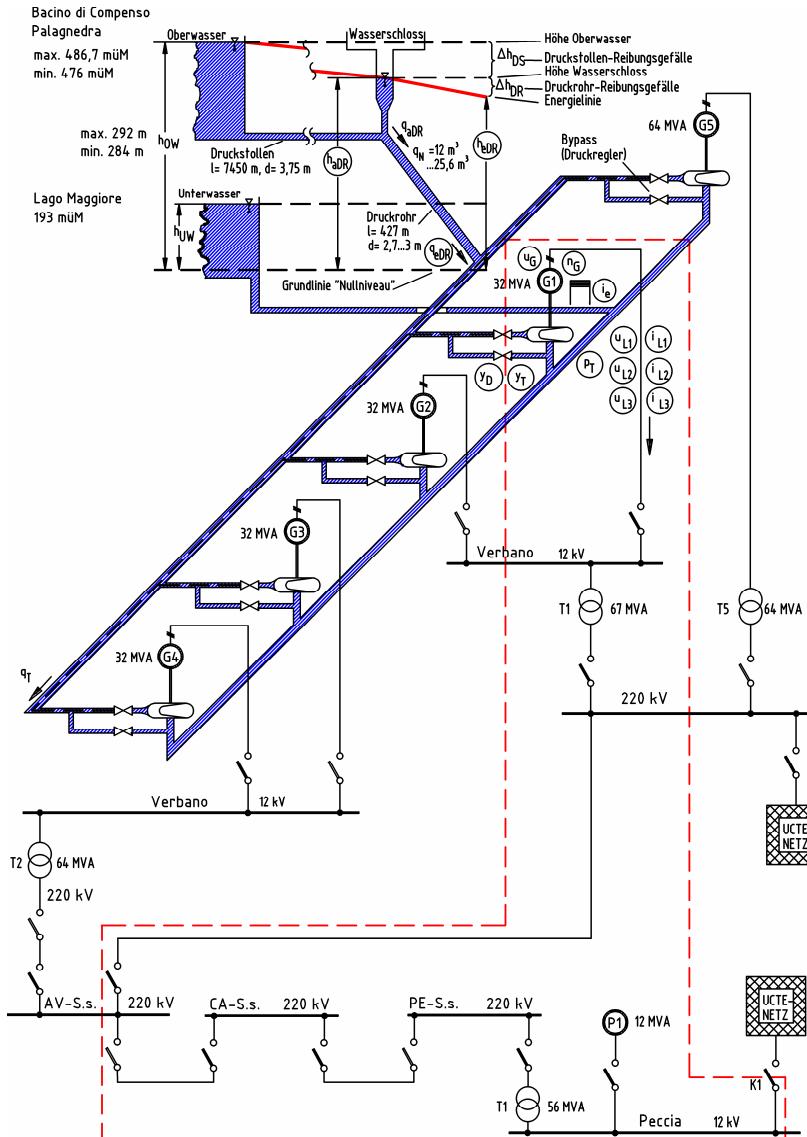
Dynamic Identification Principle



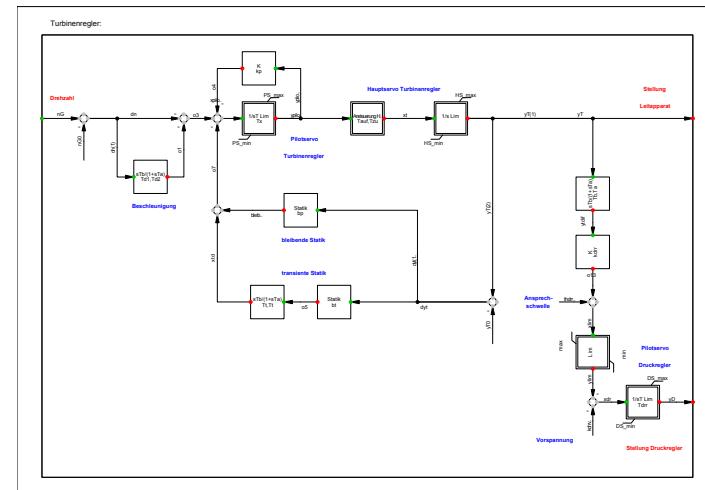
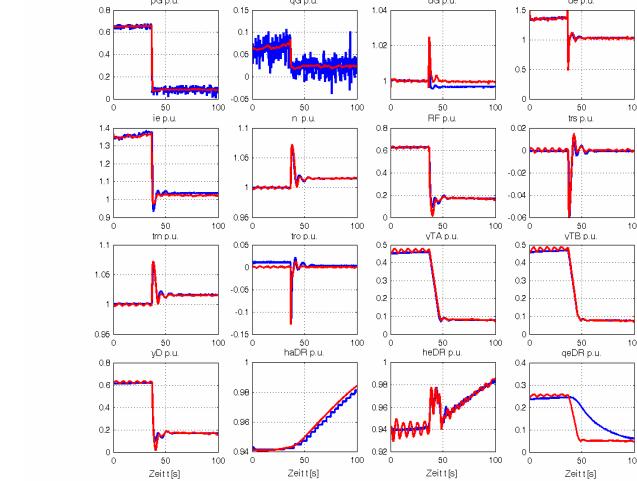


Detailed Identified Power Plants



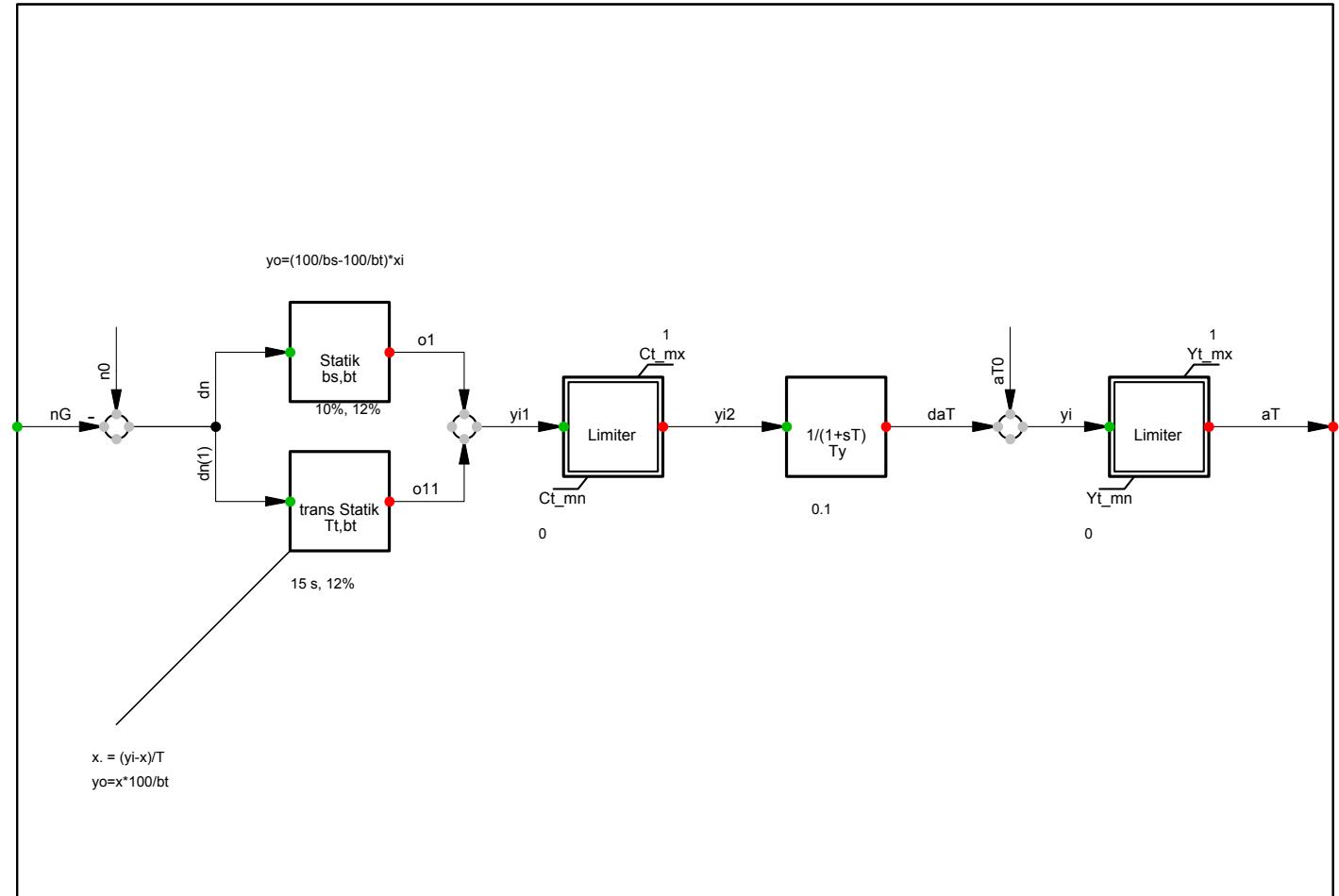


Monitoring of Power System Dynamic Performance, Tutorial 2c, 2006, April 25th, Moscow



Model Setup and Parameter Identification

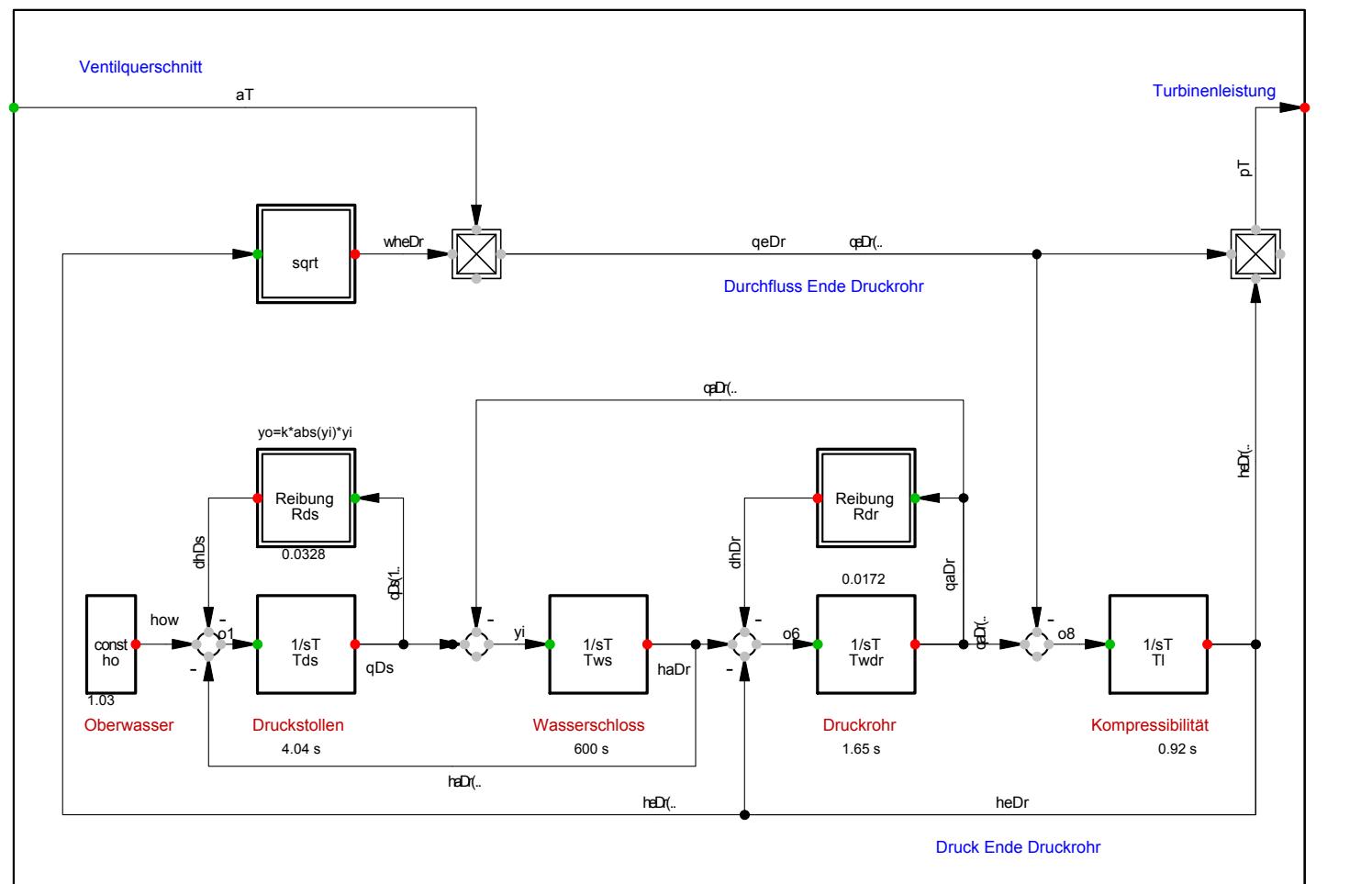
PCO 8: Drehzahlregler mit transiente Statik



DIGILENT

Hydro PP – Turbine Controller

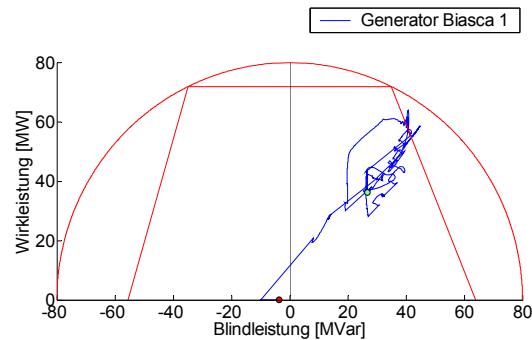
PGS 12: Wasserkraftwerk



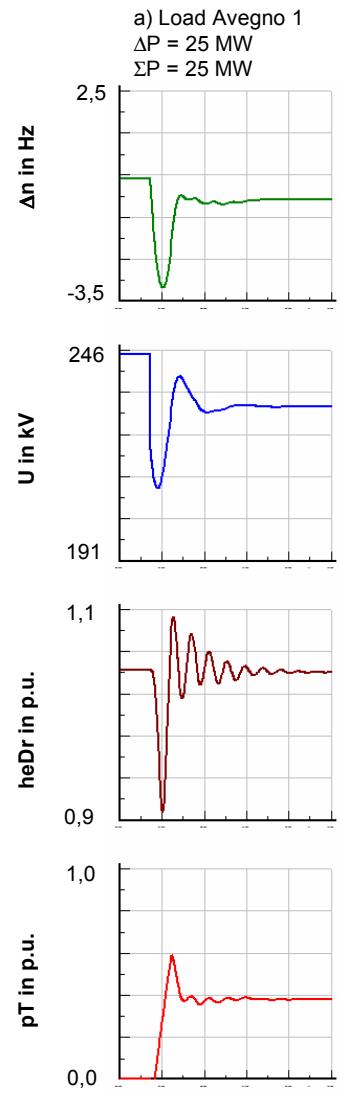
Hydro PP Turbine & Penstock



Analysis of Simulation Results



- Possible protection triggering
 - Delay of system restoration
- Discover potential instabilities
- Define investments for PP upgrades
- Adapt restoration plans





Thank you for your attention