



Monitoring of Power System Dynamic Performance

Tutorial Part 2, Section 4:

On-line Monitoring of Dynamic System Behaviour

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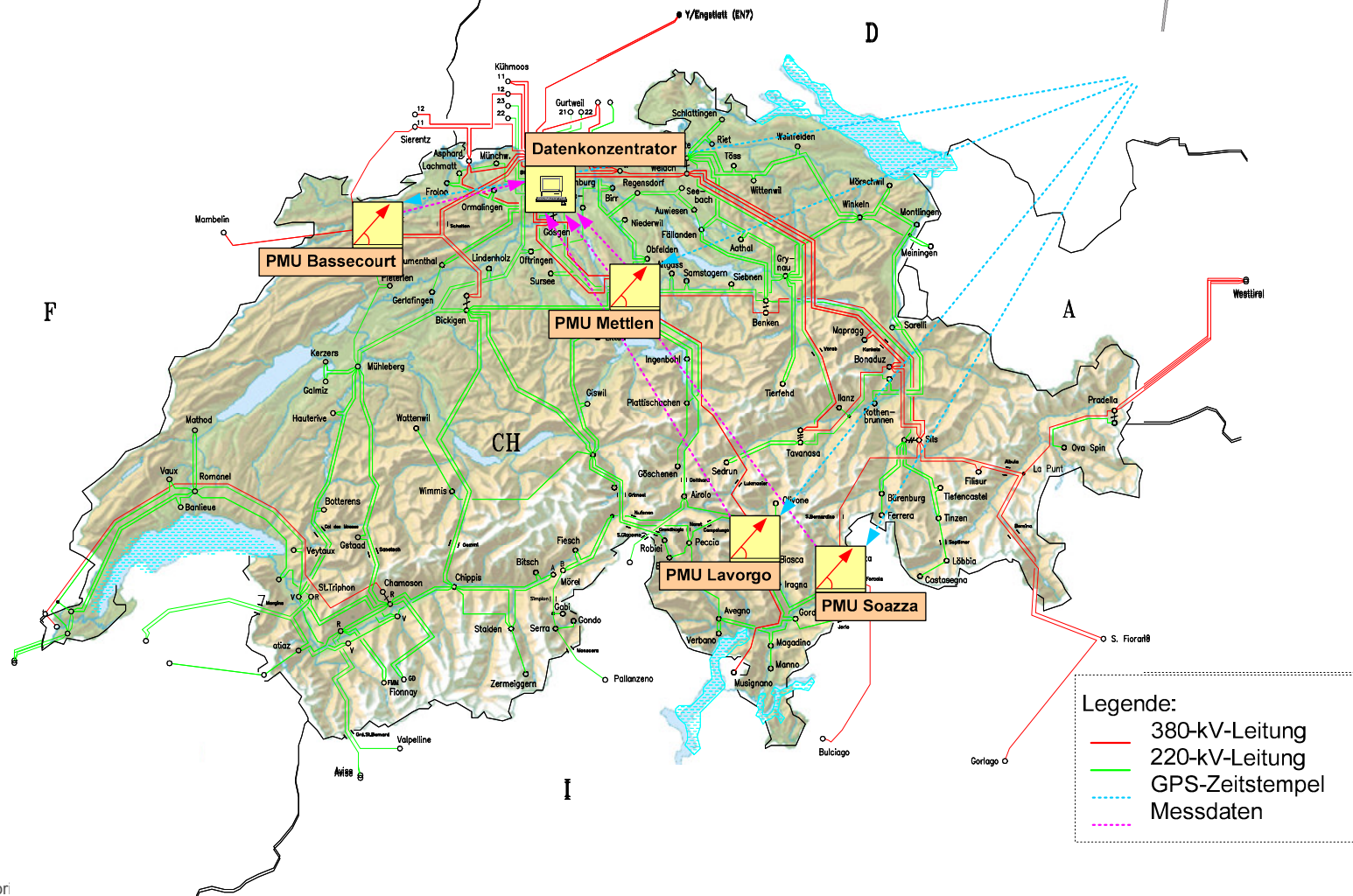
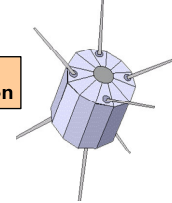


Content

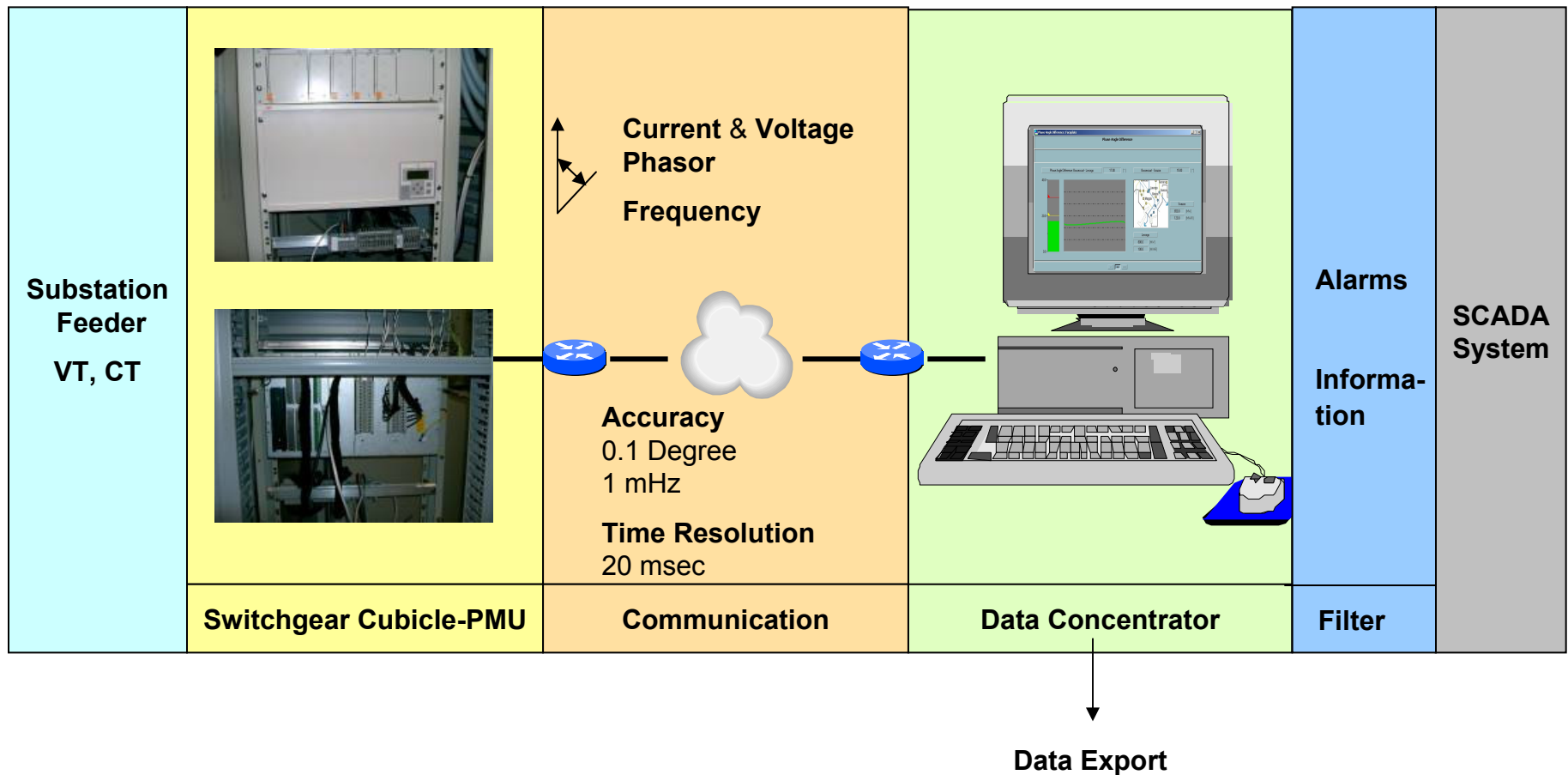
- Swiss **Wide Area Monitoring** approach
- WAM system configuration
- Application results
 - Corridor monitoring
 - Oscillation monitoring
- Use of the WAM system during the resynchronisation of the UCTE system
- Outlook

Wide Area Monitoring – Early Warning System

GPS-Synchronisation

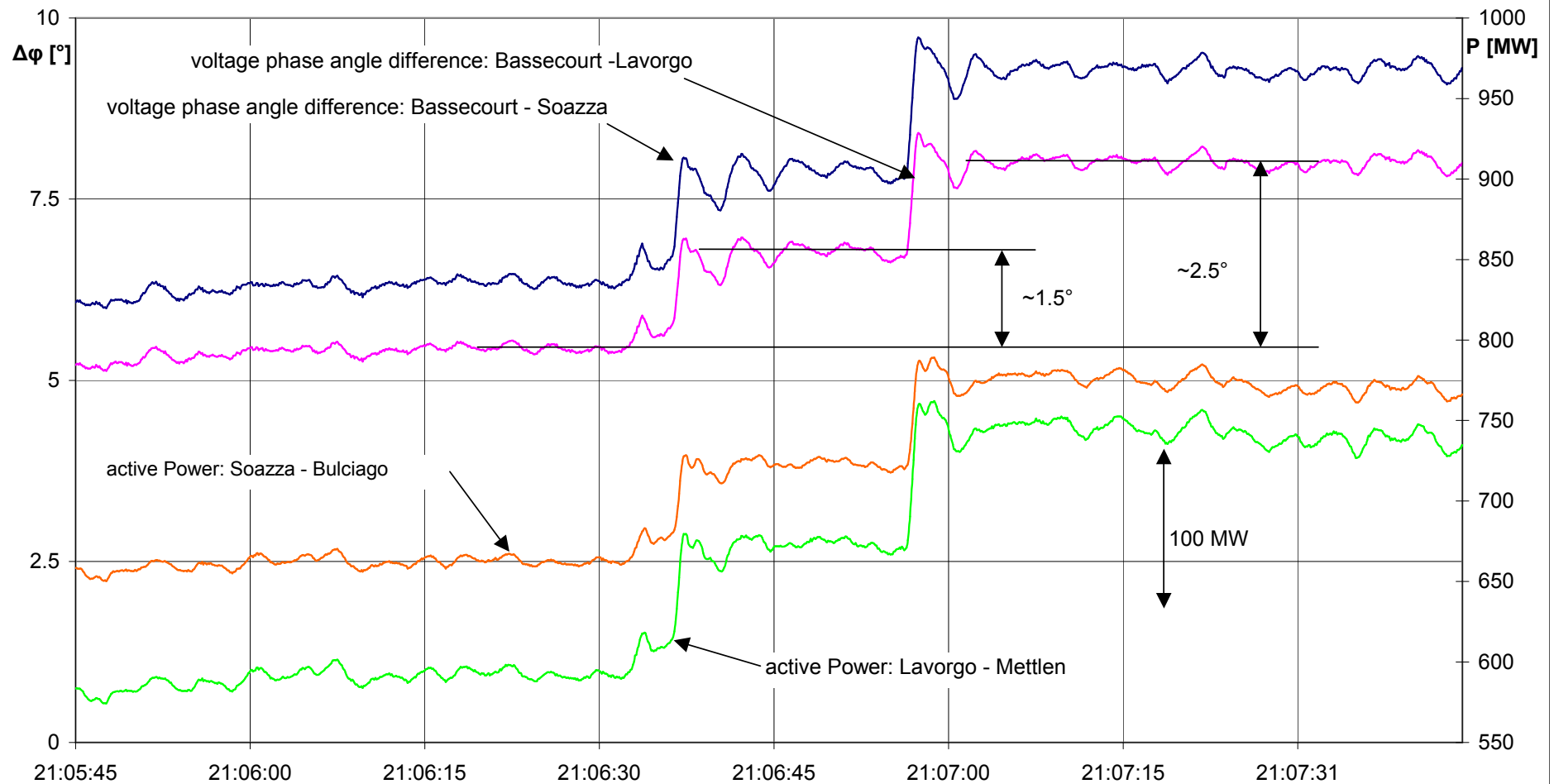


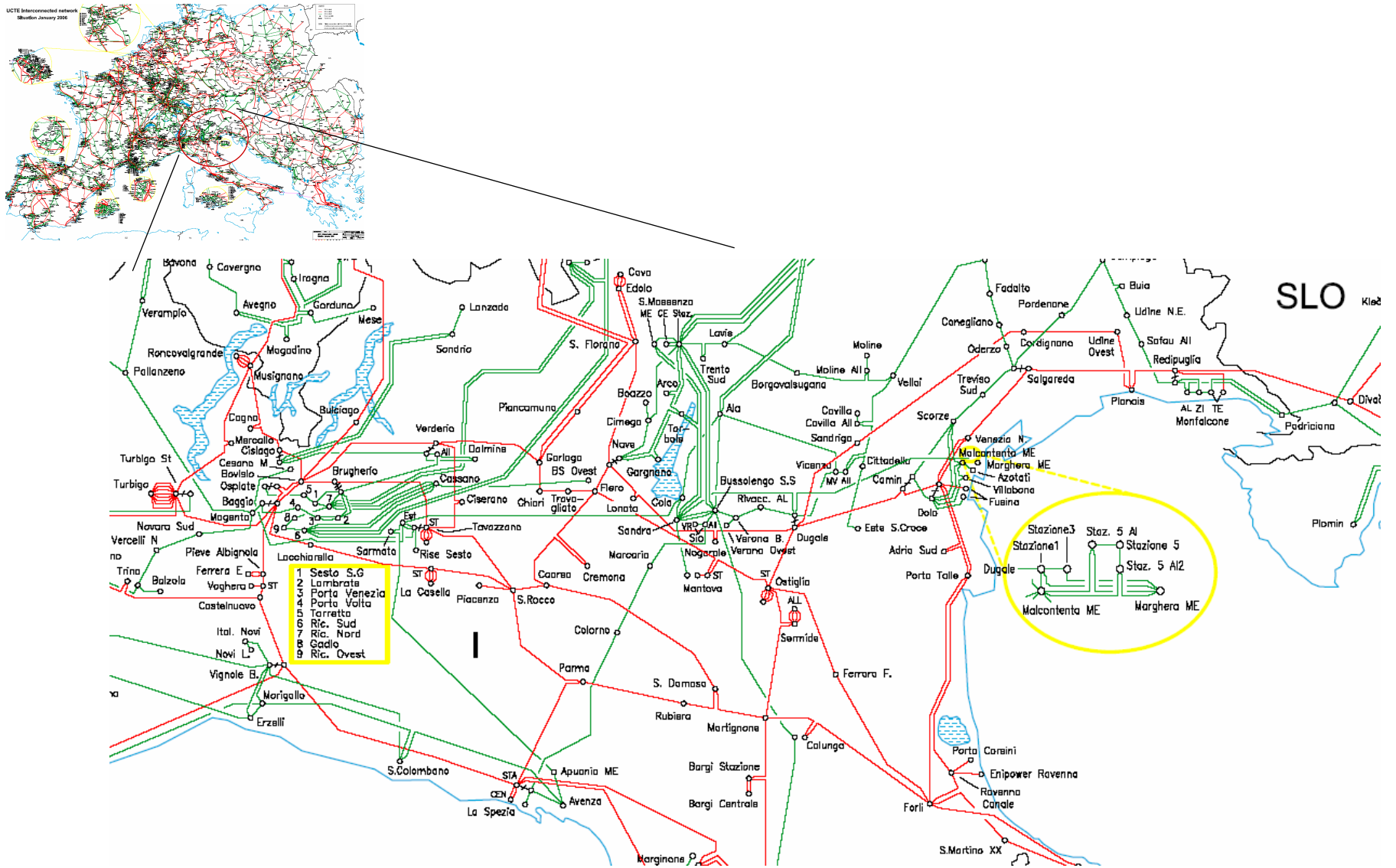
Swiss Wide Area Monitoring System Configuration



Monitor more than the own system operation 1a

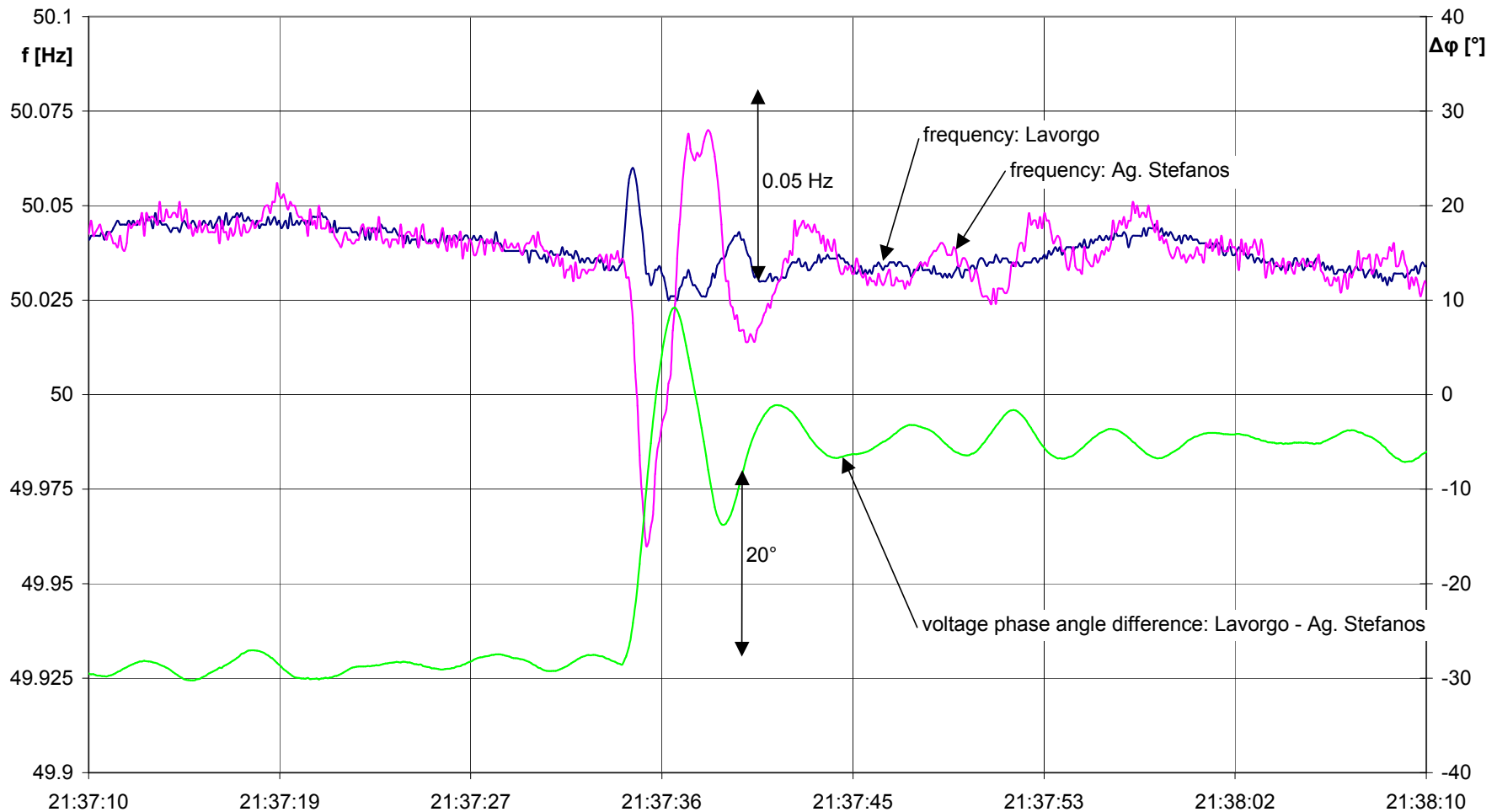
10.04.2005 21:06:30 - Outage: Slovenia-Italy Link (Divaca-Redipuglia, Divaca-Padriciano)
1278 MW for complete Interconnection





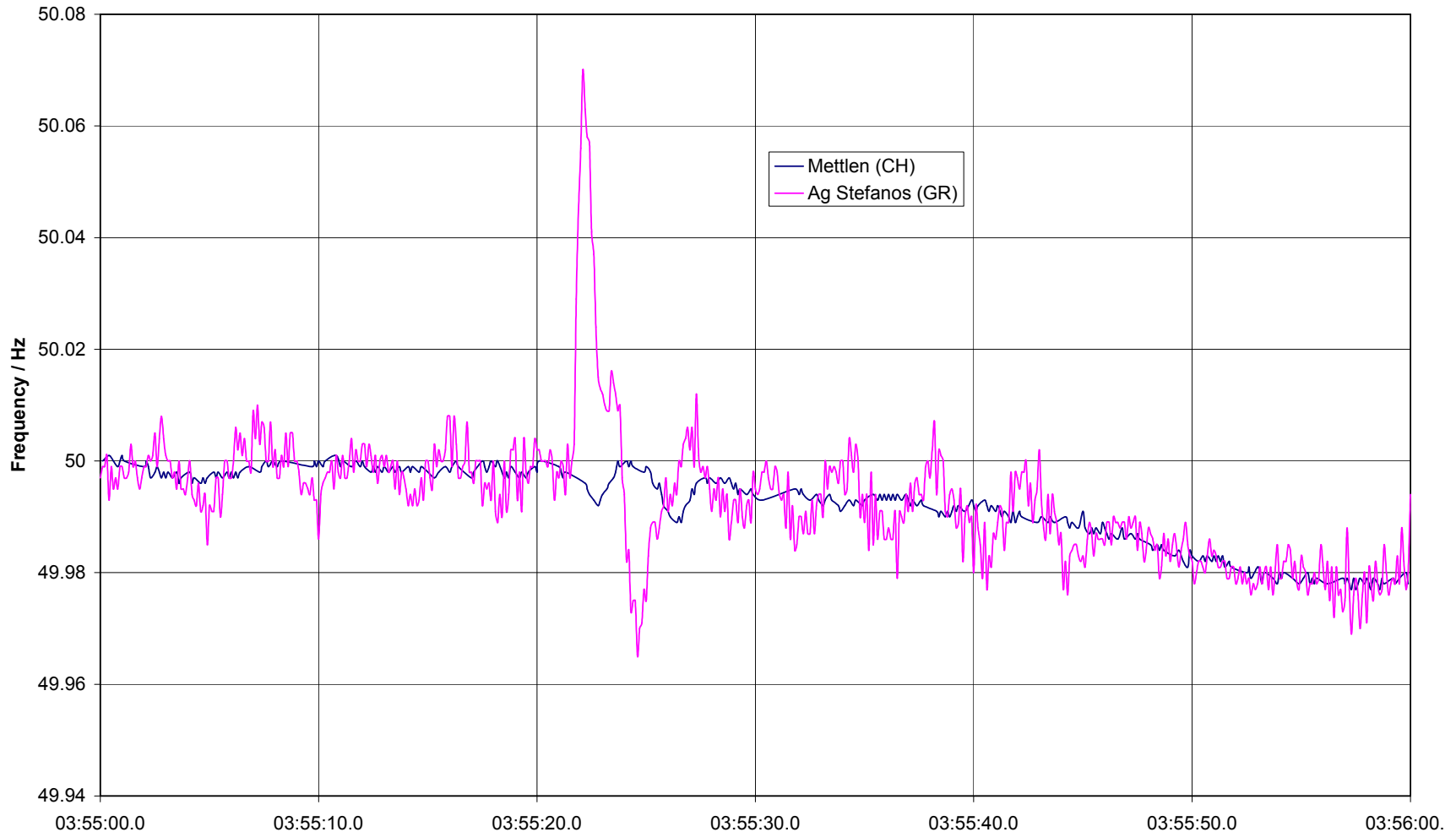
Monitor more than the own system operation 1b

10.04.2005 21:37:10 - Reconnection: Slovenia-Italy Link (Divaca-Redipuglia, Divaca-Padriciano)
 1249 MW for complete Interconnection



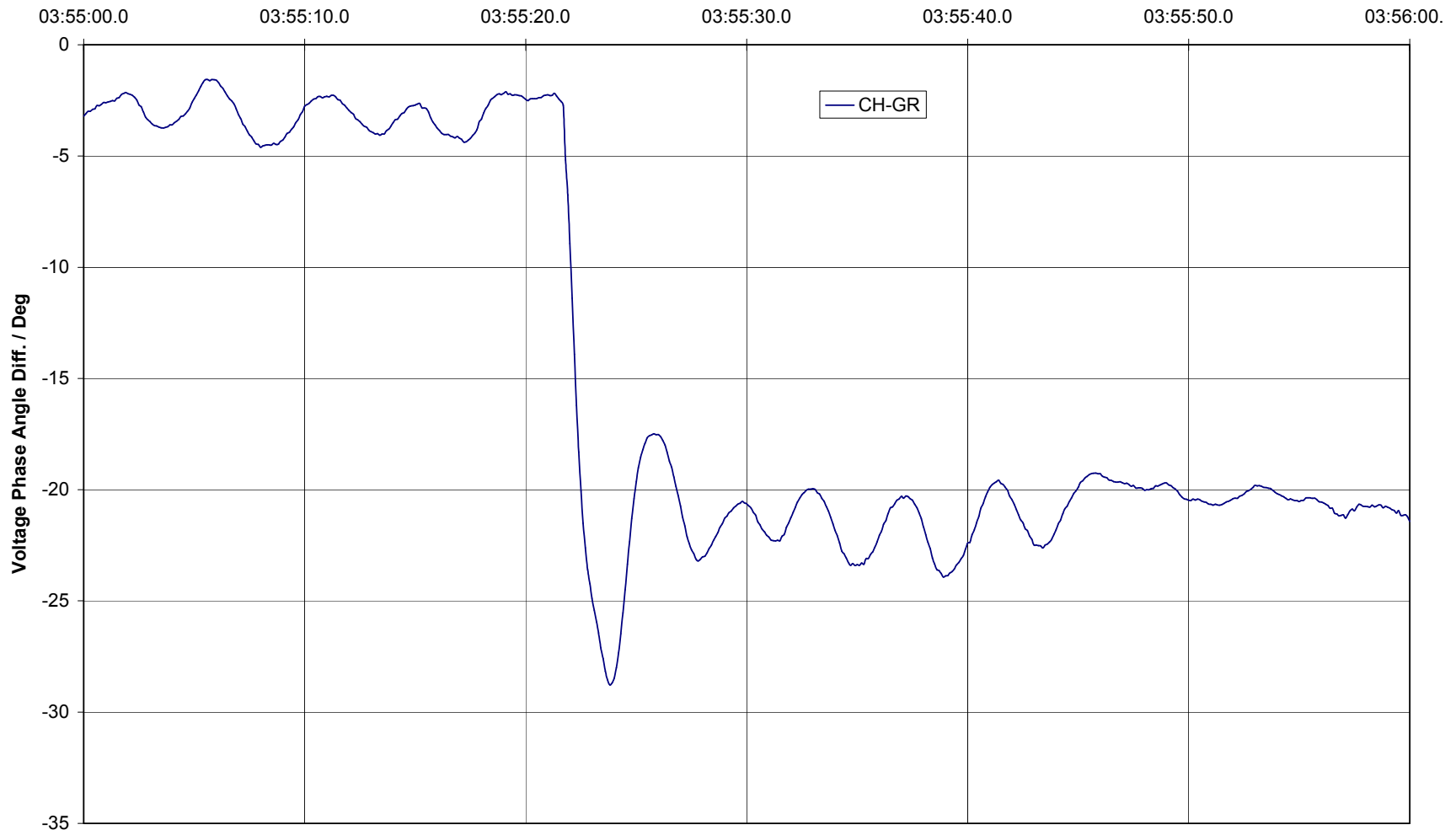
Monitor more than the own system operation 2a

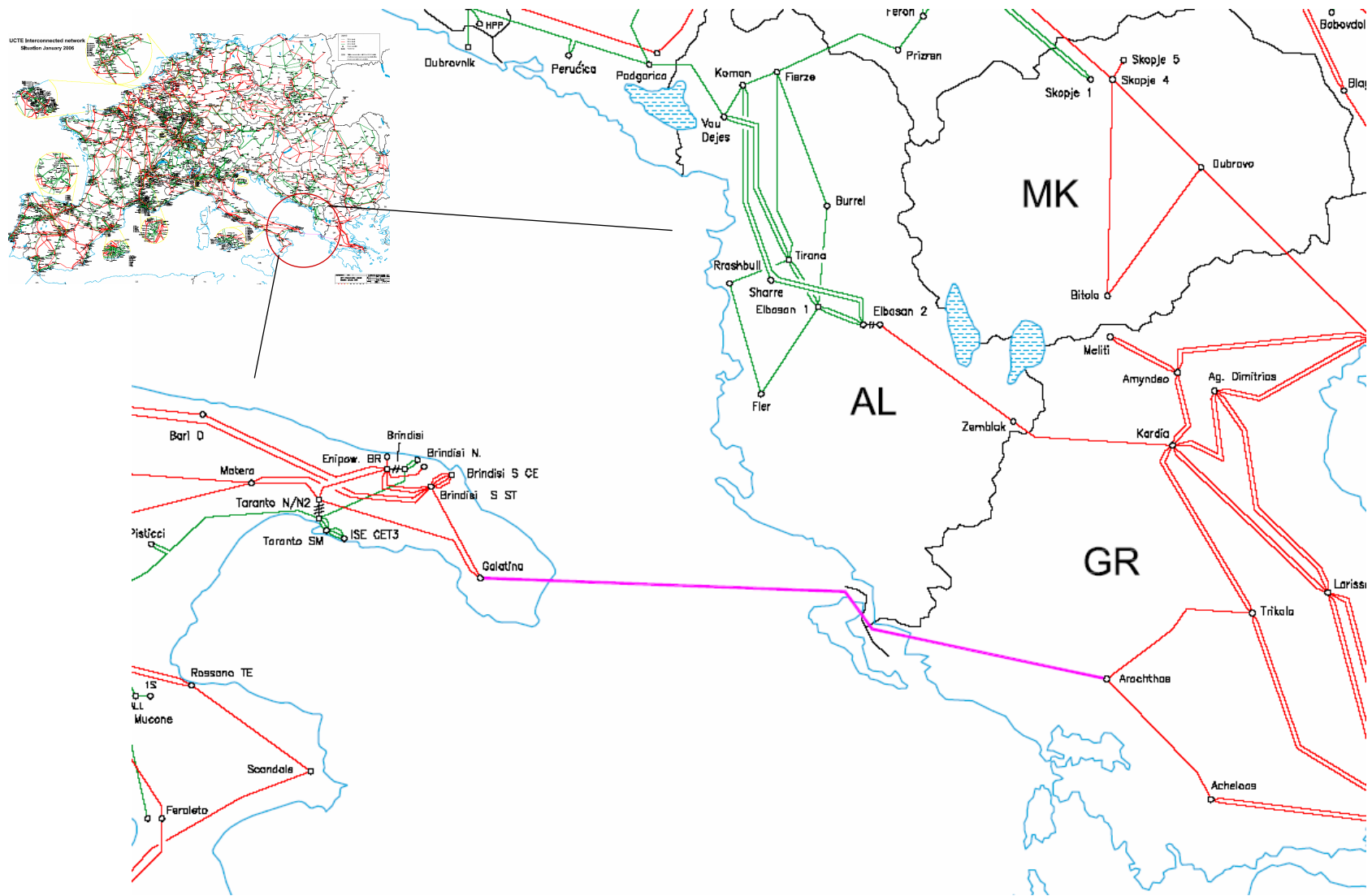
March 22th 2005 03:55:36 Outage: DC-Link Italy-Greece 455 MW



Monitor more than the own system operation 2b

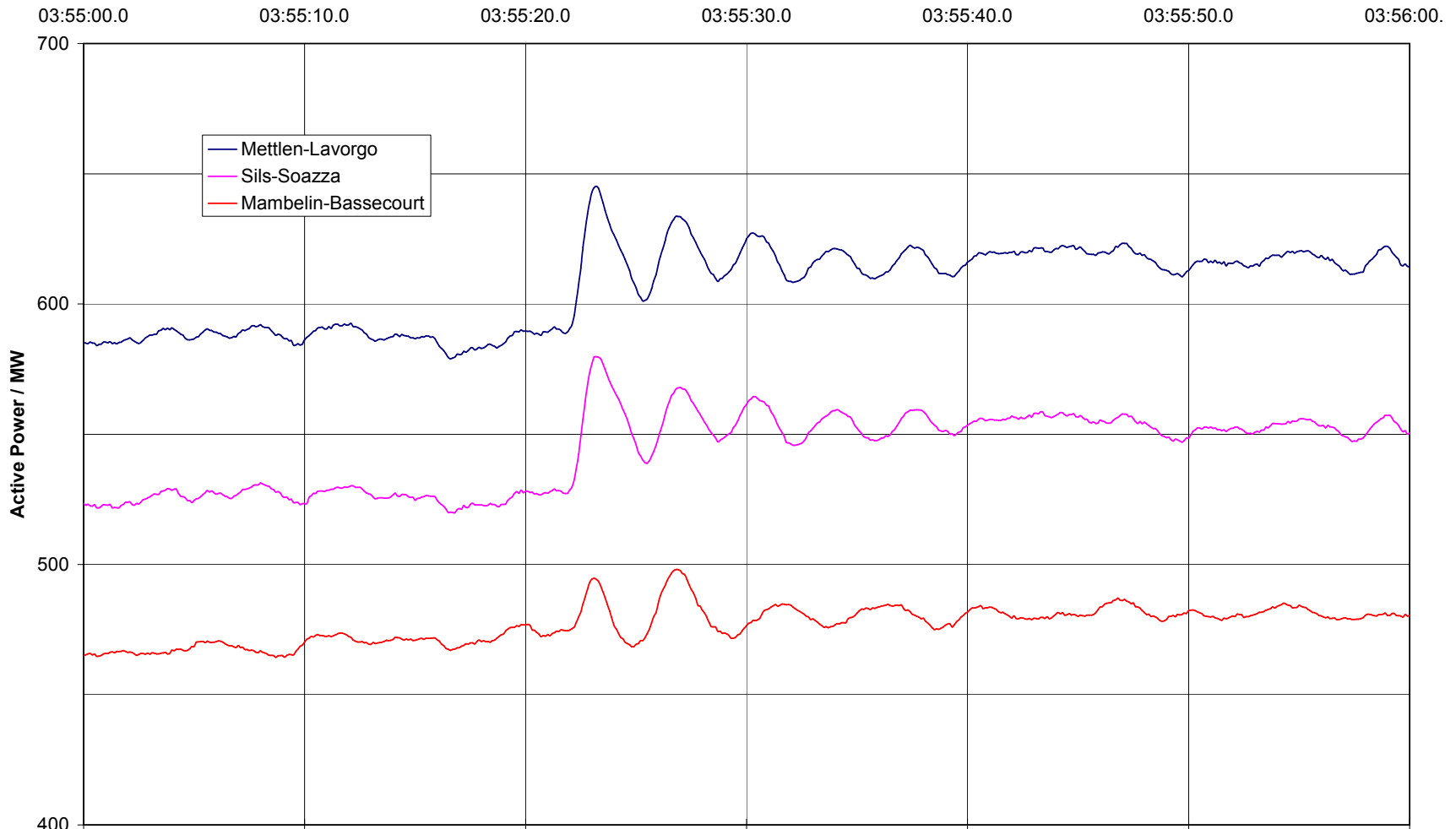
March 22th 2005 03:55:36 Outage: DC-Link Italy-Greece 455 MW





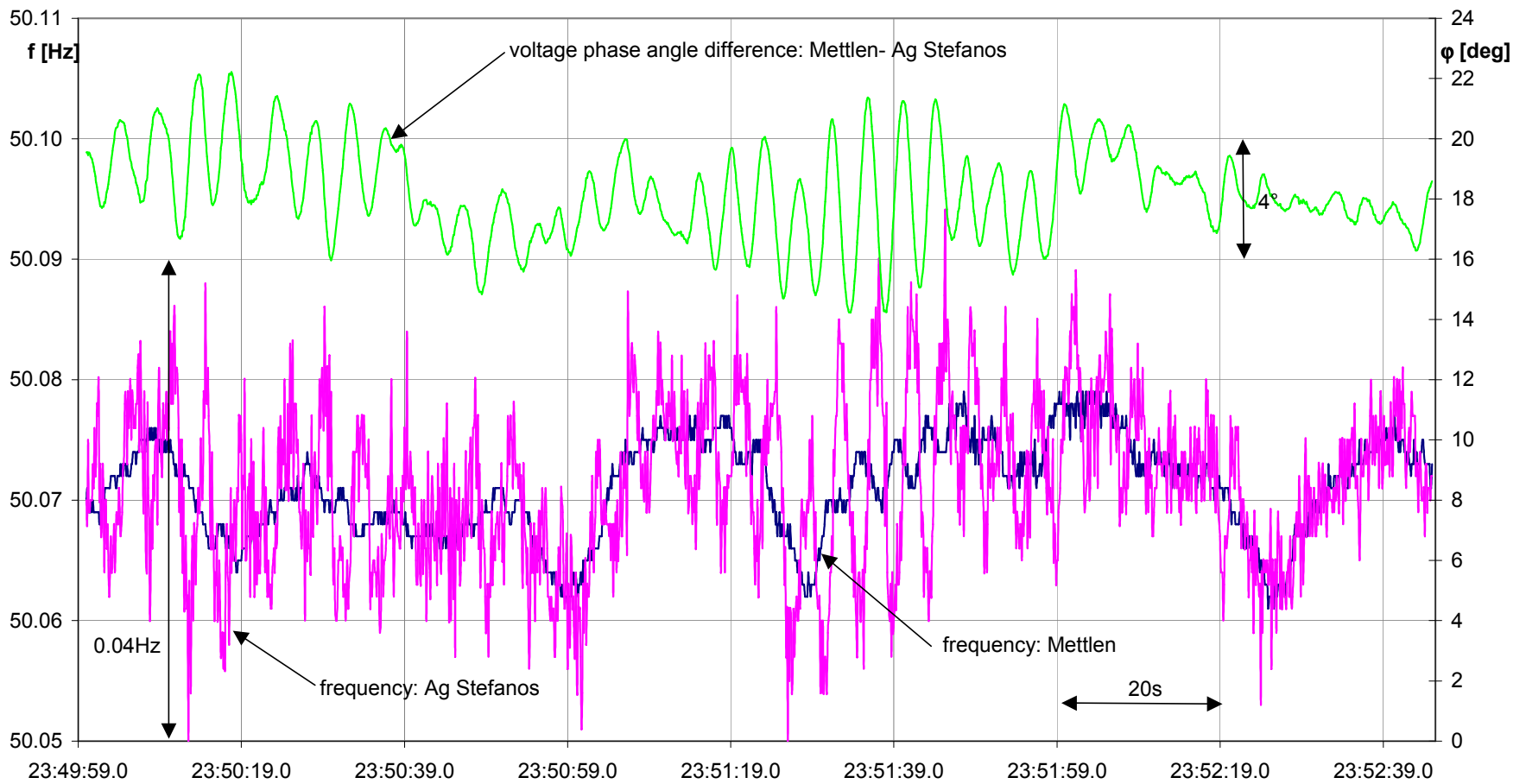
Monitor more than the own system operation 2c

March 22th 2005 03:55:36 Outage: DC-Link Italy-Greece 455 MW



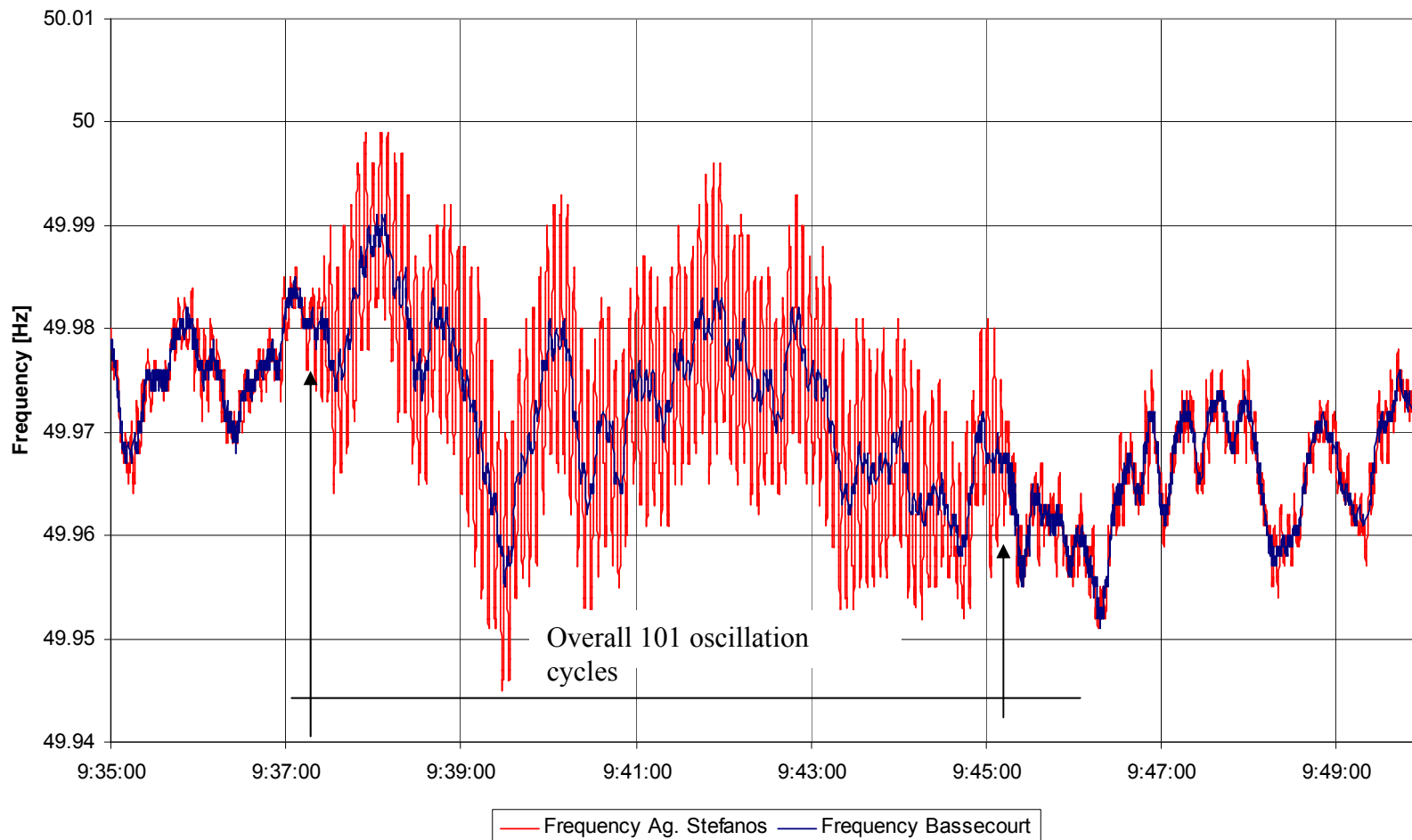
Inter-Area Oscillations: 1

2004-11-07; 23:51 - Oscillation



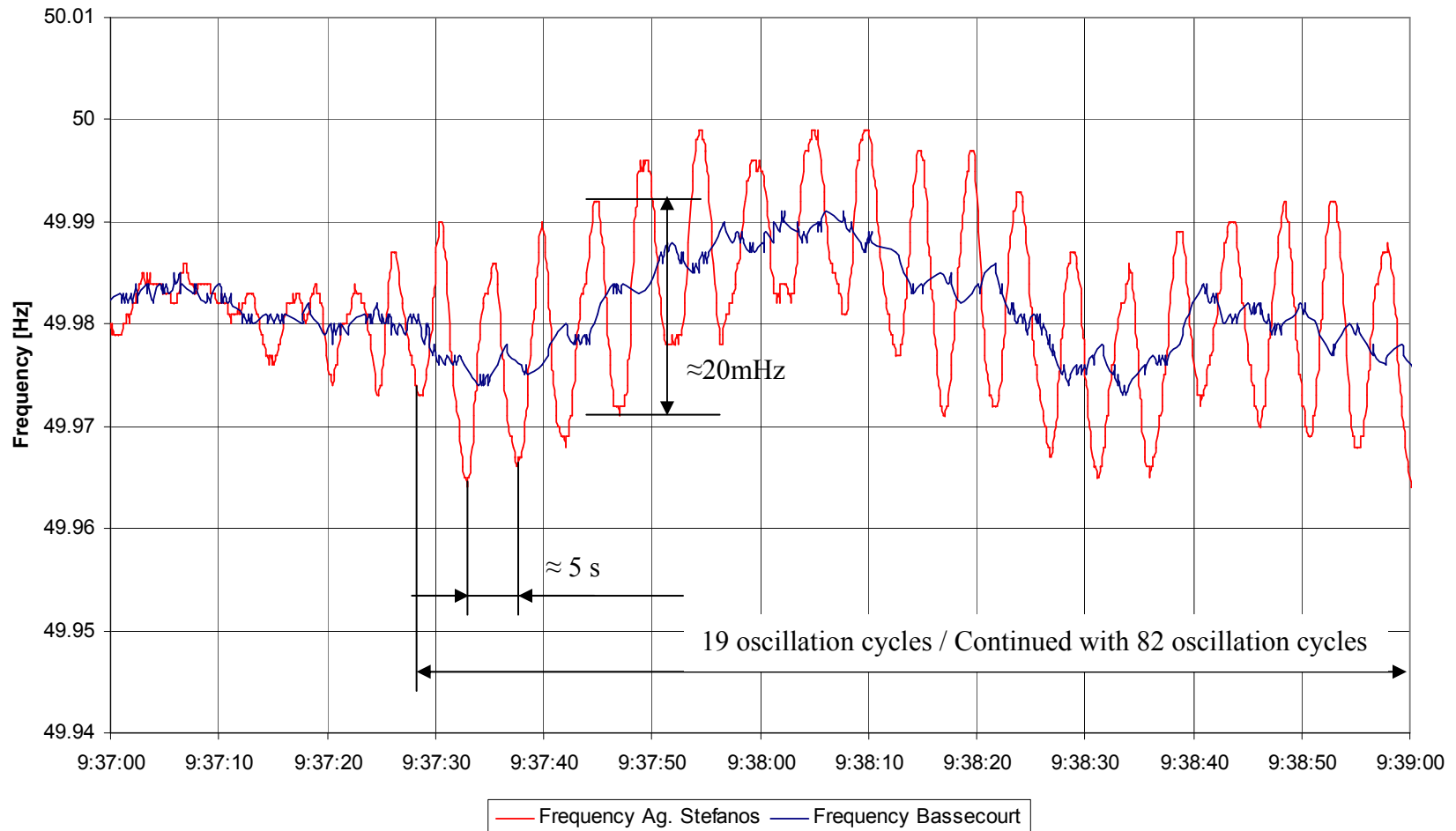
Inter-Area Oscillations 2a

01.05.2005 09:35:00 UCTE inter-area oscillation



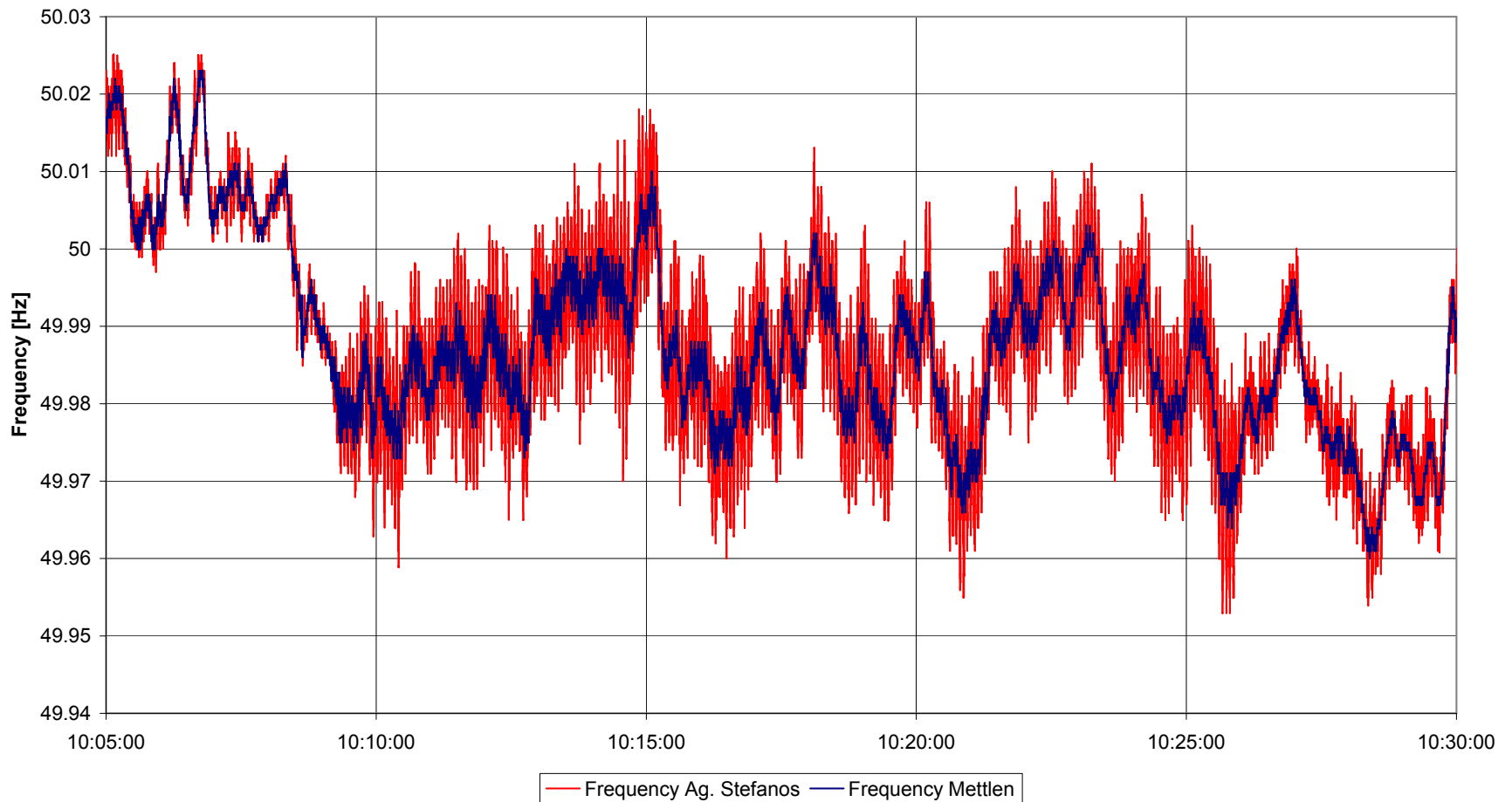
Inter-Area Oscillations 2b

01.05.2005 09:35:00 UCTE inter-area oscillation



Inter-Area Oscillations: 3

26.06.2005 10:09:14 UCTE inter-area oscillation



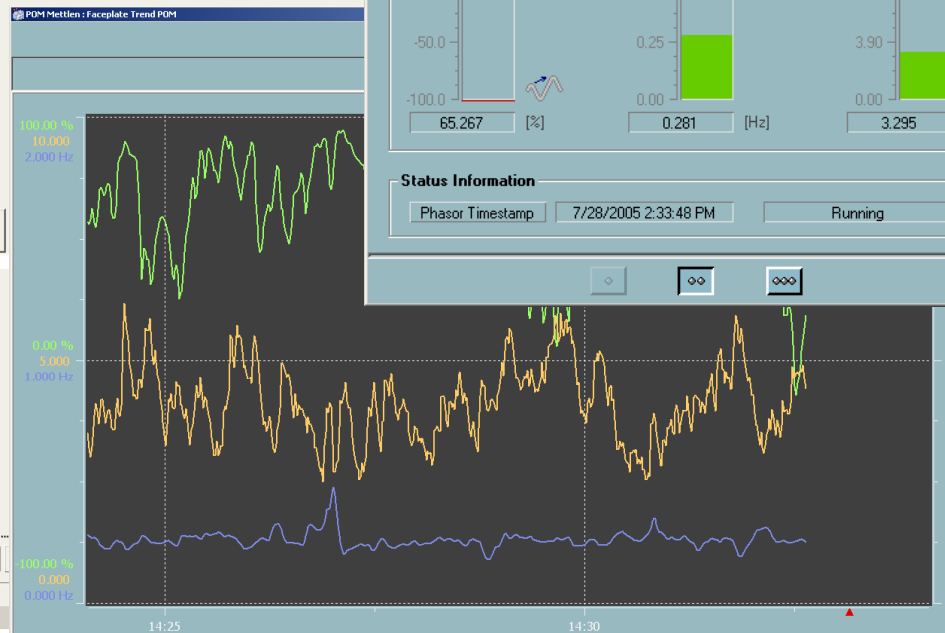
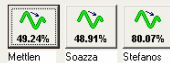
POM History Recording

PSG System // ETRANS Power System Operator Workplace

AS	Active Time	Object Name	Condition	Message Description	AckTime
AS	05-07-28 14:32:36.000	POM Mettlen	POM Damping OK	The power oscillation damping is OK	XXXXXXXXXX
AS	05-07-28 14:32:35.000	POM Mettlen	POM Damping Warning	The power oscillation damping was in dangerous state	XXXXXXXXXX
AS	05-07-28 14:32:28.000	POM Mettlen	POM Damping Alarm	The power oscillation damping is in critical state	XXXXXXXXXX

PSGuard
PSG830 Wide Area Monitoring

- System Information
- Alarm List
 - Voltage Phasor Monitoring
 - External Interface



POM Mettlen : Faceplate POM

POM Mettlen

Power Oscillations Monitoring (POM)

Input Signal: Active Power Mettlen 459.27 [MW]

Damping: 65.267 [%]

Frequency: 0.281 [Hz]

Magnitude: 3.295 [MW]

Status Information

Phasor Timestamp: 7/28/2005 2:33:48 PM

Running

Color	Qual	Object	Aspect	Property	Log Name	Current Value	Low Range	High Range	Ruler Time	Ruler Value	Treatment	Min Value	Max Value
1	Green	POM Mettlen	Control Connection	ad	PSG_Med_Re	22.23 %	-100.00	100.00			Average	-14.61 %	94.73 %
2	Yellow	POM Mettlen	Control Connection	ma	PSG_Med_Re	4.447	0.00	10.00			Average	2.496	6.173
3	Blue	POM Mettlen	Control Connection	ft	PSG_Med_Re	0.249 Hz	0.00	2.00			TimeAverage	0.181 Hz	0.478 Hz

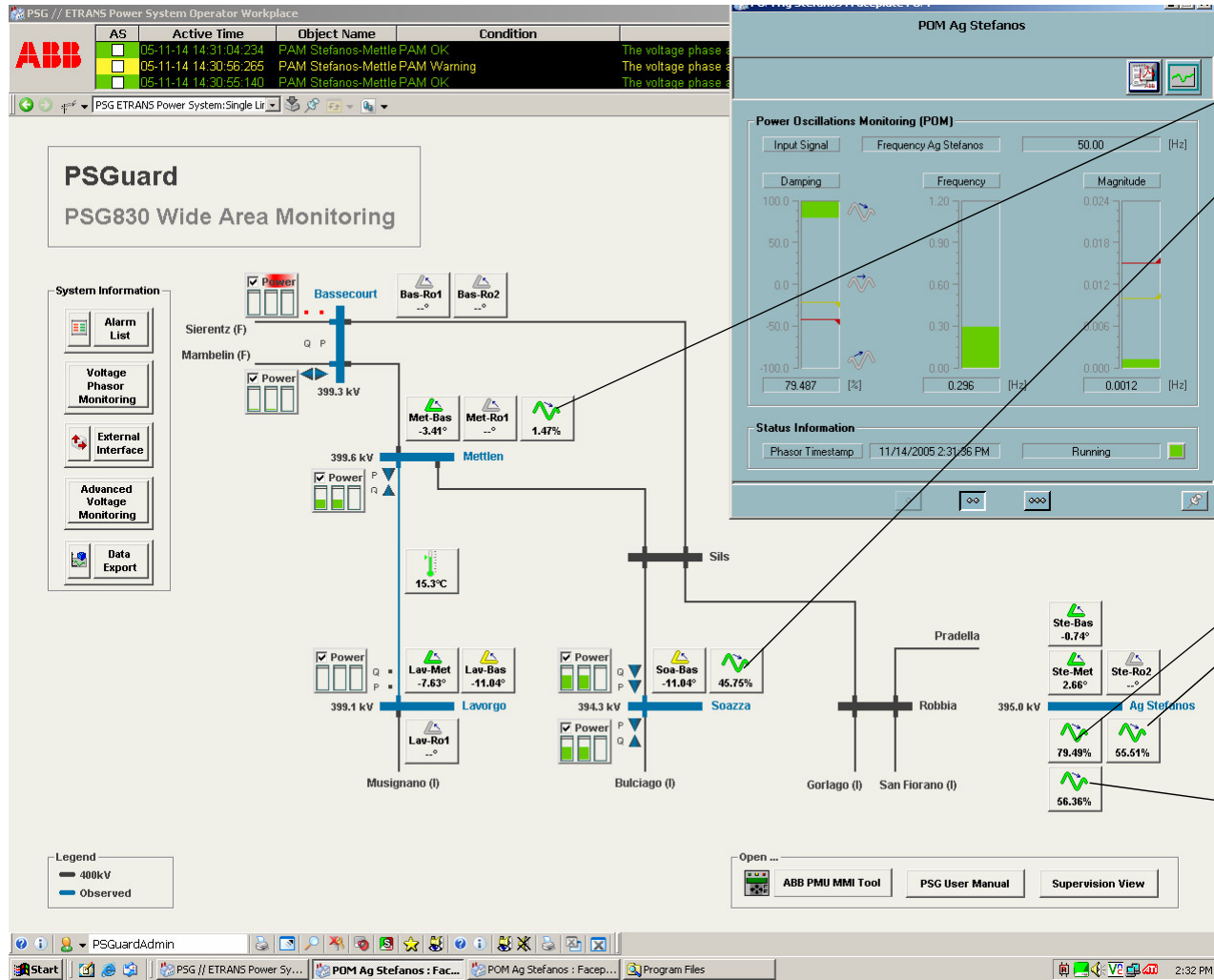
Stability Monitoring Approach

POM - Input

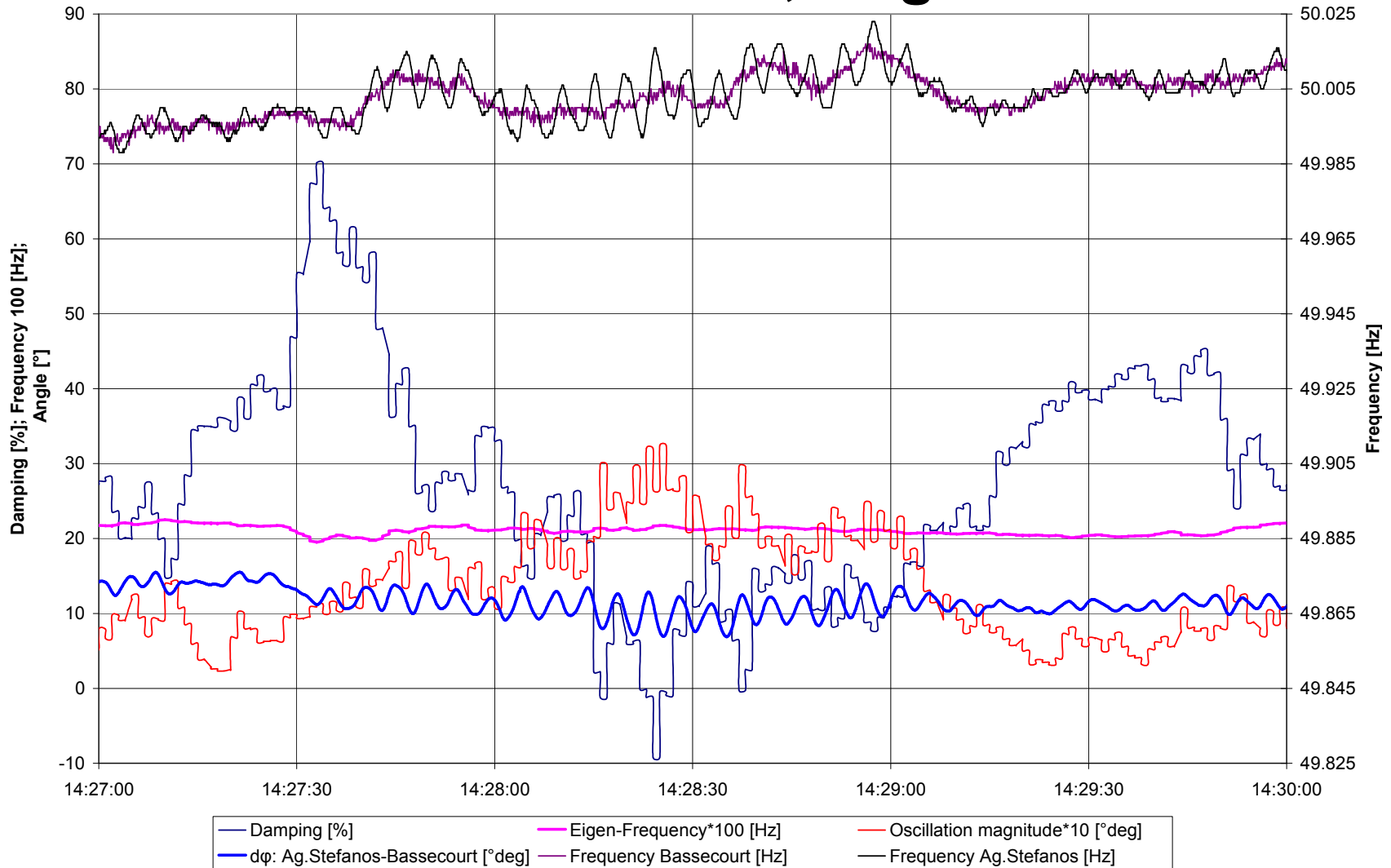
Active power

Voltage phase angle difference

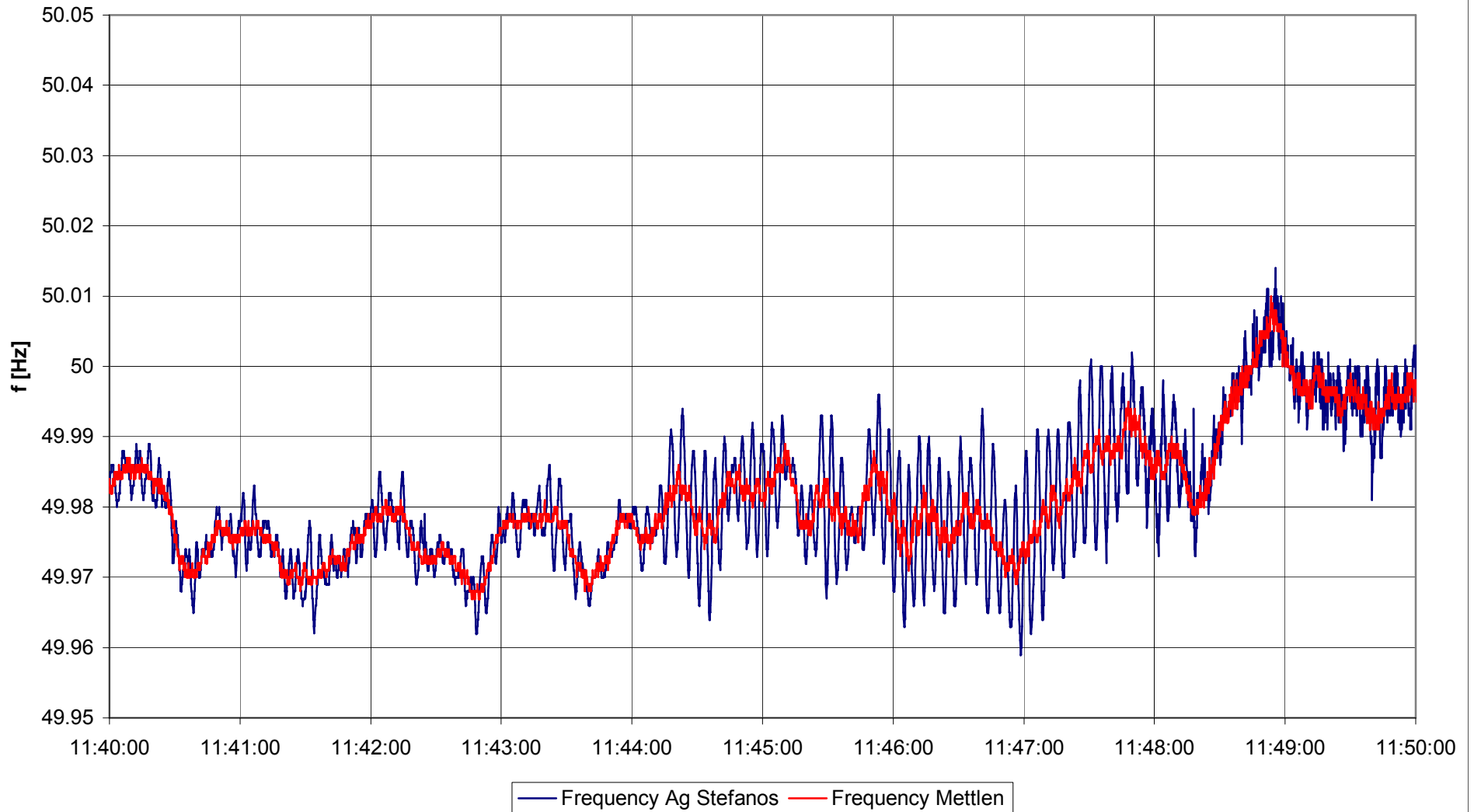
Frequency



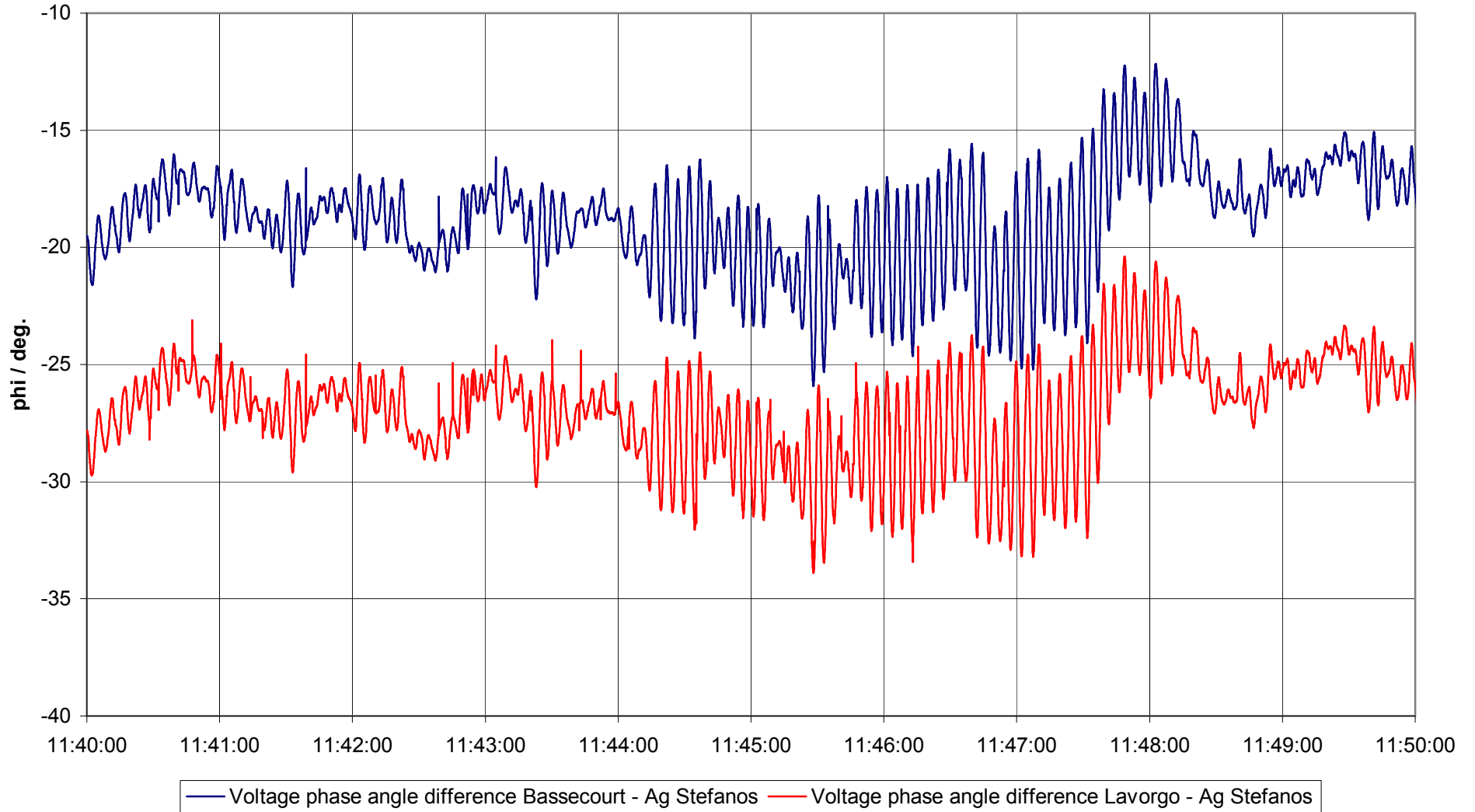
UCTE Inter-Area Oscillation, Aug. 21th 2005



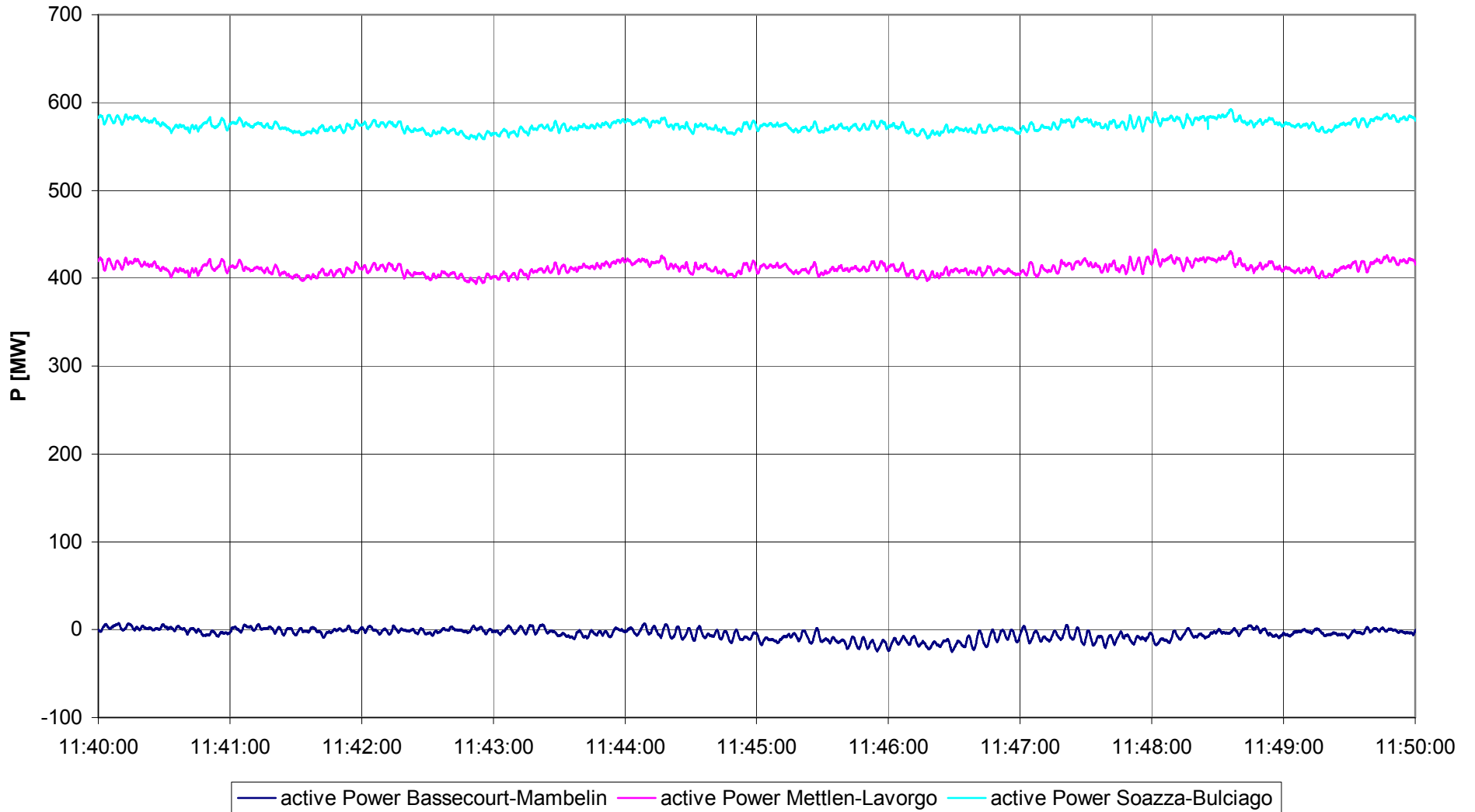
24/03/2006 11:45:00 Inter-area oscillation



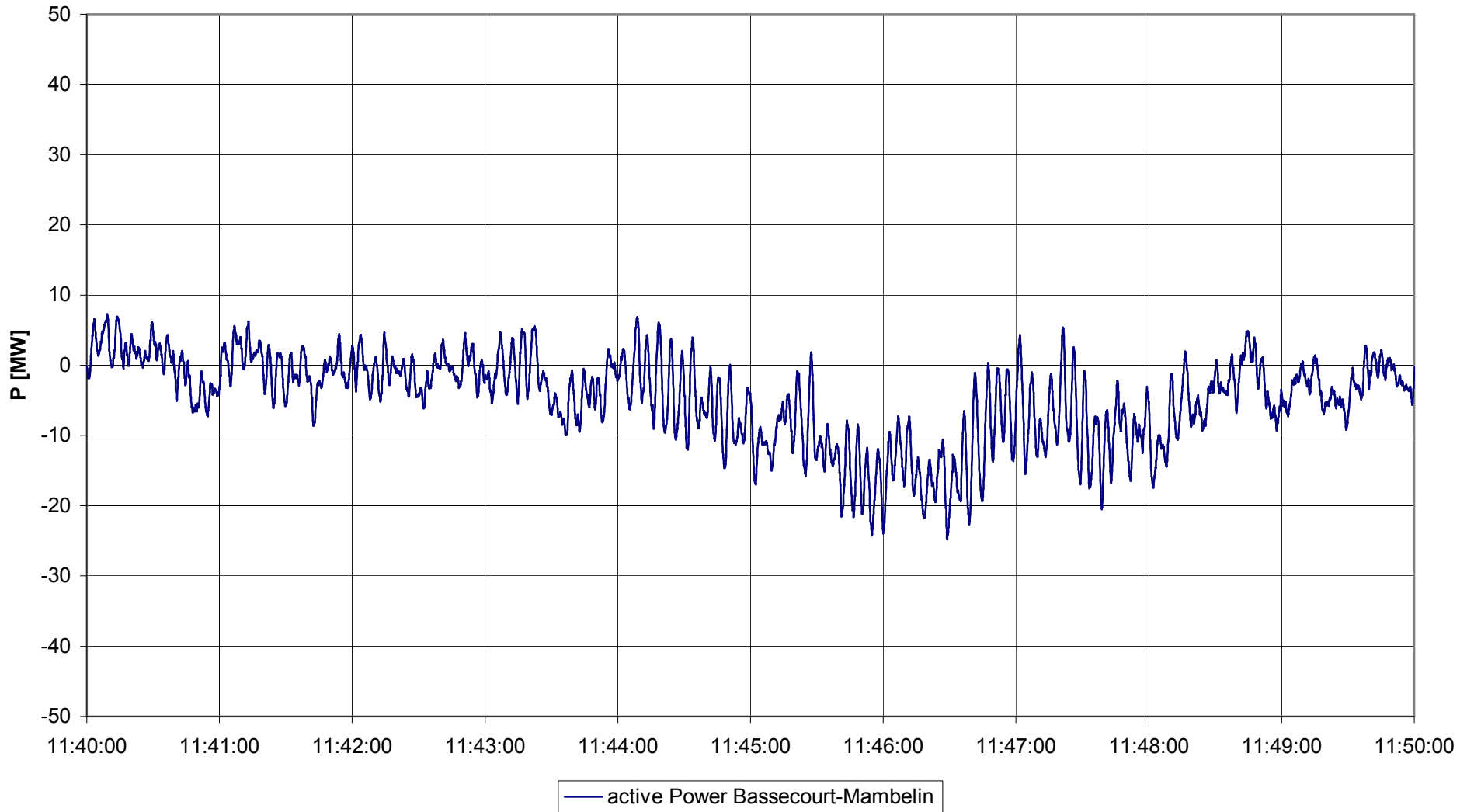
24/03/2006 11:45:00 Inter-area oscillation



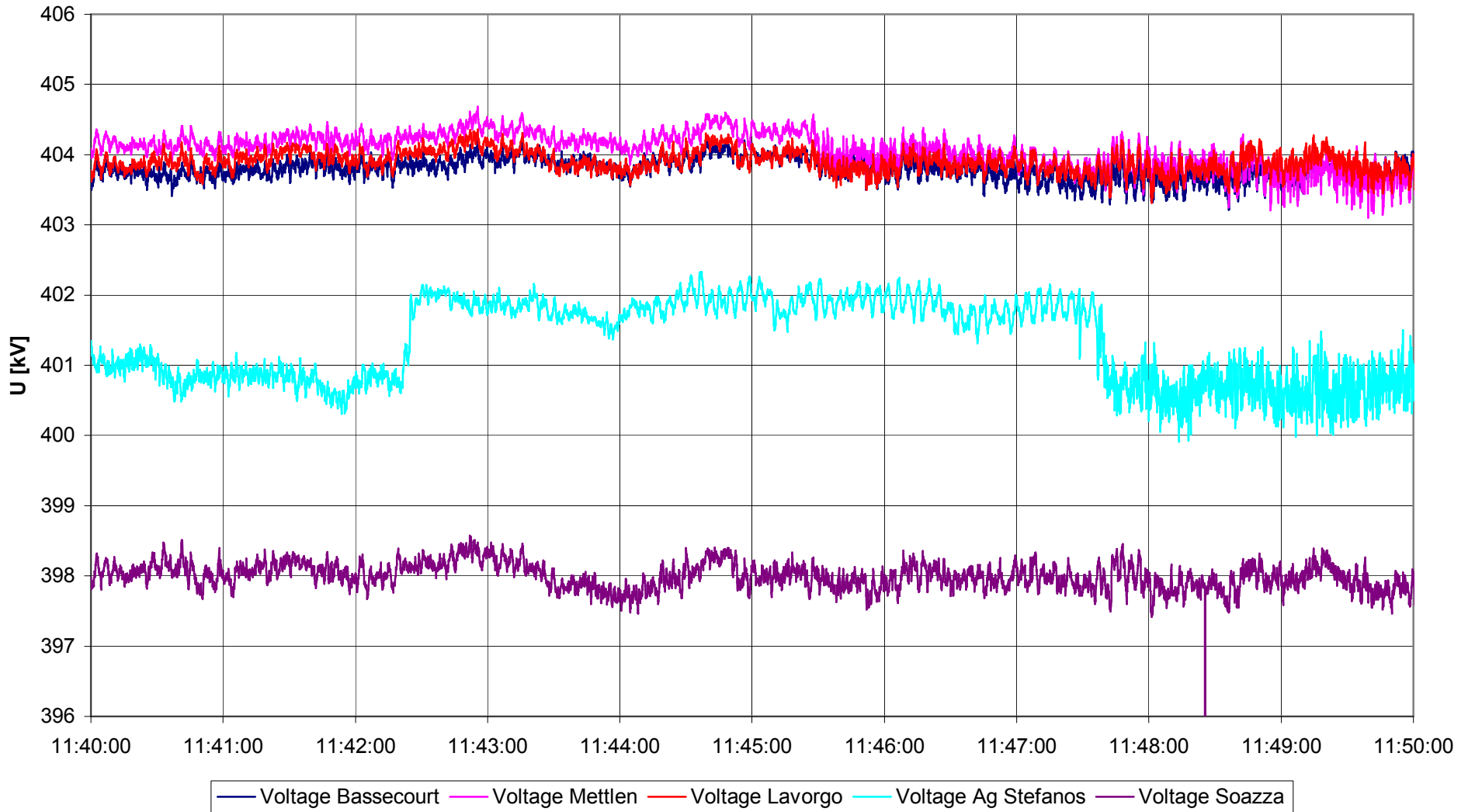
24/03/2006 11:45:00 Inter-area oscillation



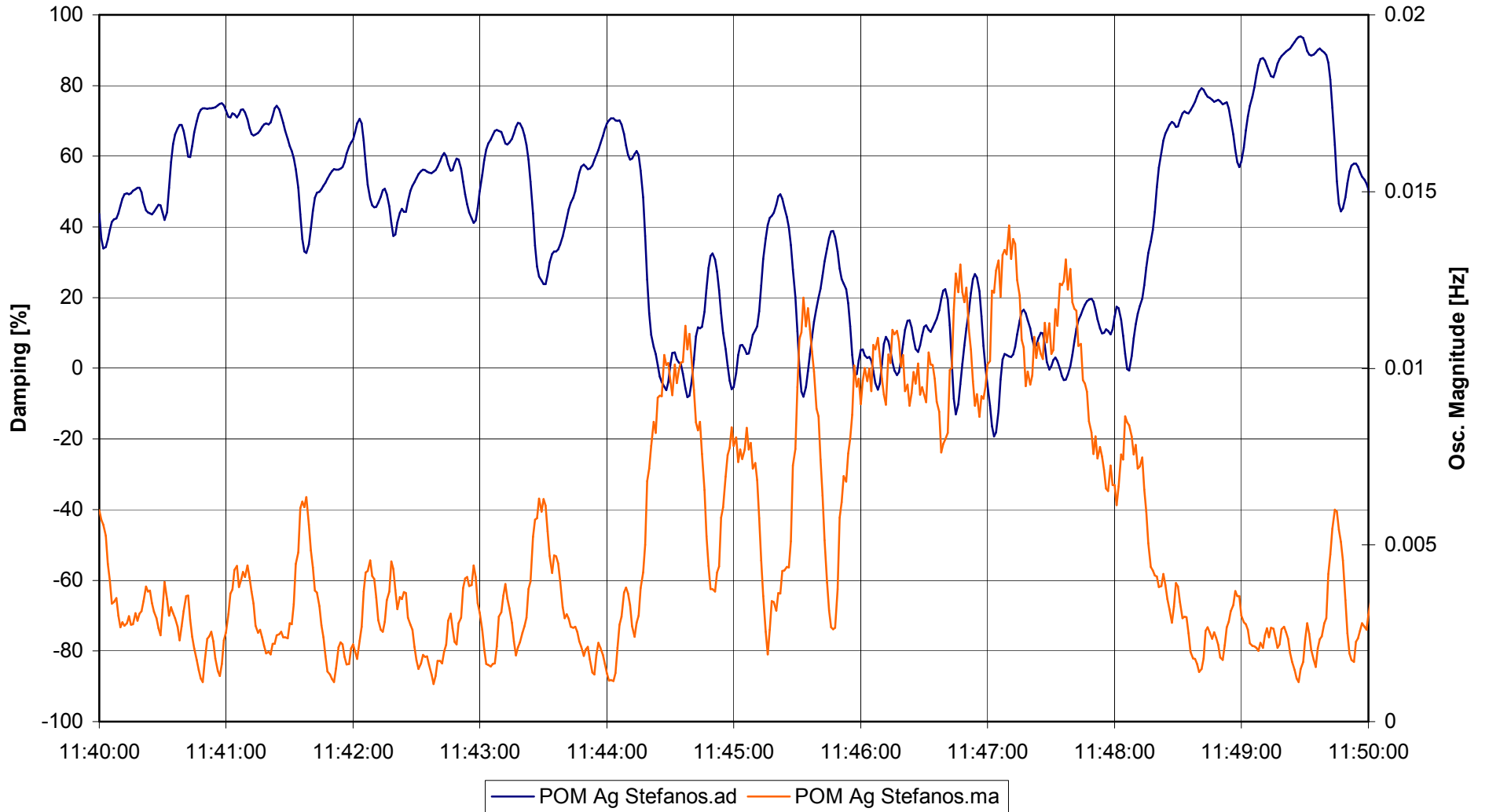
24/03/2006 11:45:00 Inter-area oscillation



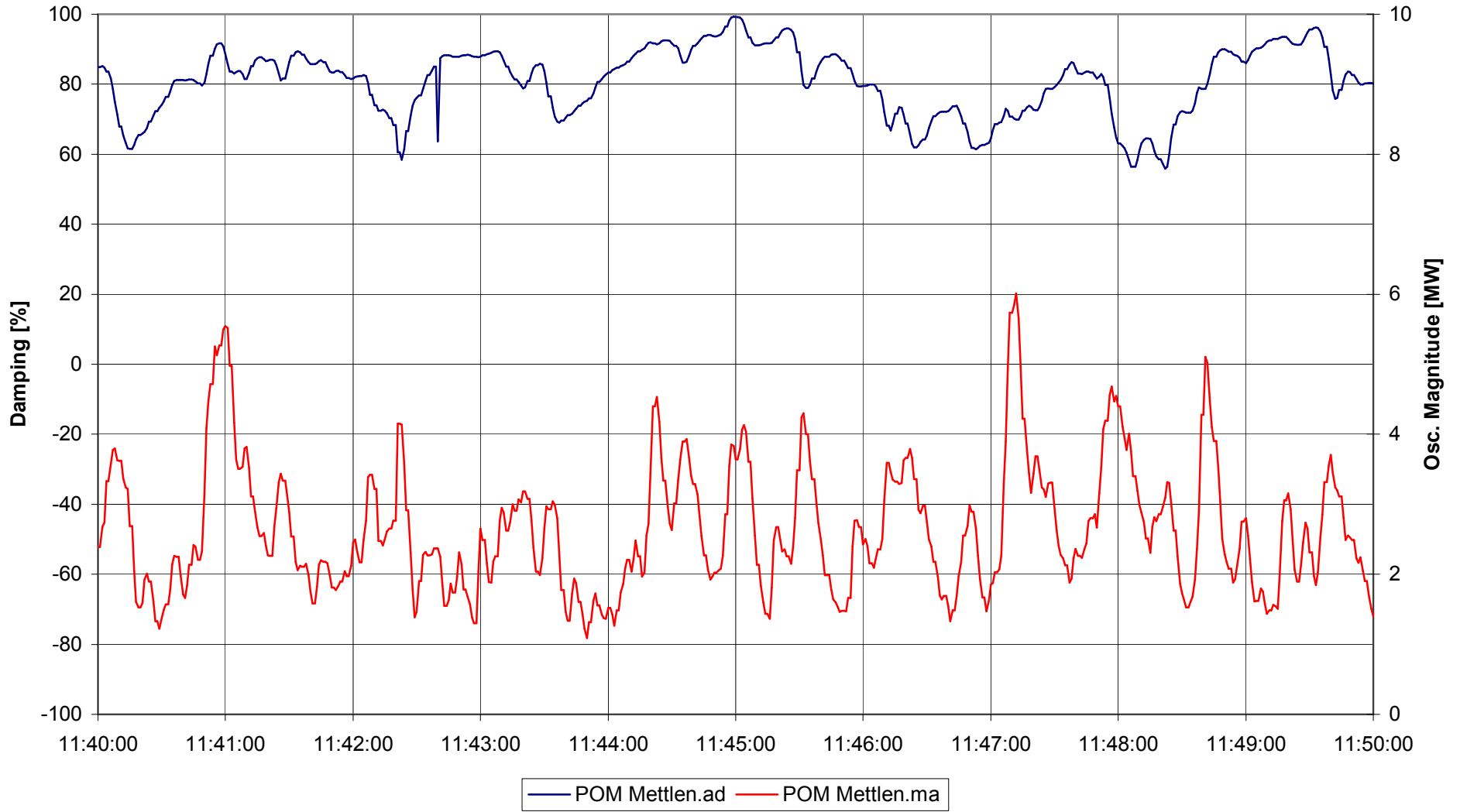
24/03/2006 11:45:00 Inter-area oscillation



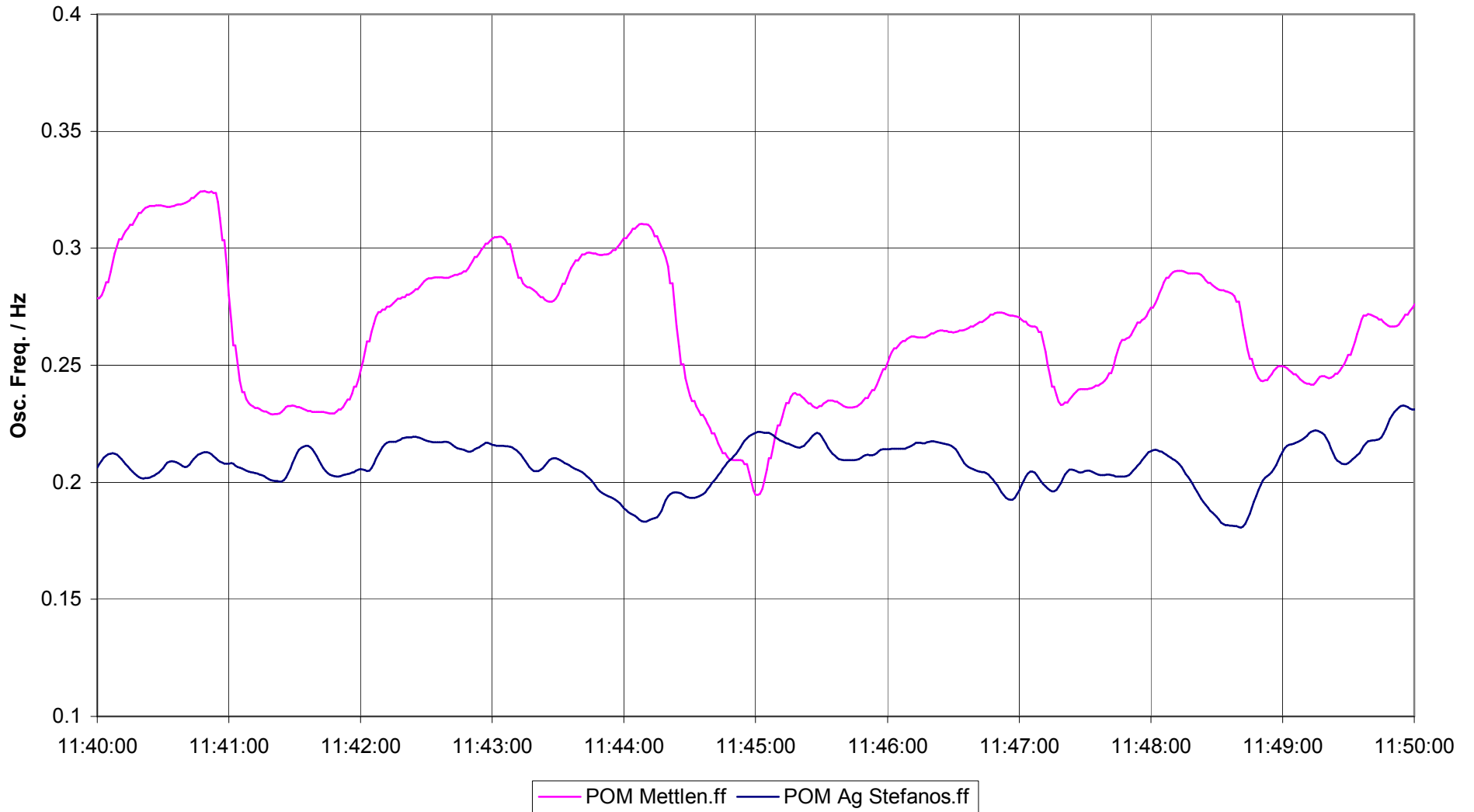
24/03/2005 11:45:00 Inter-area oscillation

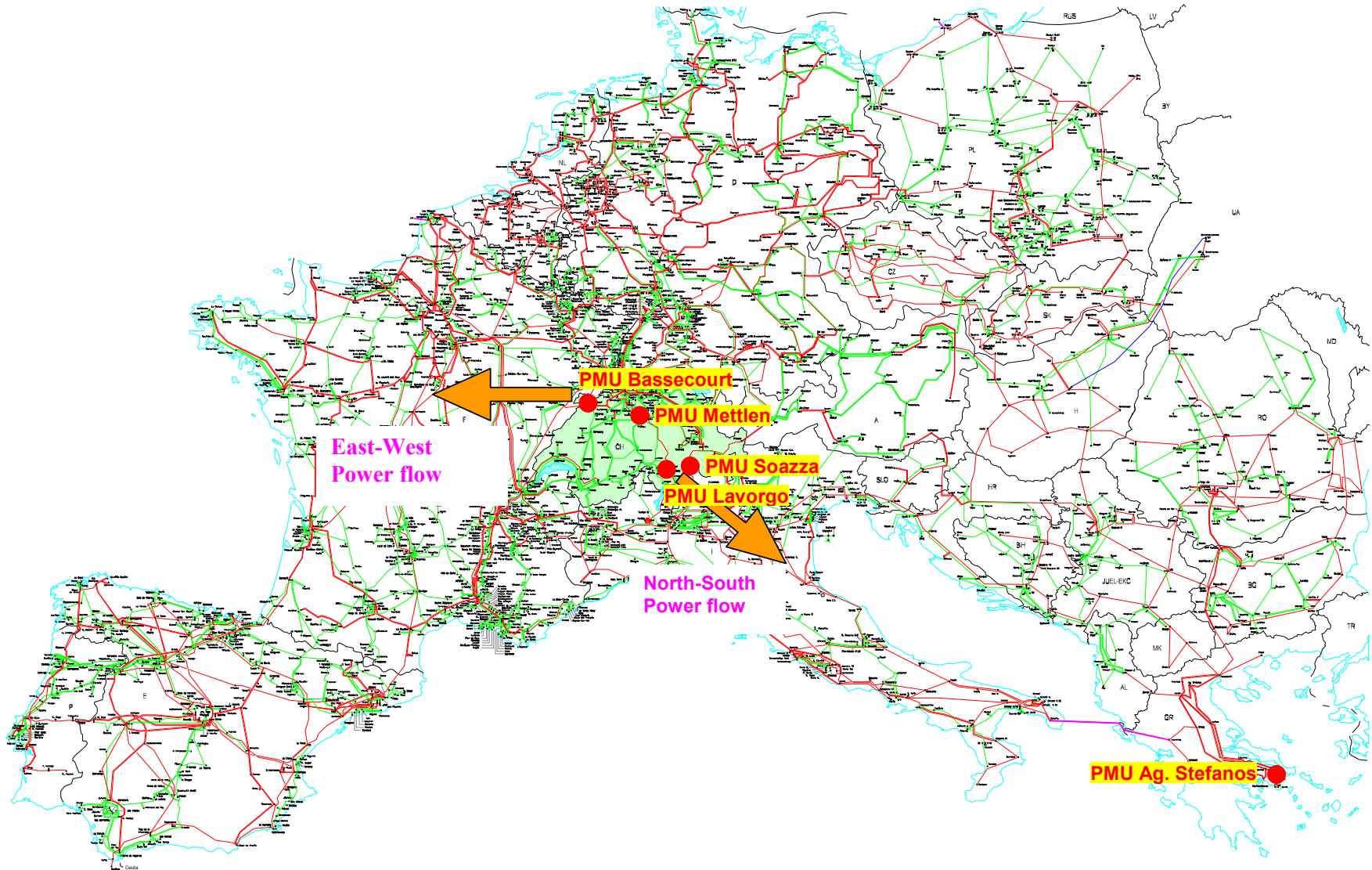


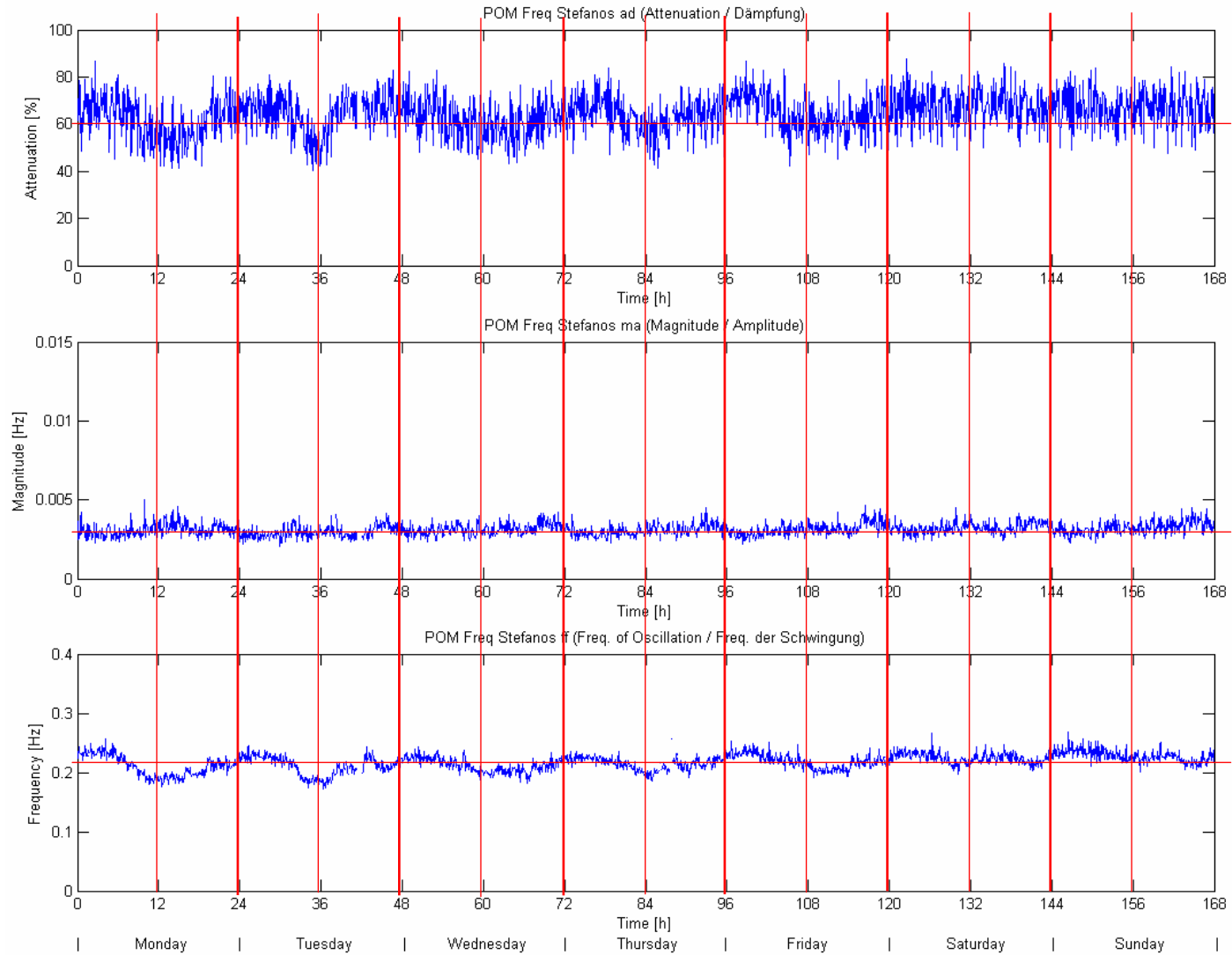
24/03/2005 11:45:00 Inter-area oscillation



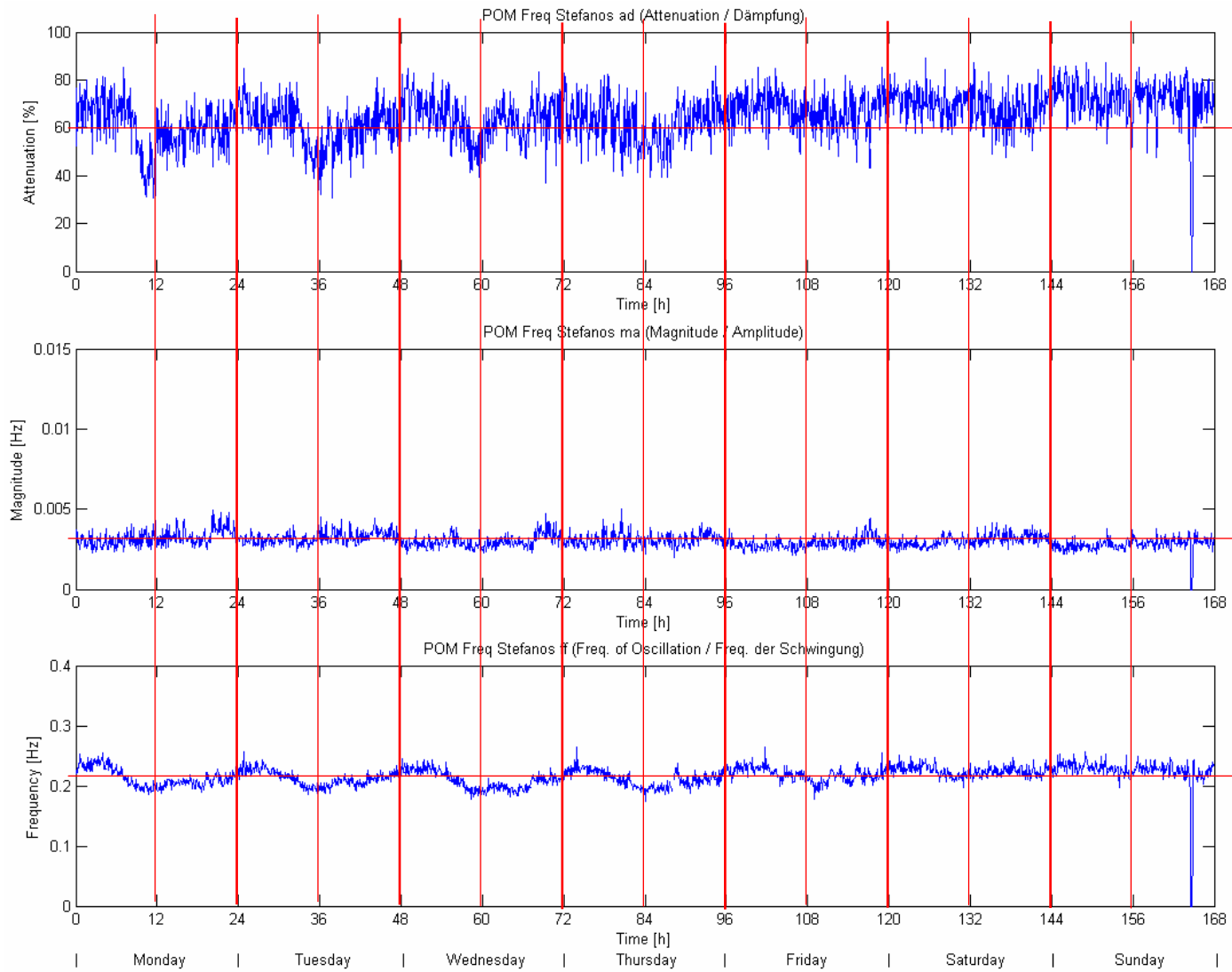
24/03/2005 11:45:00 Inter-area oscillation



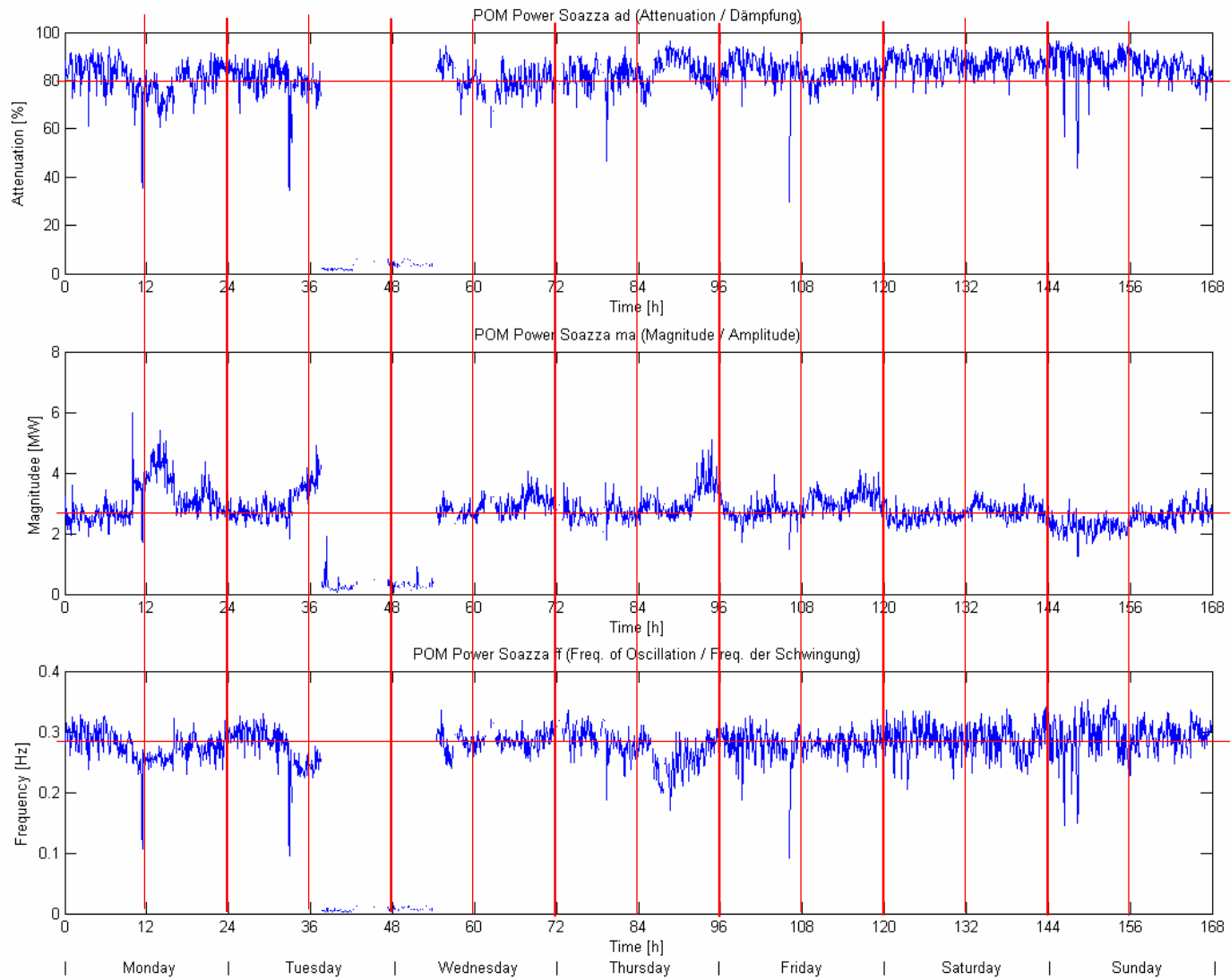




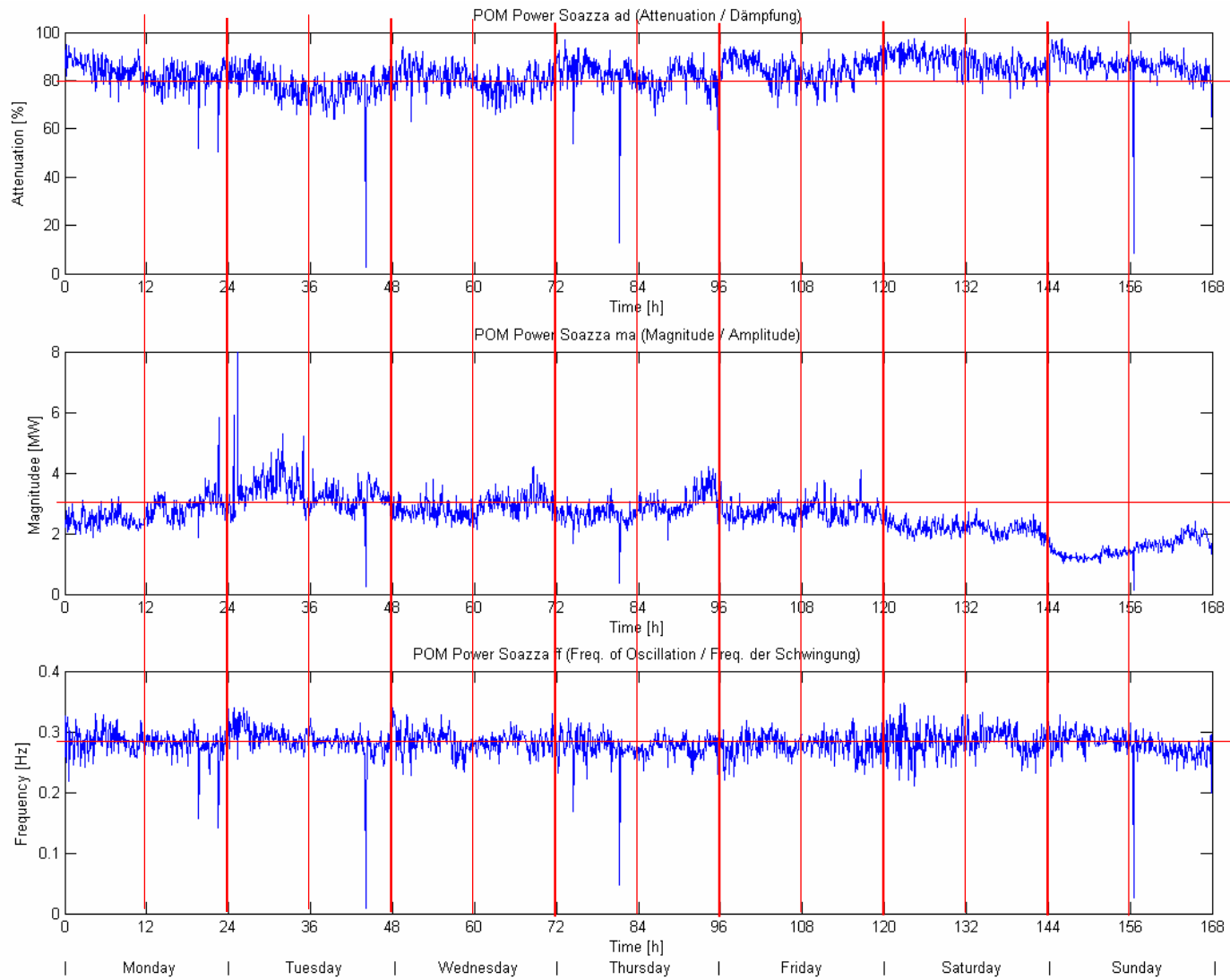
Week 14 – 2004: April 3th-9th - east-west oscillation



Week 15 – 2004: April 10th-16th - east-west oscillation



Week 14 – 2004: April 3th-9th - north-south oscillation



Week 15 – 2004: April 10th-16th - north-south oscillation

Conclusion

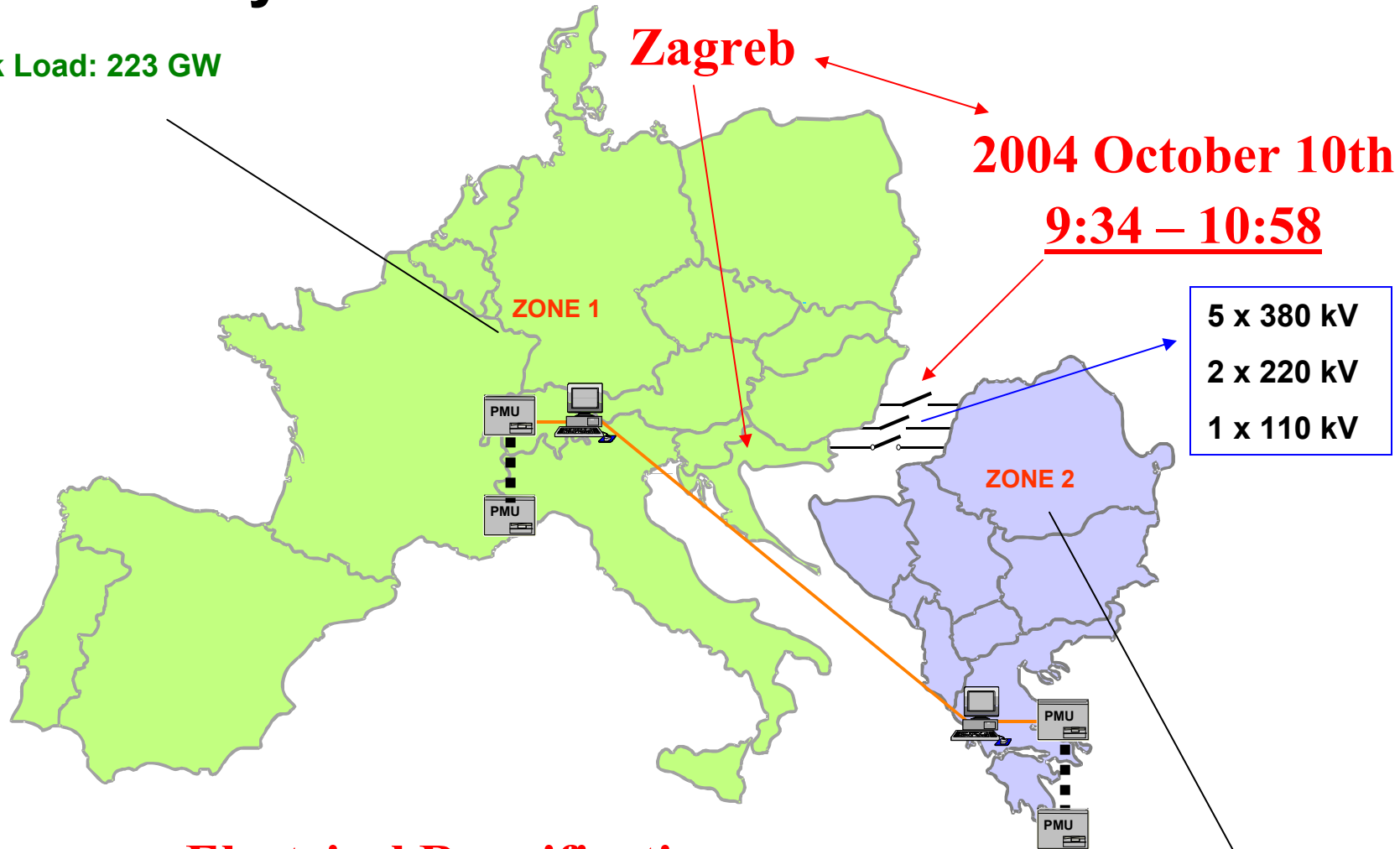
- **Inter-area oscillation for 4 minutes / two oscillation modes observed**
 - **East-west direction dominant – mode 1: 0.22 Hz / 4.55 s**
 - **Nord-south mode good damping – mode 2: 0.28 Hz / 3.57 s**

- **Correlation with voltage change in Greece**

- **Friday midday oscillation**

UCTE Resynchronisation

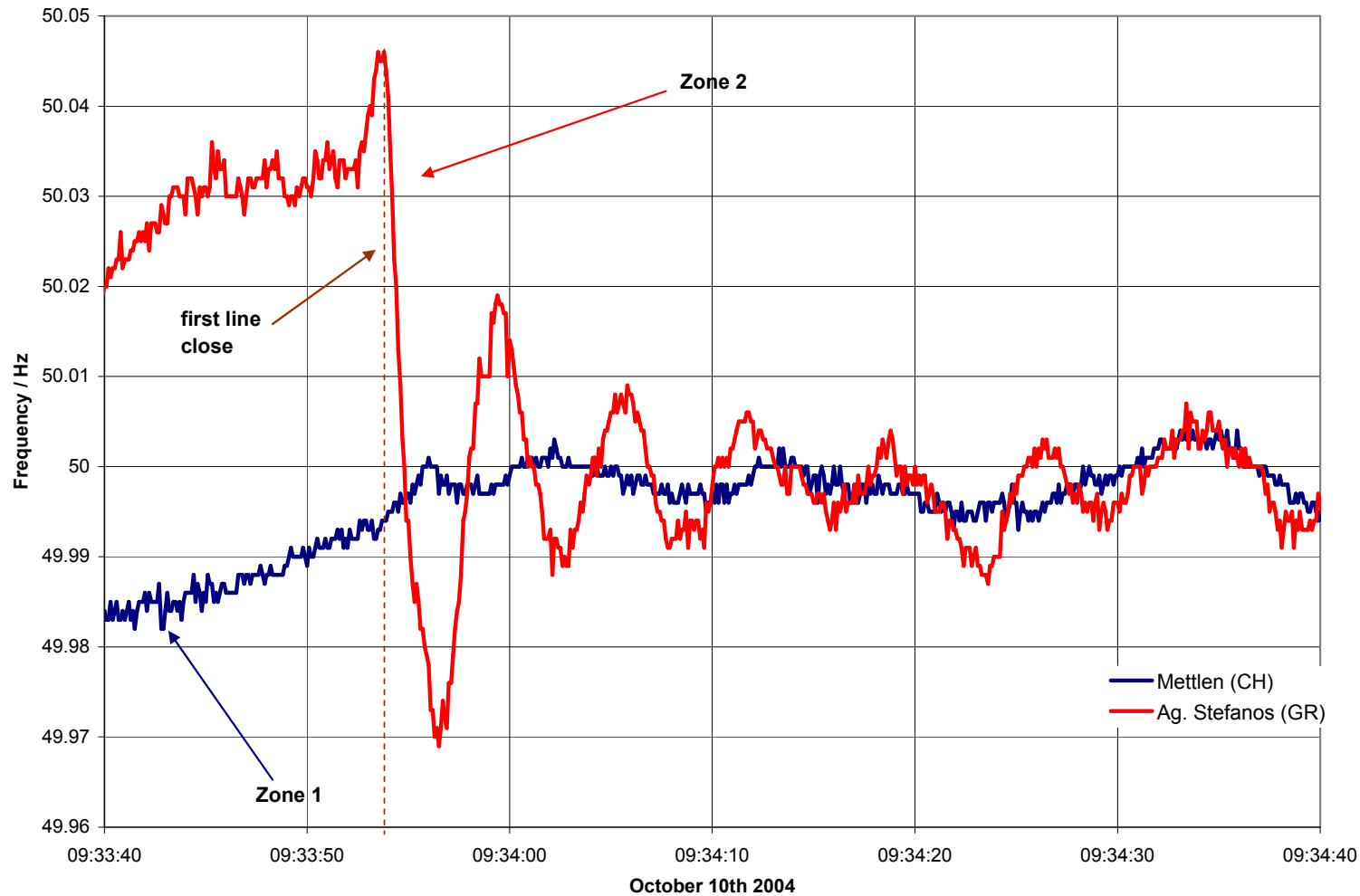
Peak Load: 223 GW

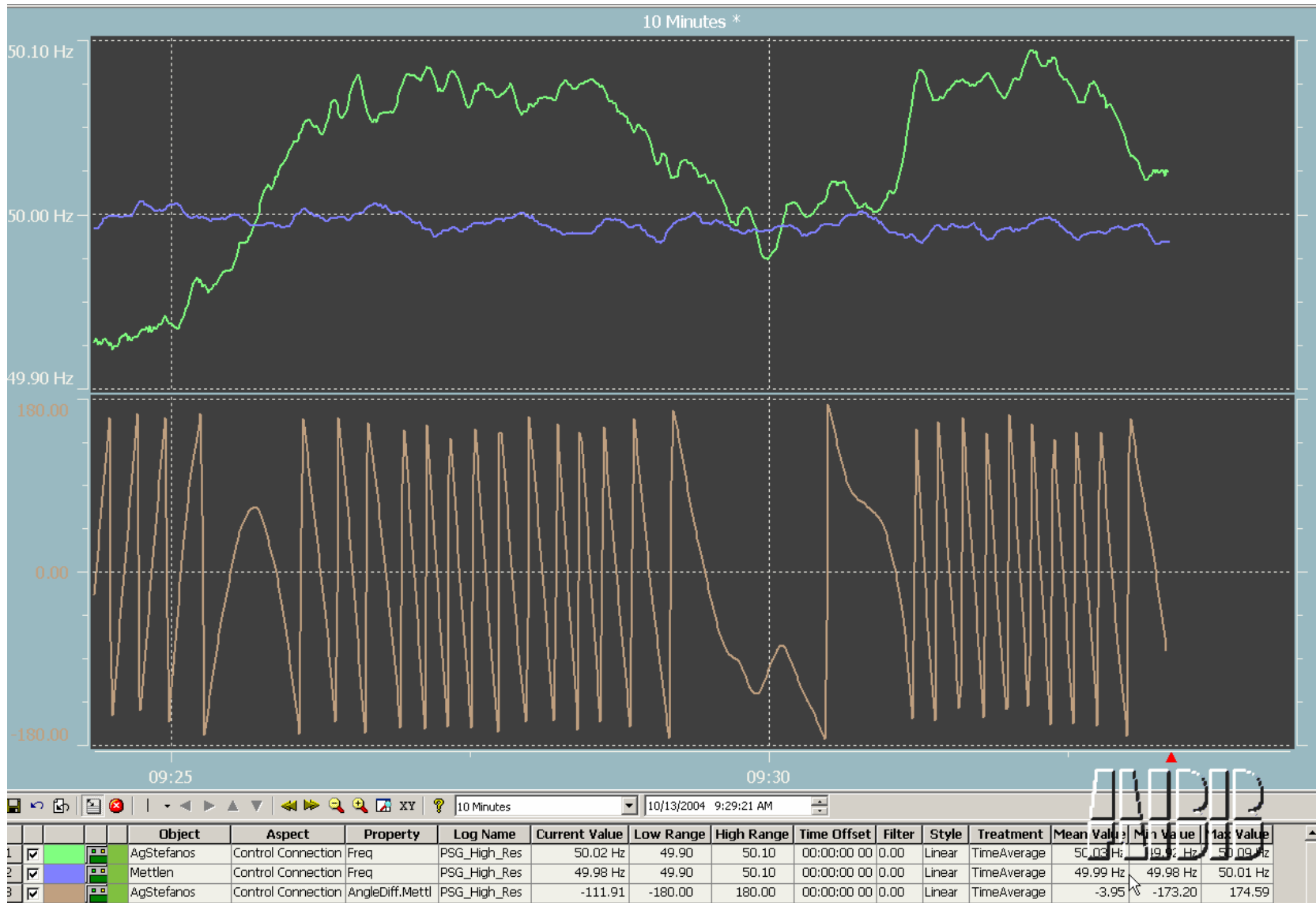


European Electrical Reunification

Peak Load : 21 GW

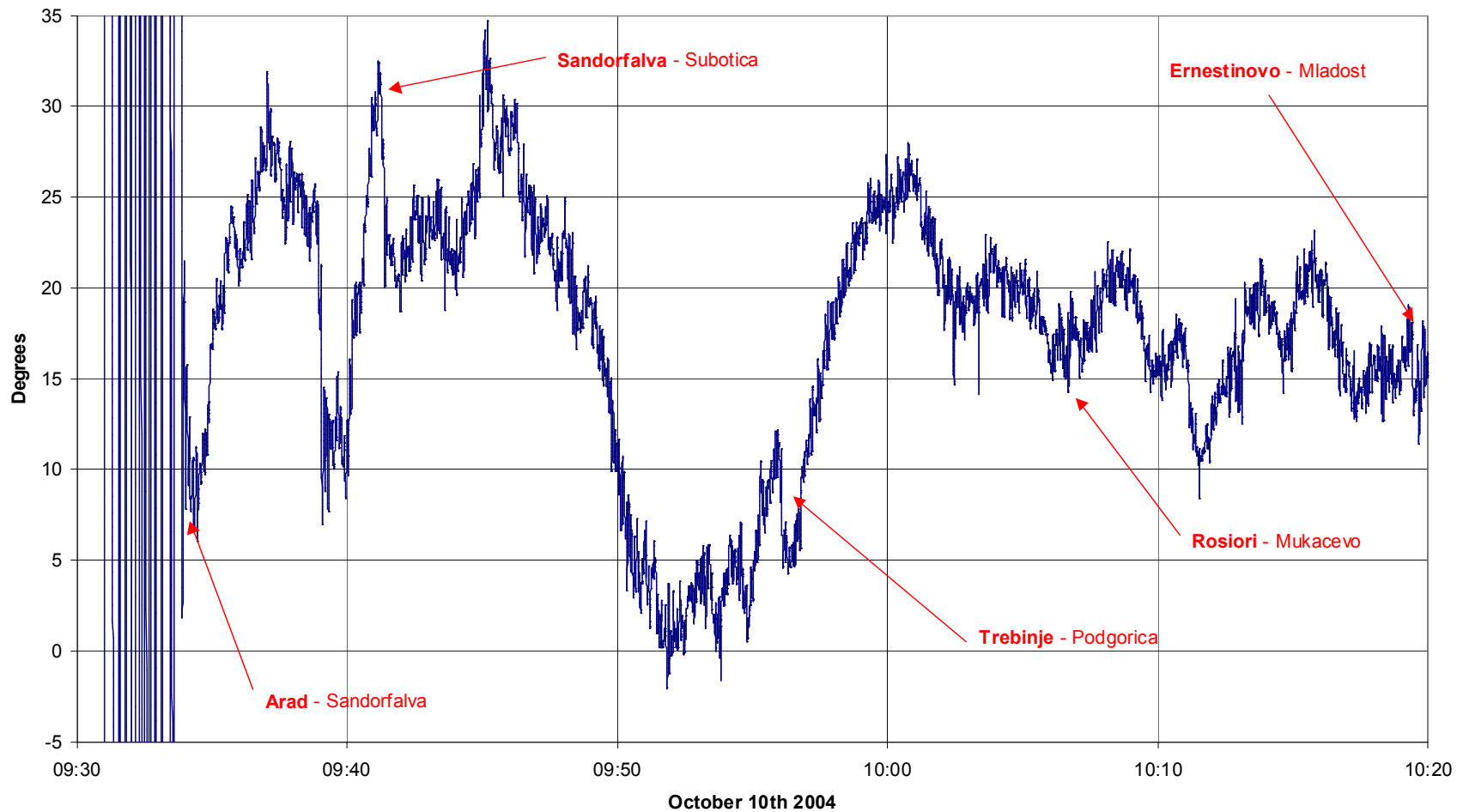
Frequency – System Stability Index





Voltage phase angle difference – stability indicator

Voltage Phase Angle Difference (Mettlen - Ag. Stefanos)



Application of different WAM Systems in UCTE

- RWE / Germany
 - Offline measurements – data acquisition via modem contact
 - Use of pre-defined trigger conditions for file saving
 - Fourier analysis – setup of binary signals in order to trigger alarms
 - Lead in efforts to re-activate PSS operation in Spain and Greece (TSO forum group)
- GRTN / Italy
 - Setup of centralised comprehensive system with 30 PMUs
 - Frequency monitoring, voltage monitoring, phase angle monitoring, line temperature control, islanding control, online modal analysis, data storage, system operator support
- ELES / Slovenia
 - Operator support in emergency conditions
 - Increase of EMS functionality
 - Use of five PMUs located in strategic substations of the system
- HEP / Croatia
 - Corridor monitoring
- APG / Austria
 - Corridor monitoring and control
- ETRANS / Switzerland
 - Corridor monitoring
 - Dynamic stability monitoring
 - System overview

Conclusions 1

- WAM Technology:
 - Is an excellent tool to be used for improving system operation security
 - Has to be applied on a larger scale in order to increase the benefit for **wide** area applications
 - Offers the possibility to “see” more as the own system in order to ensure secure interconnected system operation
 - Has to be improved especially on the interface level (more input channels, implement busbar intelligence, insert modems in PMUs, different GPS interfaces)
 - Will be developed in the direction of closed loop operation, currently used for monitoring only or system operation decision support
- Reliable Telecommunication required
 - Is the backbone of the system
 - Centralised data acquisition and common information sharing
- Further efforts to be done
 - Concentrate efforts and share results of WAM technology application

Conclusion 2

- Operation of the well-meshed central European power system becomes more complex
- Unfavourable system conditions can be detected by exact monitoring of the system frequency
- Increased market activities lead to a worsening of the system frequency quality
- Distance to the system stability limit is not too far

- Intensive cooperation and coordination between TSOs is required
- New technologies should be used in order to ensure a secure operation of the interconnected power systems

Thank you for your attention