Analysis of Events using Phasor Measurement

(The Experience of Medfasee Project)

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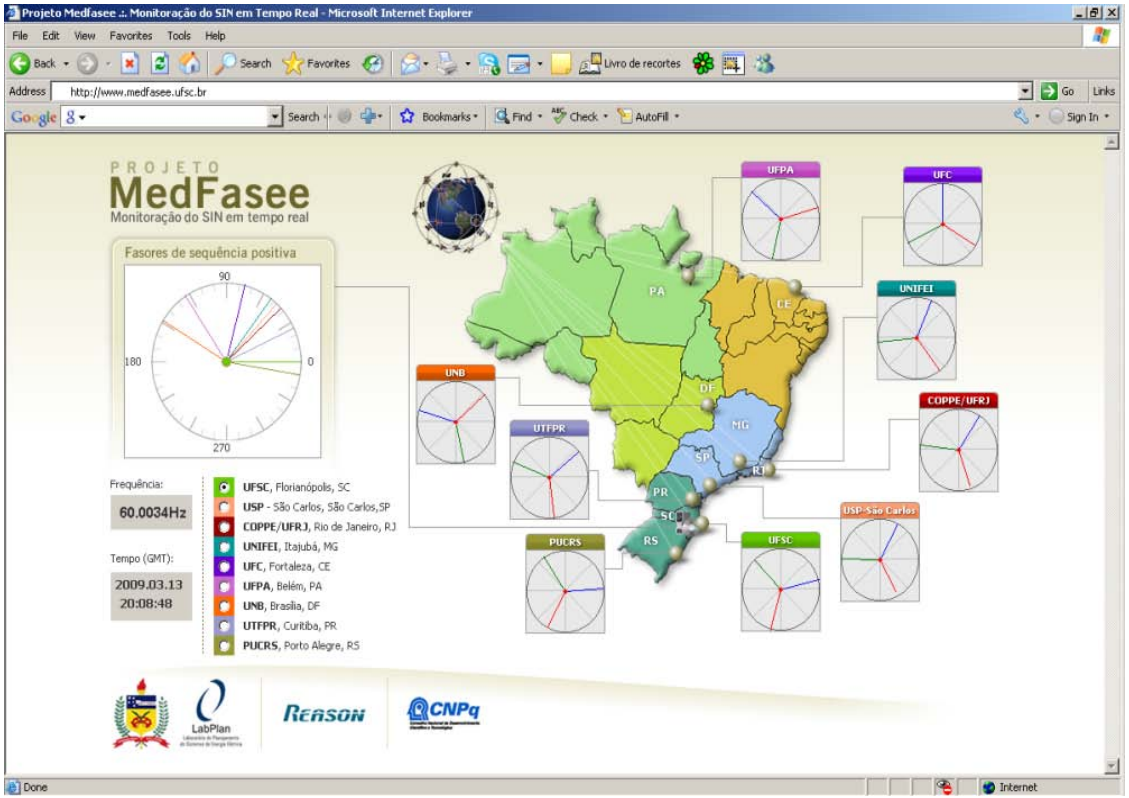
The MedFasee Project
(Main Characteristics)

- Project started in 2003
- Project Characteristics :
  - Development of a prototype
  - Study, dissemination and educational use of the WAMS technology
  - Applications for power system monitoring, control and fault location
- All hardware and software components were developed by the MedFasee team

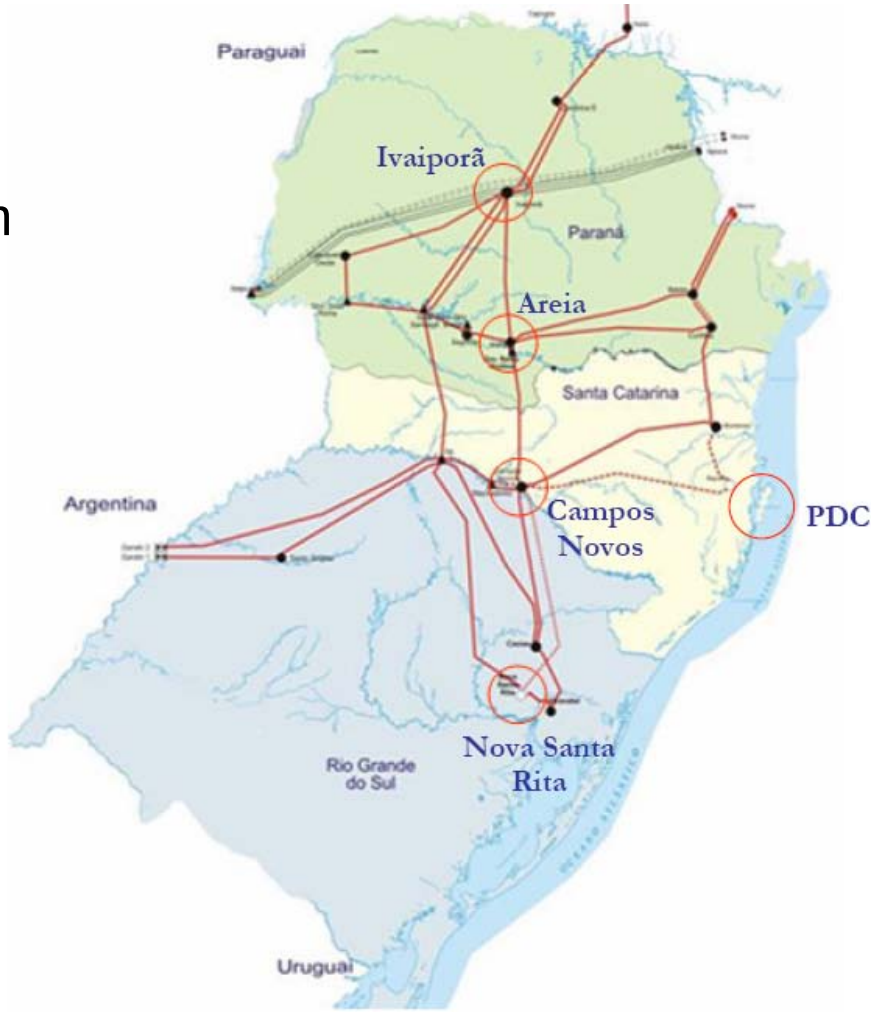
MedFasee Project
(Structure and Geographical Location)



- Five geographical regions are covered (9 universities)
- Virtual Private Network over Internet for communication

The MedFasee Eletrosul Project

- Developments:
  - First installation in a 500kV system in Brazil
  - Main transmission utility of south
  - 4 PMUs and 1 PDC
  - Applications for monitoring tools and fault location
  - Power system performance analysis



PMU – RPV Reason

- Multifunctional device
  - PMU
  - Digital Fault Recorder
  - Power Quality Recorder
  - Continuous Recorder
  - Travelling Wave fault locator
  - More…
- IEEE C37.118 compliant
  - ONS testing at NIST: conditionally passed
- **Sending 60 phasors per second (3Φ)**
- Link Ethernet and UDP/IP protocol
- Configurable to 10, 12, 15, 20, 30 and 60 phasors per second and positive sequence

RPV 304

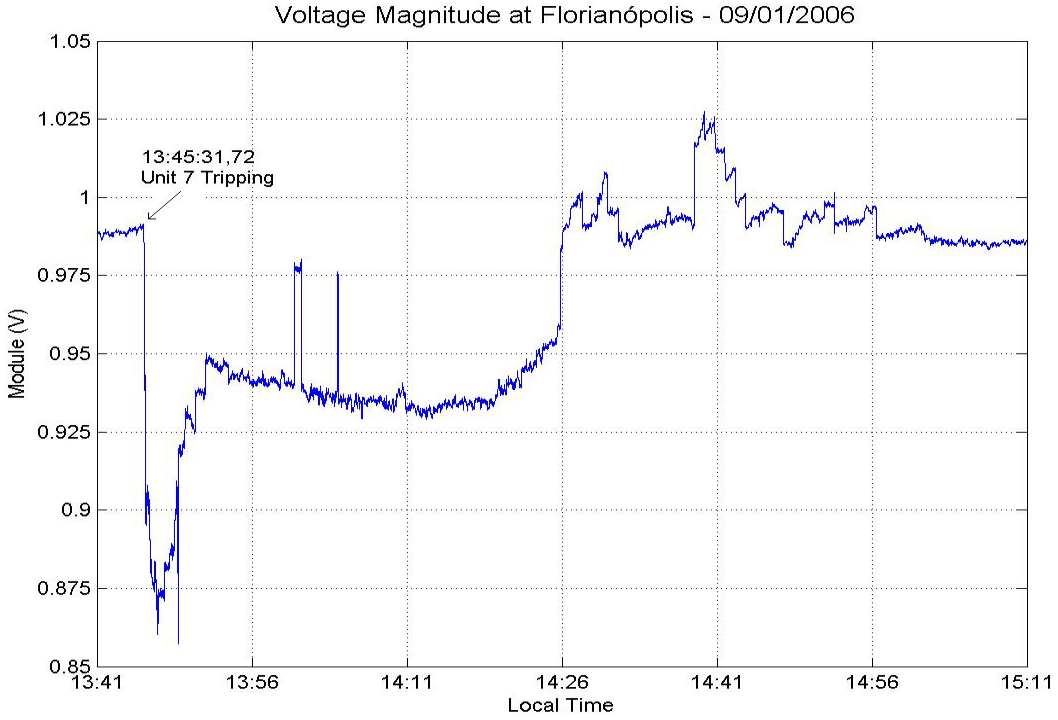
RPV 310

Selected cases

- 01/09/2006 - Generation dropping in a coal thermal plant
  - Comparison between simulation and measured oscillations
- 07/04/2009 – Special protection schema Itaipu (14000 MW) – Tucurui (8340 MW)
  - Measured oscillations modes and damping
- 10/04/2009 – System splitting in 2 islands
  - Causes not yet identified
- 09/08/2009 – Transmission line tripping
  - Fault location using phasors from both terminals
- Unbalance in 525 kV lines
  - Positive sequence errors

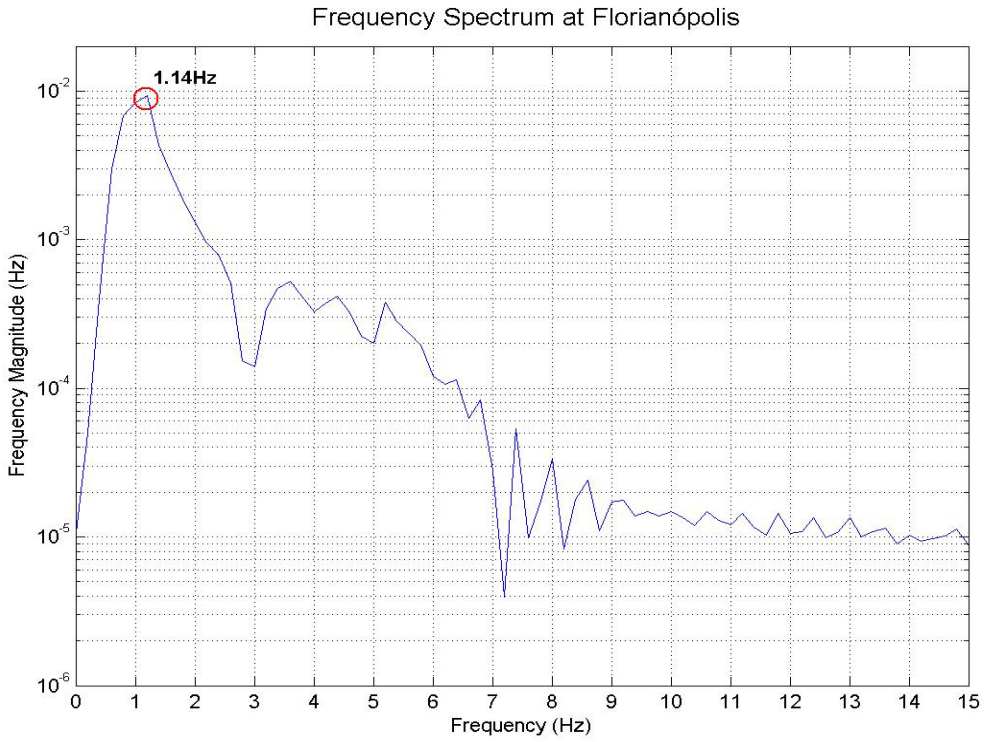
01/09/2006 - Generation Unit Tripping

- Disturbance detection
  - Generator unit tripping from a coal thermal plant
  - Jorge Lacerda – 343 MW;



01/09/2006 - Generation Unit Tripping

- An oscillation mode of 1.14 Hz was identified and attributed to a local oscillation mode of J. Lacerda

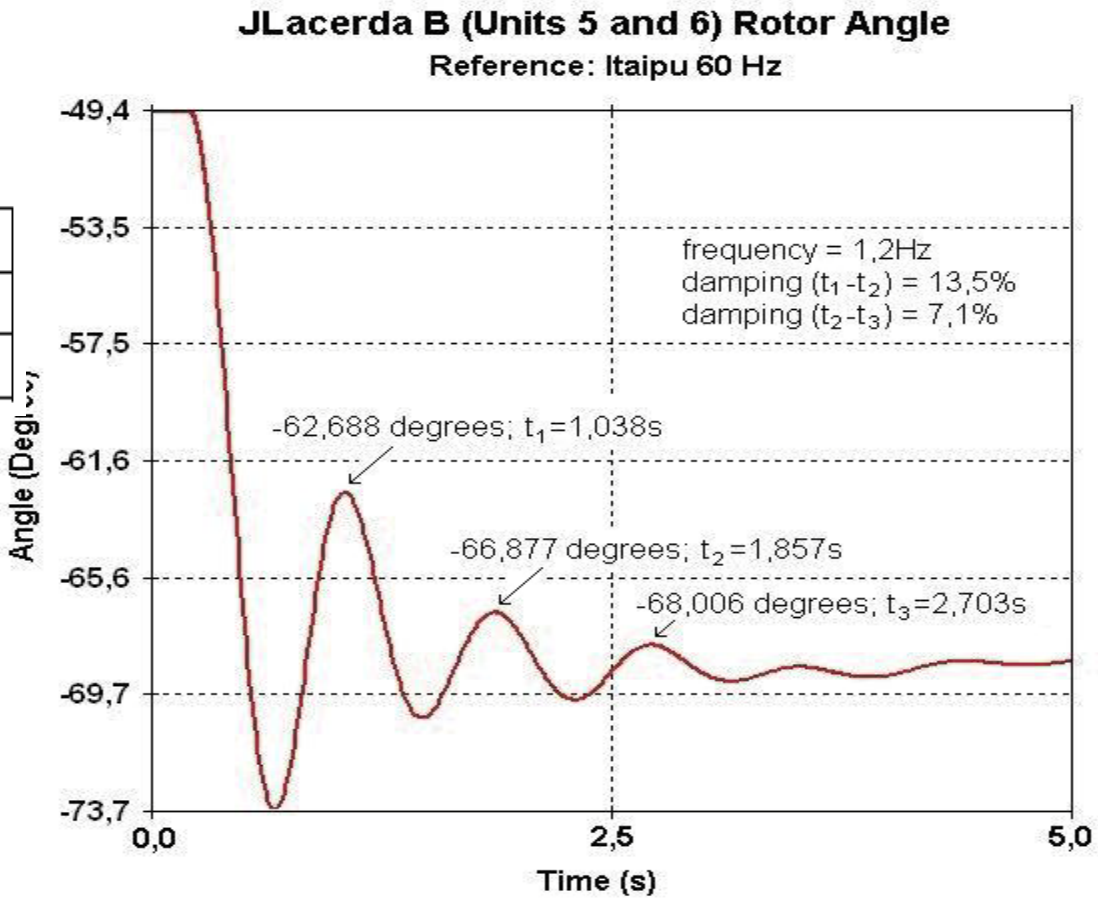


01/09/2006 - Generation Unit Tripping

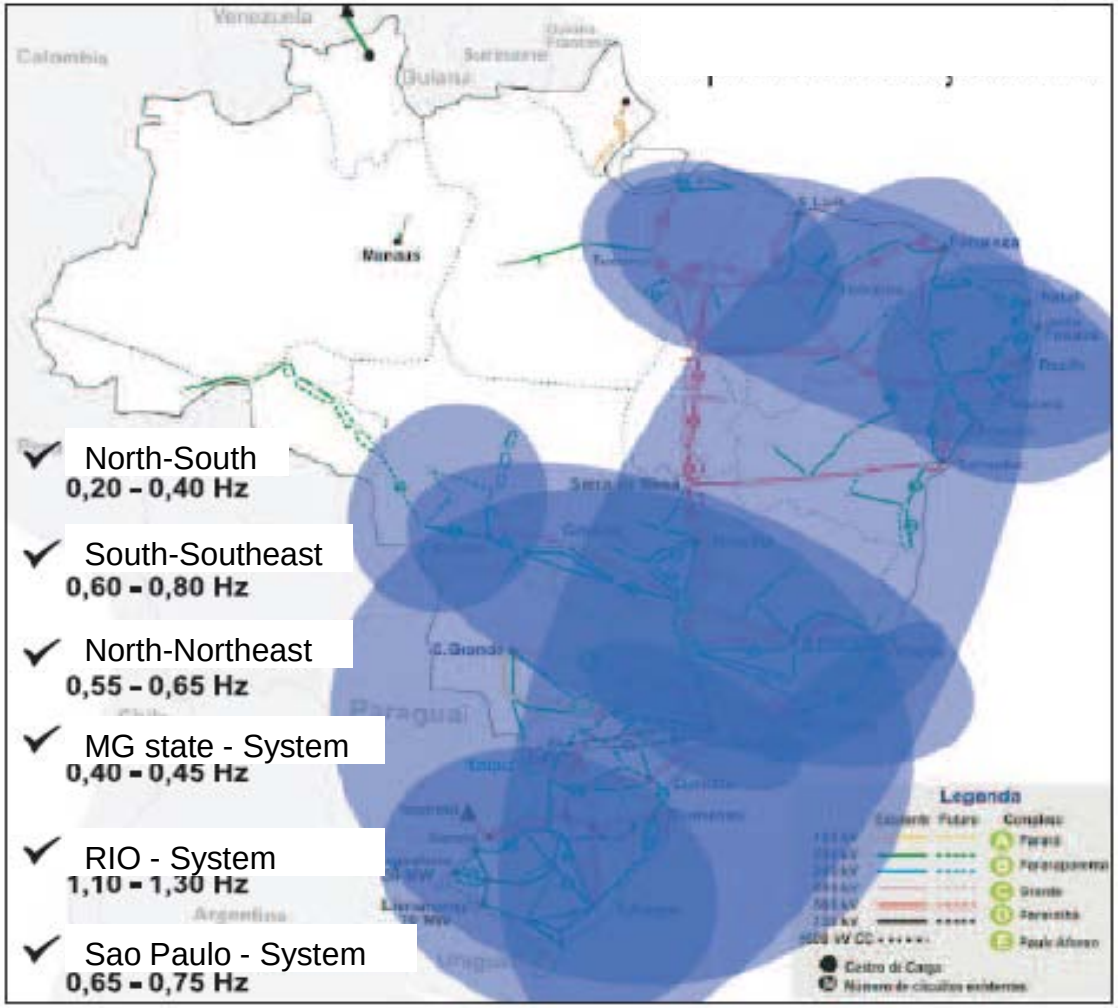
- The same mode appears in the event simulation !

Table 1 – Oscillation mode damping

Damping (ξ)	Measured (%)	Simulated (%)
ξ_1	10.1	13.5
ξ_2	6.2	7.1



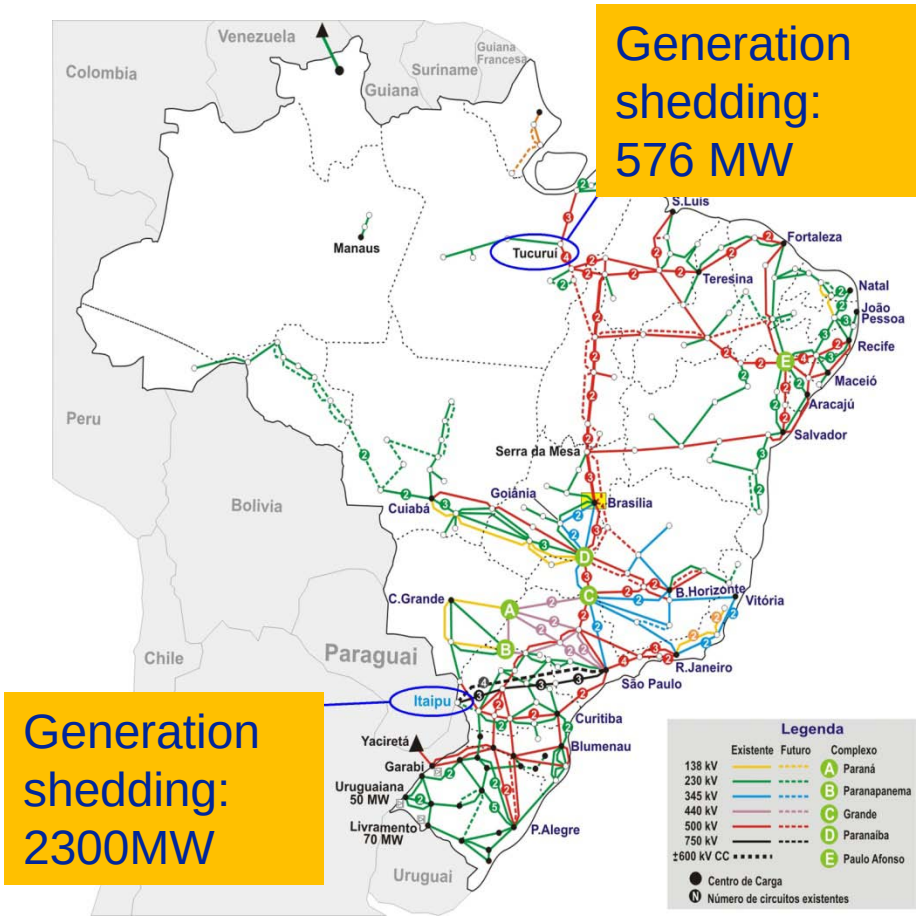
Main oscillation modes of Brazil



- North-South
  0,20 – 0,40 Hz
- South-Southeast
  0,60 – 0,80 Hz
- North-Northeast
  0,55 – 0,65 Hz
- MG state - System
  0,40 – 0,45 Hz
- RIO - System
  1,10 – 1,30 Hz
- Sao Paulo - System
  0,65 – 0,75 Hz

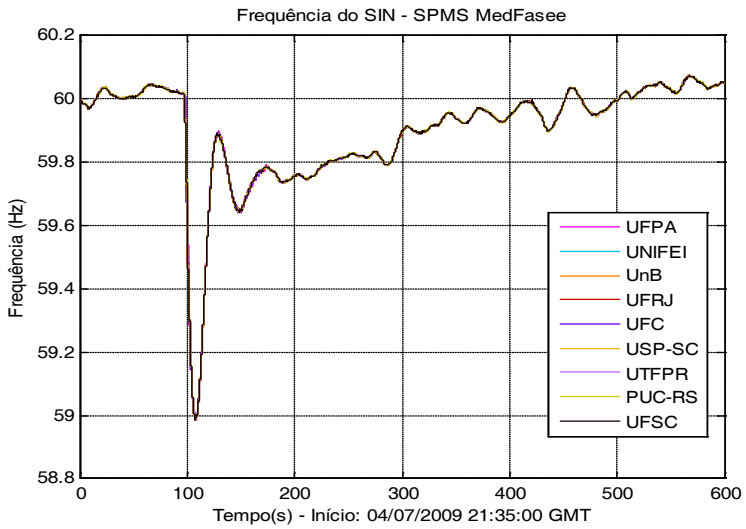
07/04/2009 - Special Protection Schema tripping

- Characteristics:
  - Automatic dropping of generation in Itaipu and in Tucurui
  - Maintain integrity of the system after loosing 765 kV circuits from Itaipu transmission
  - Power plants are 2200 miles apart
  - 33 miliseconds delay for signal transmission
- SPS raised in 900MW the transmission capacity from North-Southeast

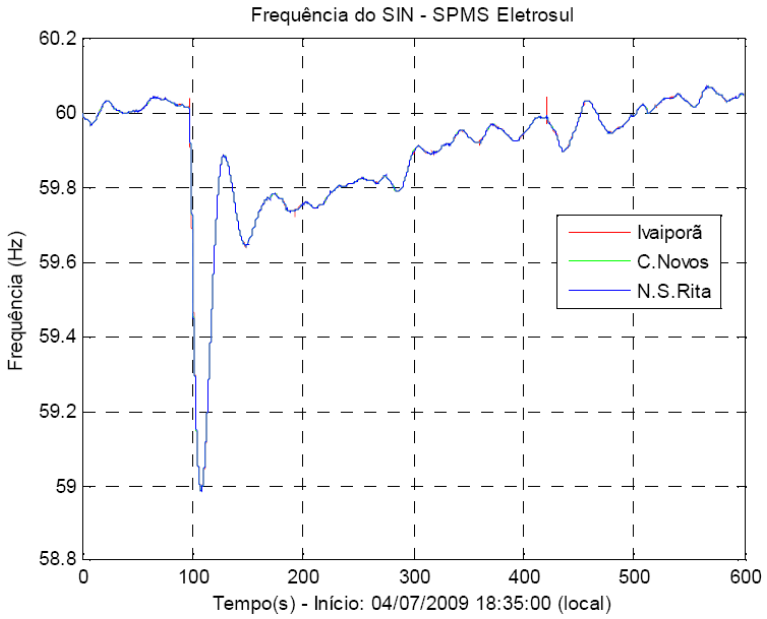


07/04/2009 - Special Protection Schema tripping

- Characteristics:
  - One-phase short circuit followed by the tripping of two circuits C1 and C2 from 765kV Foz do Iguaçu – Ivaiporã.
  - Generation dropping of 4 units of Itaipu and 2 units of Tucurui.
- Frequency Behavior



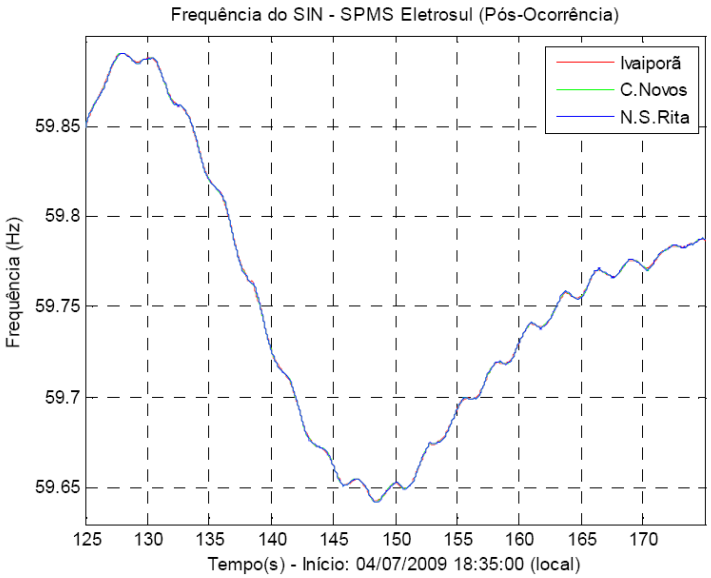
Distribution system



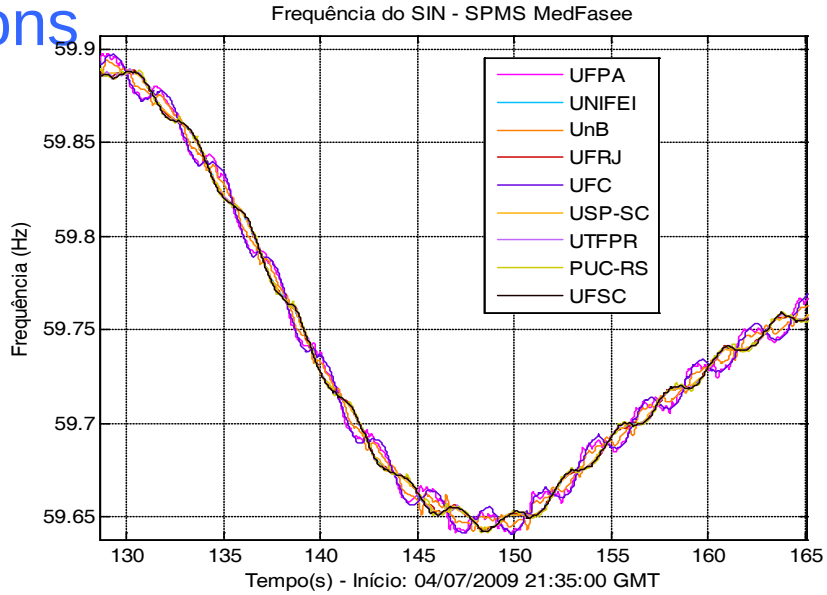
Transmission system

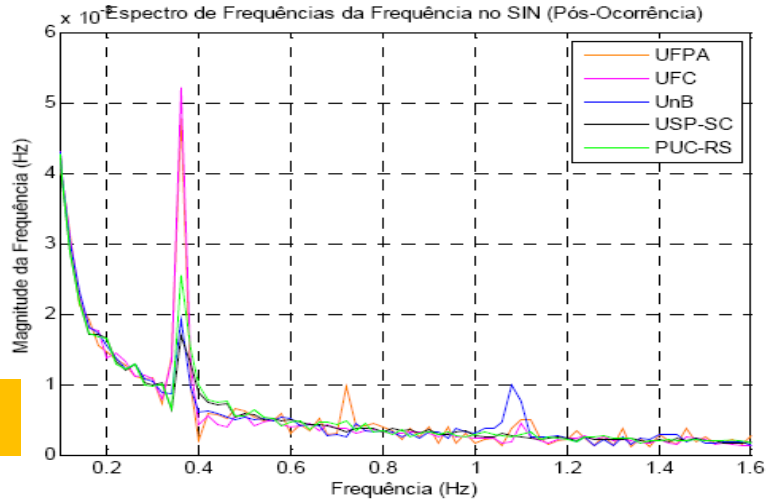
07/04/2009 - Special Protection Schema tripping

- Inter-area System Oscillations



Transmission system





Distribution system

07/04/2009 - Special Protection Schema tripping (Measured electro-mechanical oscillations modes)

- North - South mode:

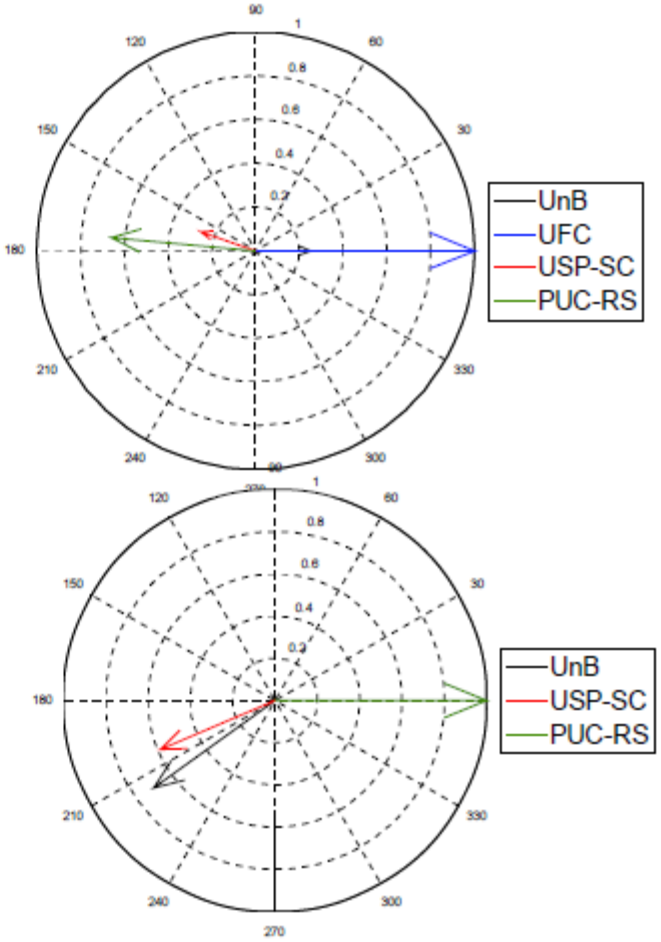
Frequency: **0.36 Hz**

Damping: **5,99 %**

- South-Southeast mode:

Frequency: **0.62 Hz**

Damping: **8.82 %**



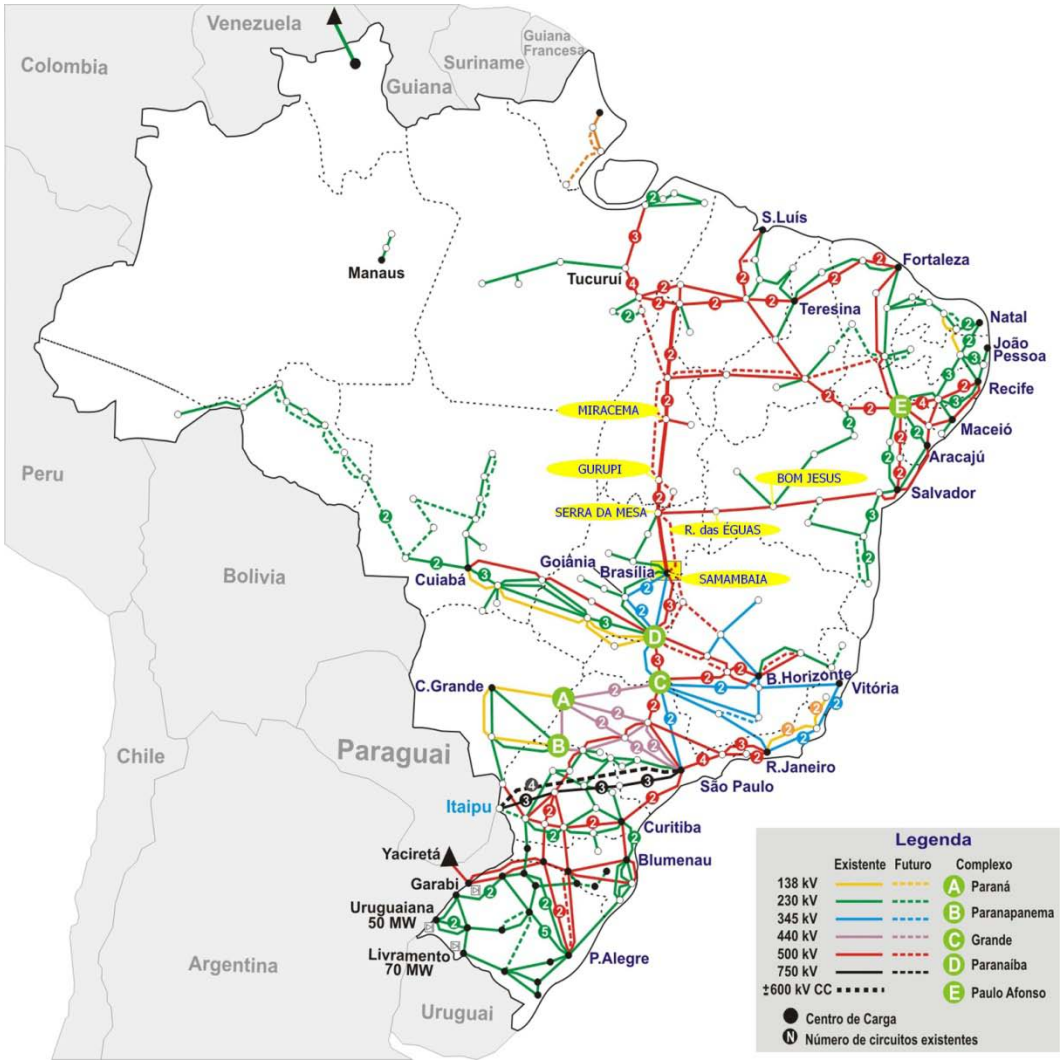
07/04/2009 - Special Protection Schema tripping

- The special protection scheme actuated again in 22/07/2009 with generation shedding of 3180 MW from Itaipu and 627 MW from Tucurui for a different disturbance (tripping of 3 x 765 kV lines)

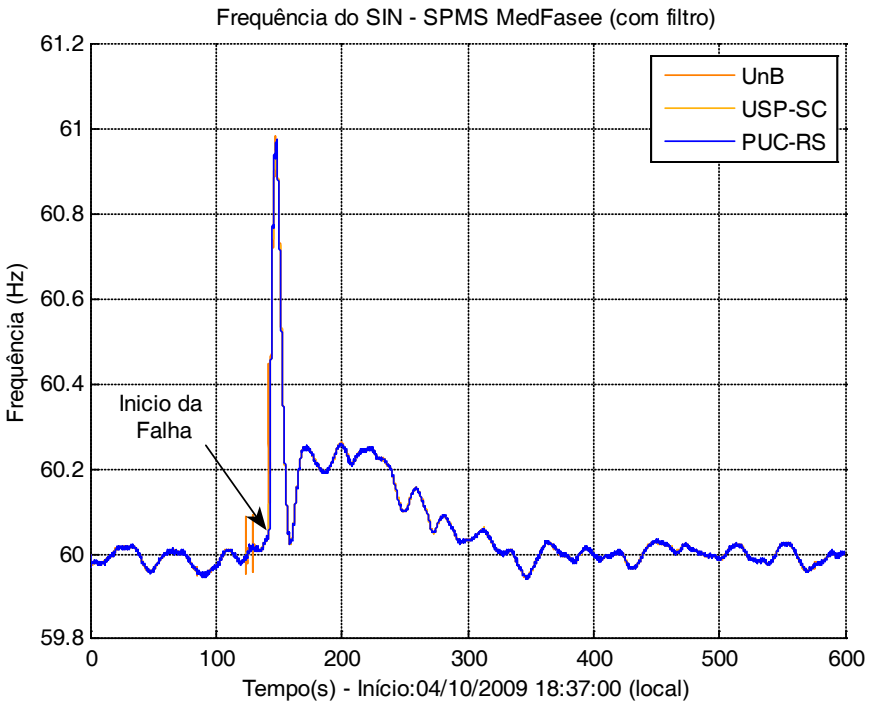
10/04/2009 - System islanding

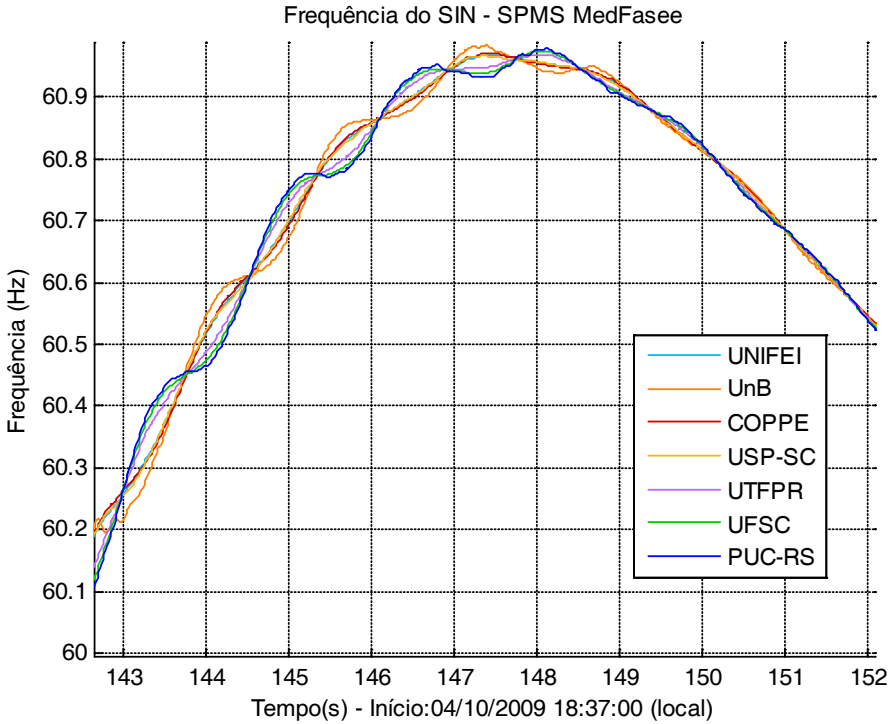
Description

- Started 18:39
- Opening of several interconnections
  - Gurupi-Miracema (LT A)
  - Serra da Mesa – Samambaia (LT B)
  - Serra da Mesa – Rio das Éguas (LT C)
  - Rio das Éguas – Bom Jesus da Lapa (LT D)
- Consequences
  - 2 separate systems: N/NE e S/SE
  - Load shedding in N/NE: 2550 MW
  - Some generation dropping in S/SE
- Restoration:
  - 18:47 – Closing of N/NE - SE
  - 19:21 – Closing of SE - NE



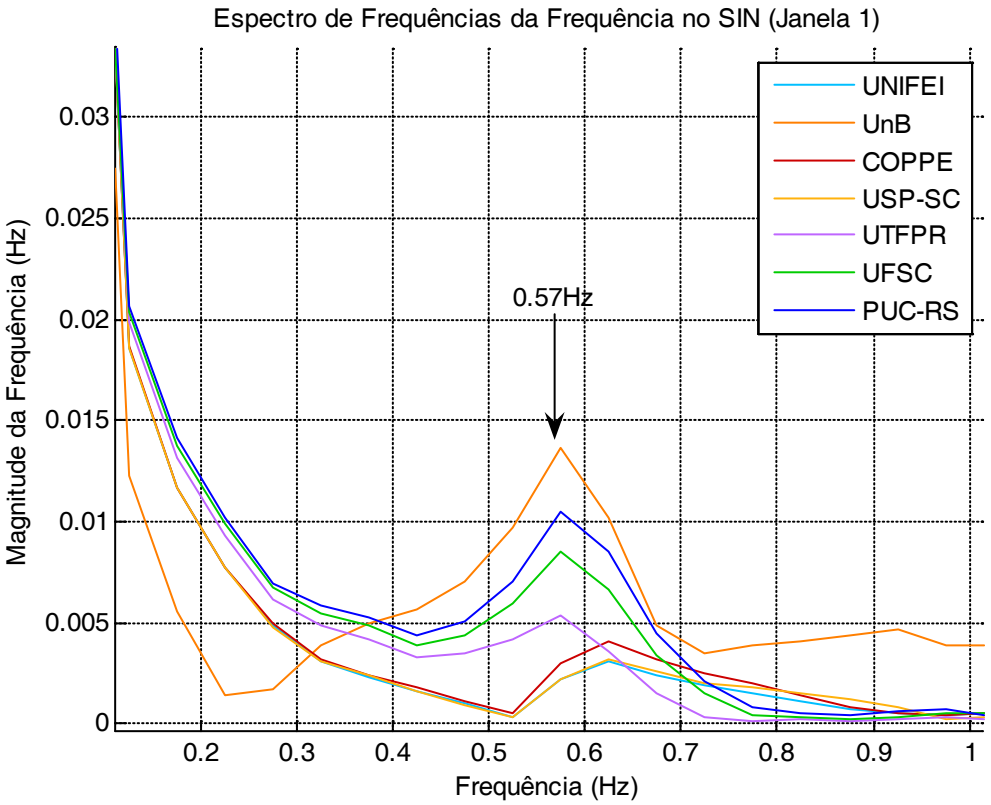
10/04/2009 - System islanding





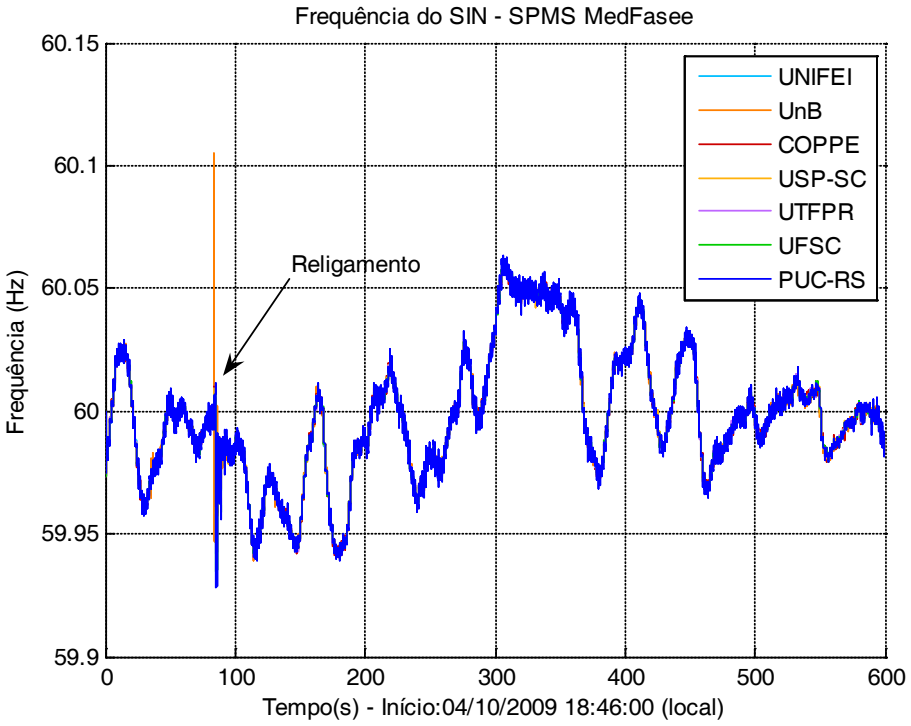
10/04/2009 - System islanding

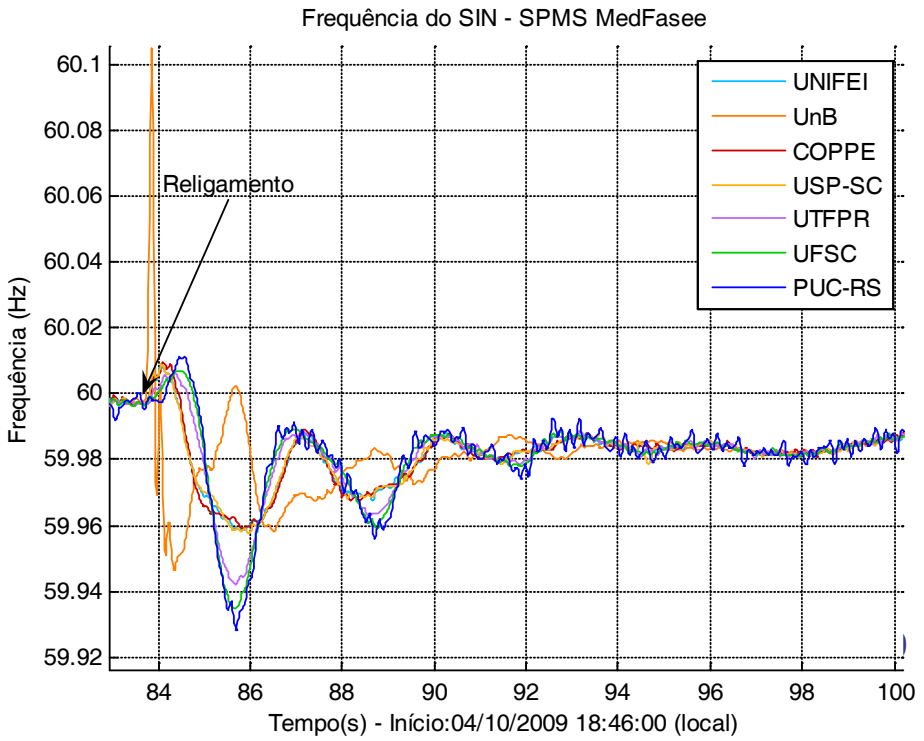
- Oscillation in S-SE – 0,57Hz



10/04/2009 - System islanding

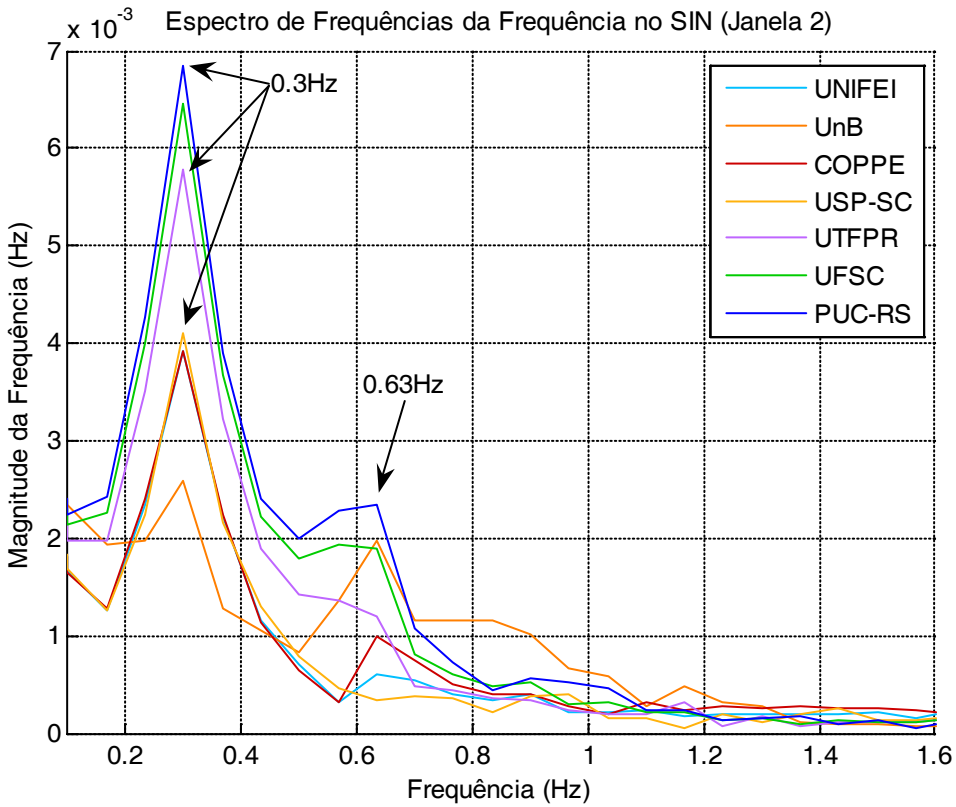
- Parcial reclosing





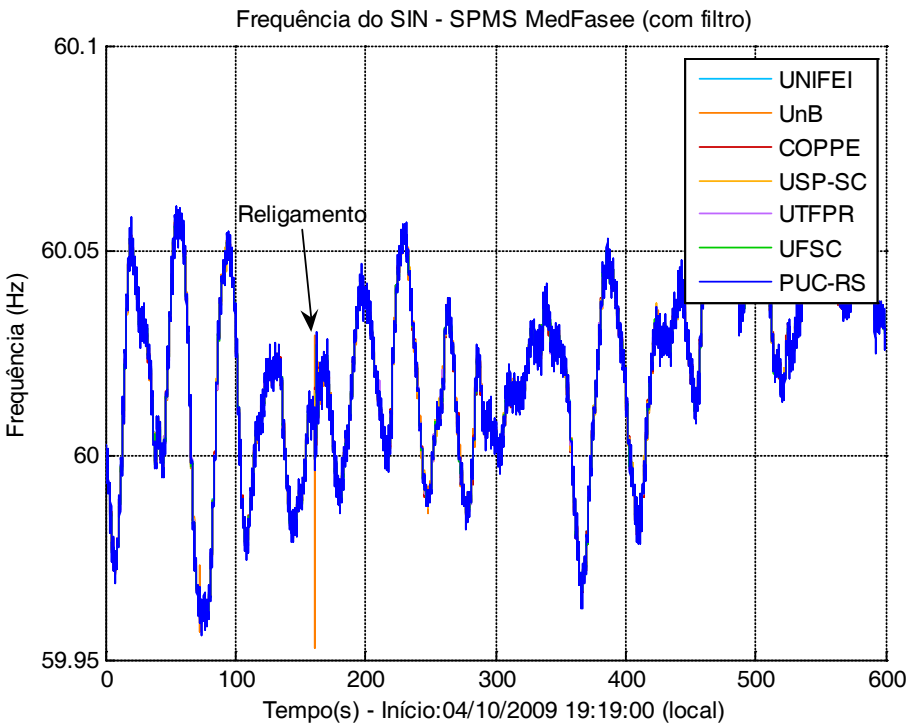
10/04/2009 - System islanding

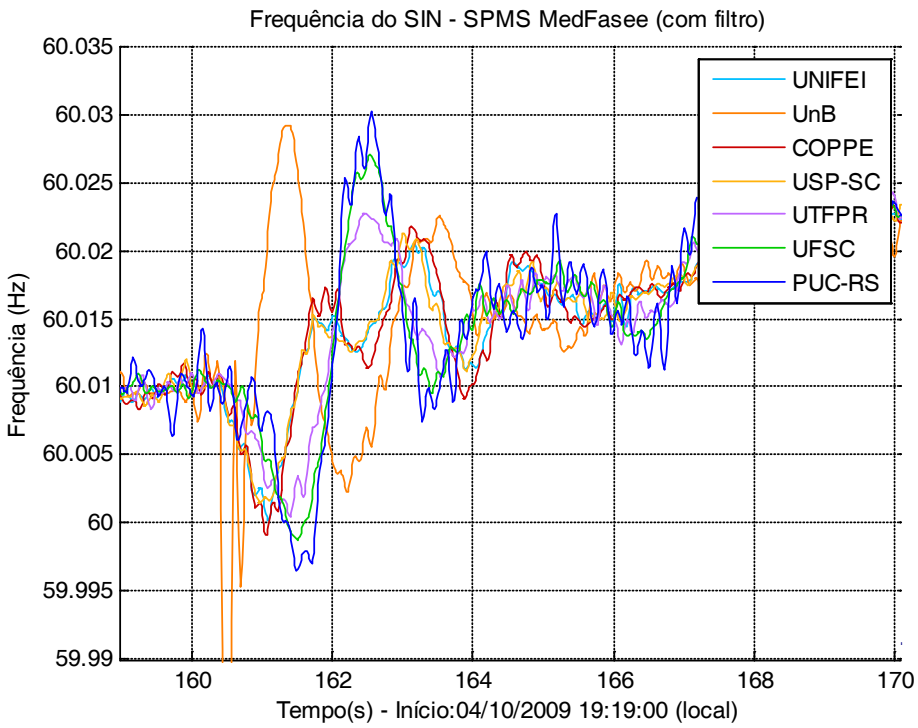
- Oscillation S-SE – 0,63Hz
- Oscillation N-S – 0,3Hz



10/04/2009 - System islanding

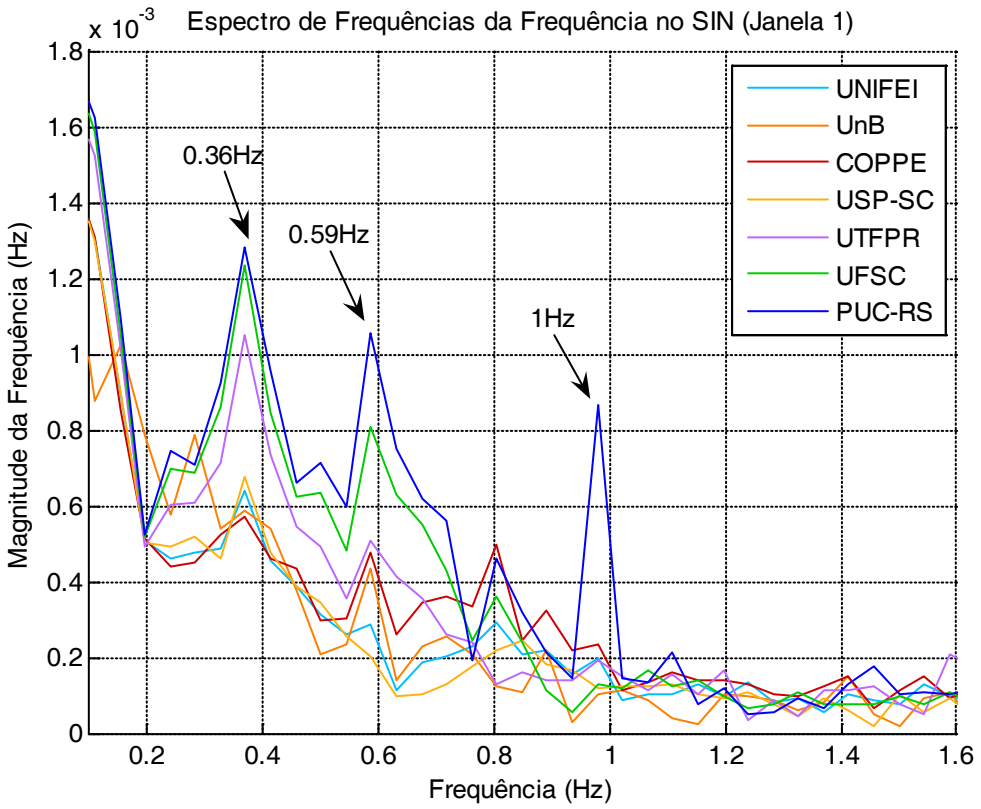
- Complete reconnection





10/04/2009 - System islanding

- S-SE – 0,59Hz.
- N-S – 0,36Hz.
- Local Oscillation in South 1Hz.

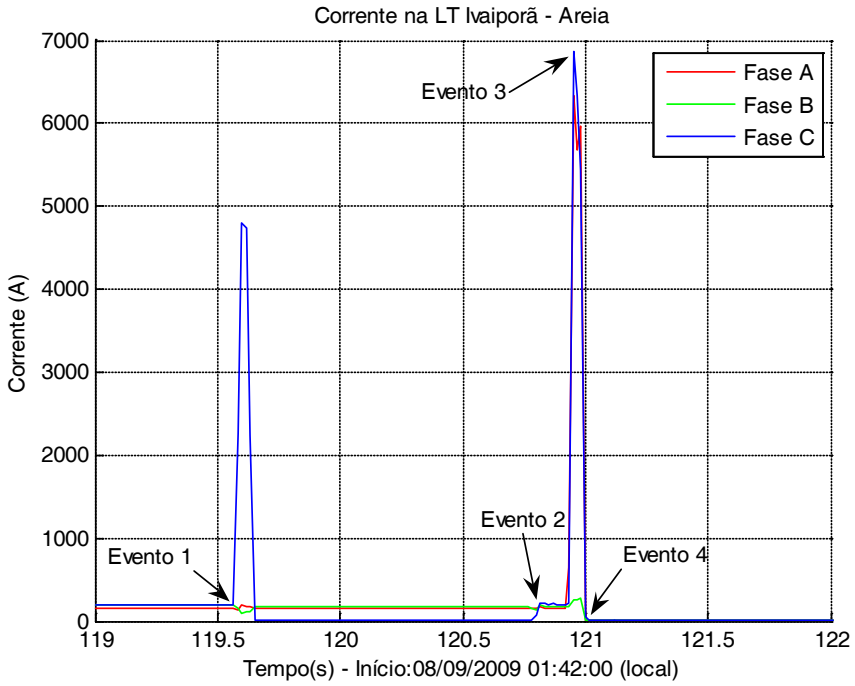


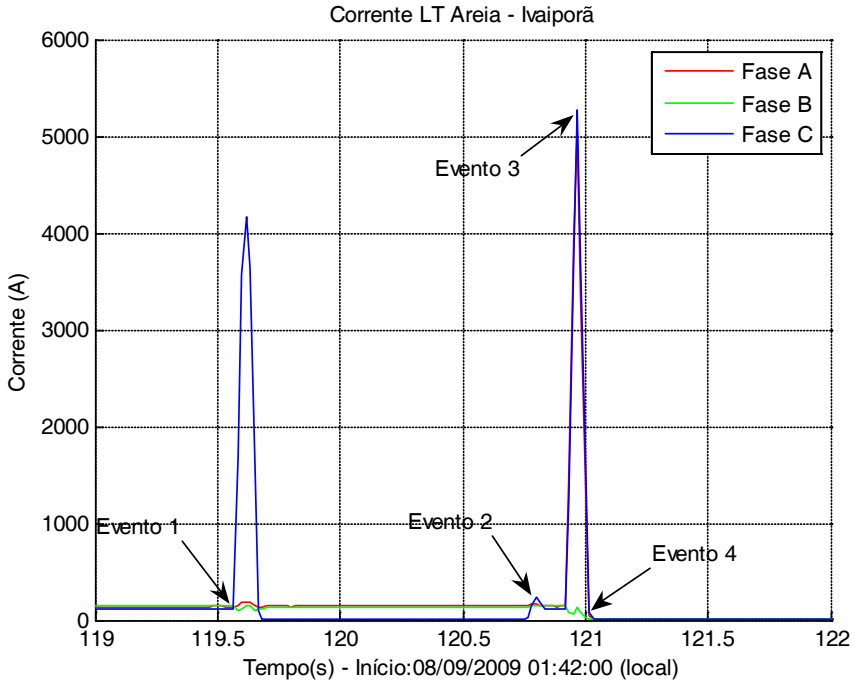
09/08/2009 - 525 kV Transmission Line Tripping

- Strong winds in the region

09/08/2009 - Transmission Line Tripping (Fault location with syncrophasors)

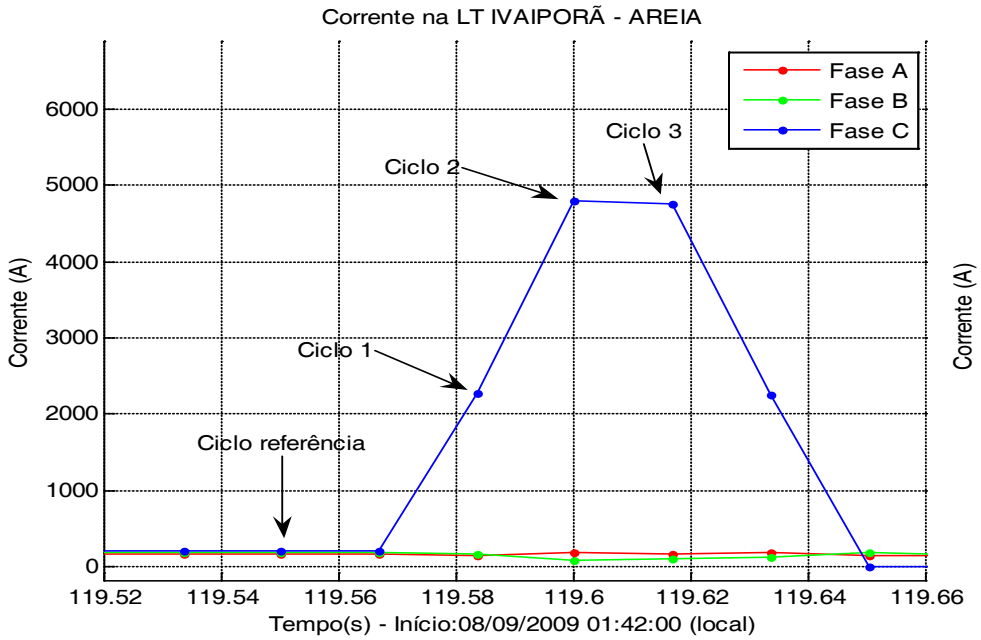
- 1st fault and tentative reclosure



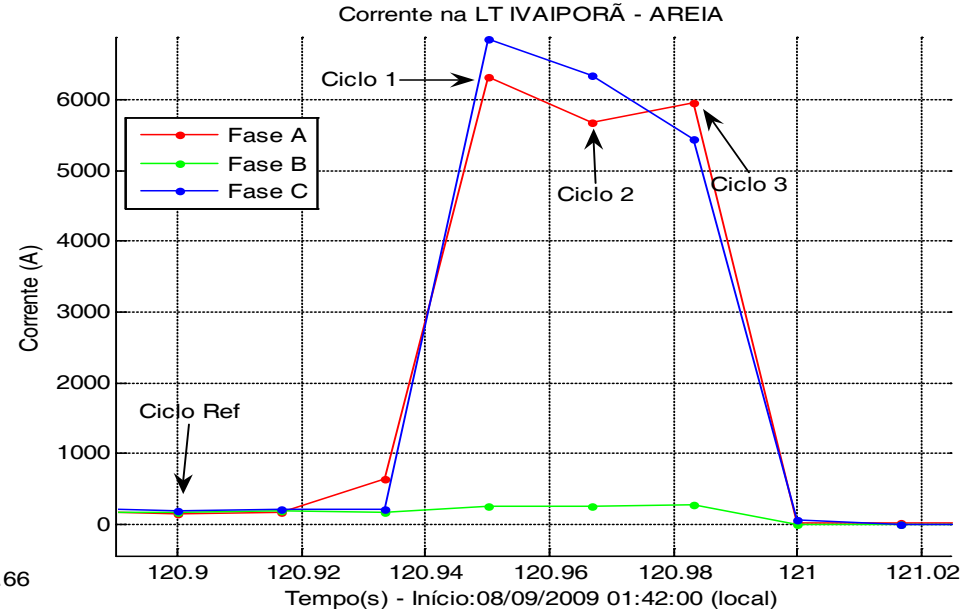


09/08/2009 - Transmission Line Tripping (Fault location with syncrophasors)

- 1st Fault C-Ground



- 2nd Fault AC-Ground

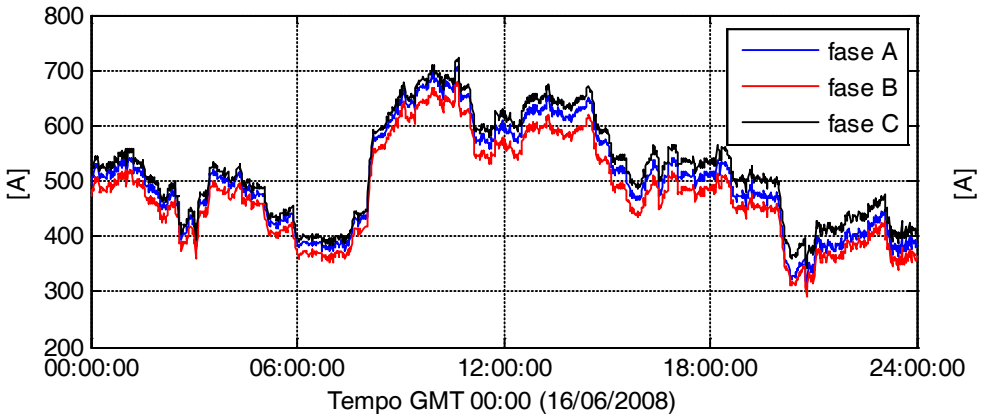


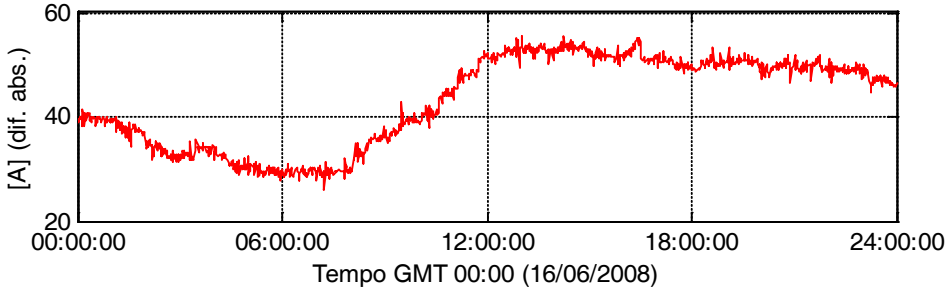
- Several 2 terminal algorithms were used
- Errors between 6 and 4 miles (5% - 4% of line length)
- Sub cycle protection interrupt the fault before a stable cycle exists

Unbalance in 525 kV line
(Current unbalance measured from both terminals)

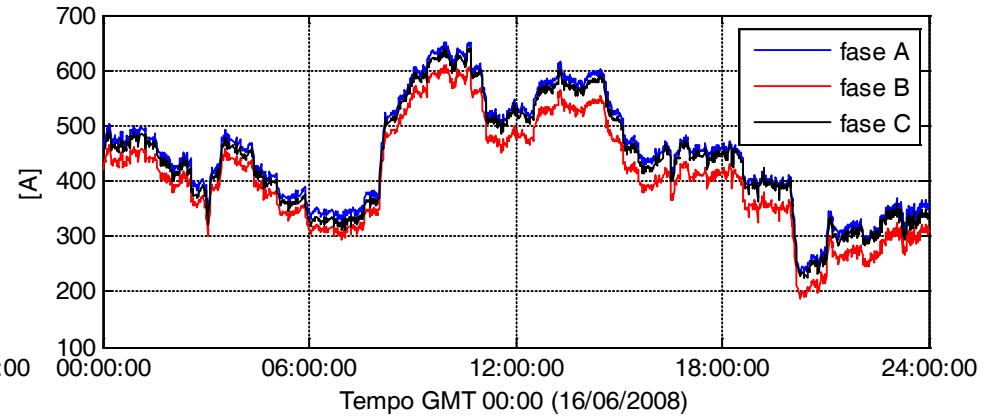
- Up to 10% in both sides
- Does positive sequence represent this line?

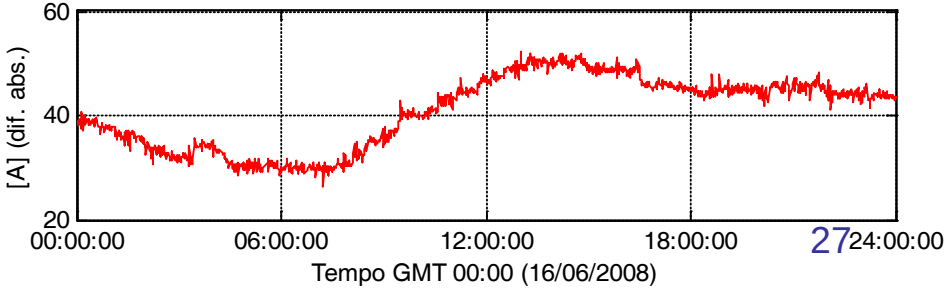
Terminal A





Terminal B





Thank you!

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