VII SEPOPE
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CURITIBA (PR) - BRASIL

A Small-Signal Stability Program Incorporating Advanced Graphical User Interface

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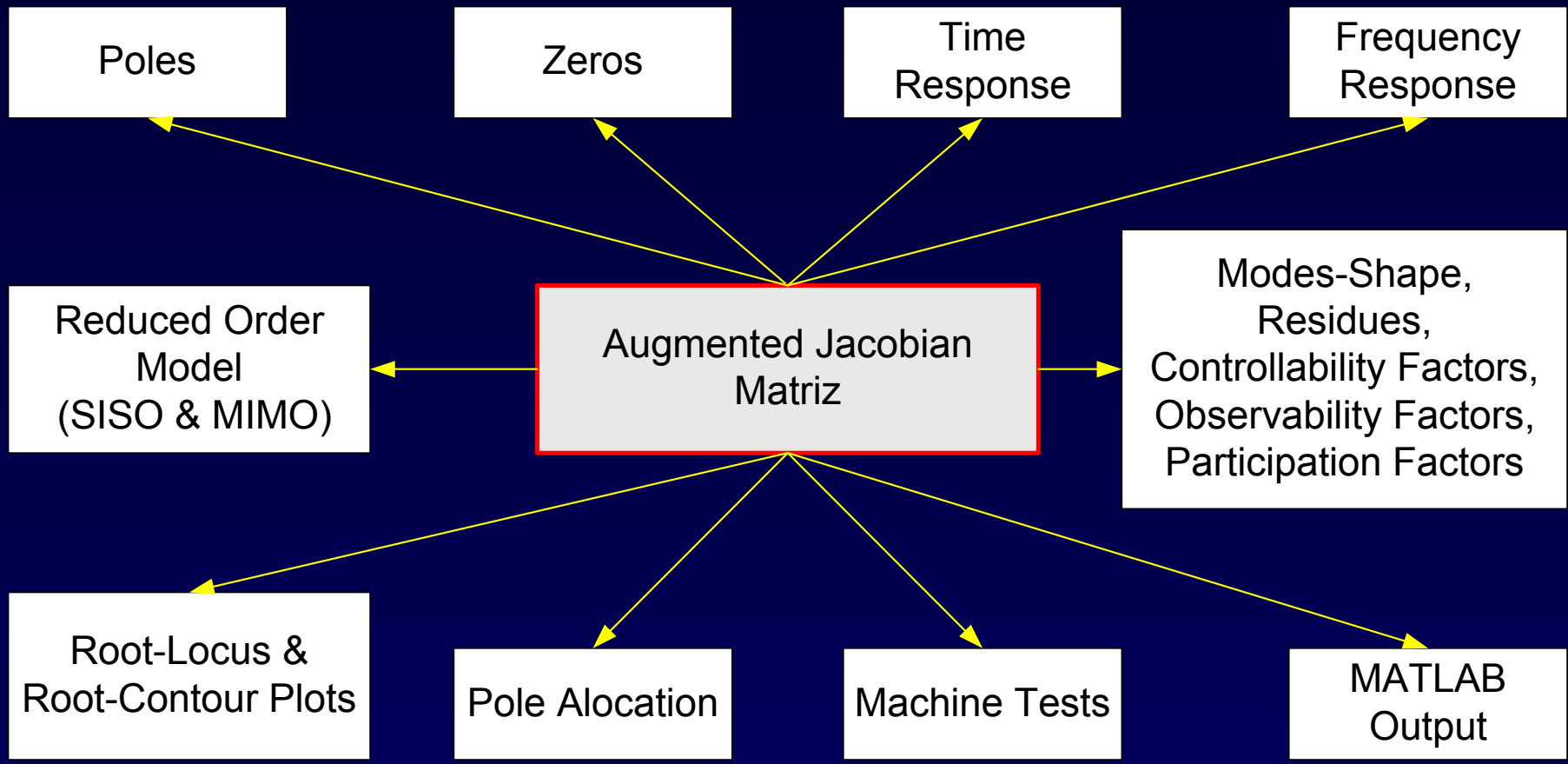
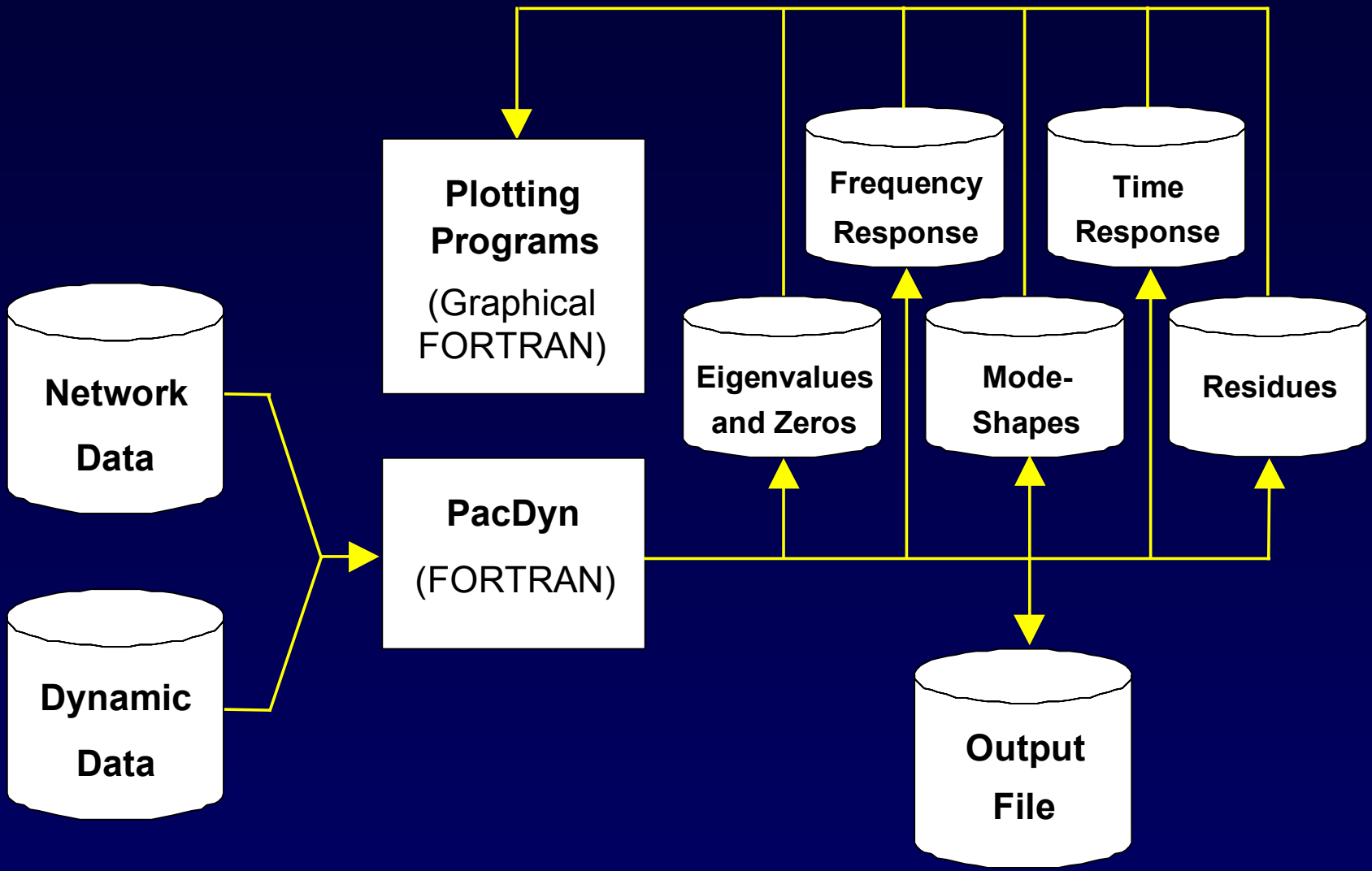
PacDyn - Small-Signal Stability Analysis and Control

- Determine nature and cause of small-signal stability problems.
- Most effective locations for placing stabilizers or FACTS devices to damp system oscillations.
- Controller design (AVR, PSS, Governor, HVDC link and FACTS devices).
- Coordinated design of multiple controllers.
- Reduced-order models (SISO & MIMO).
- Others.

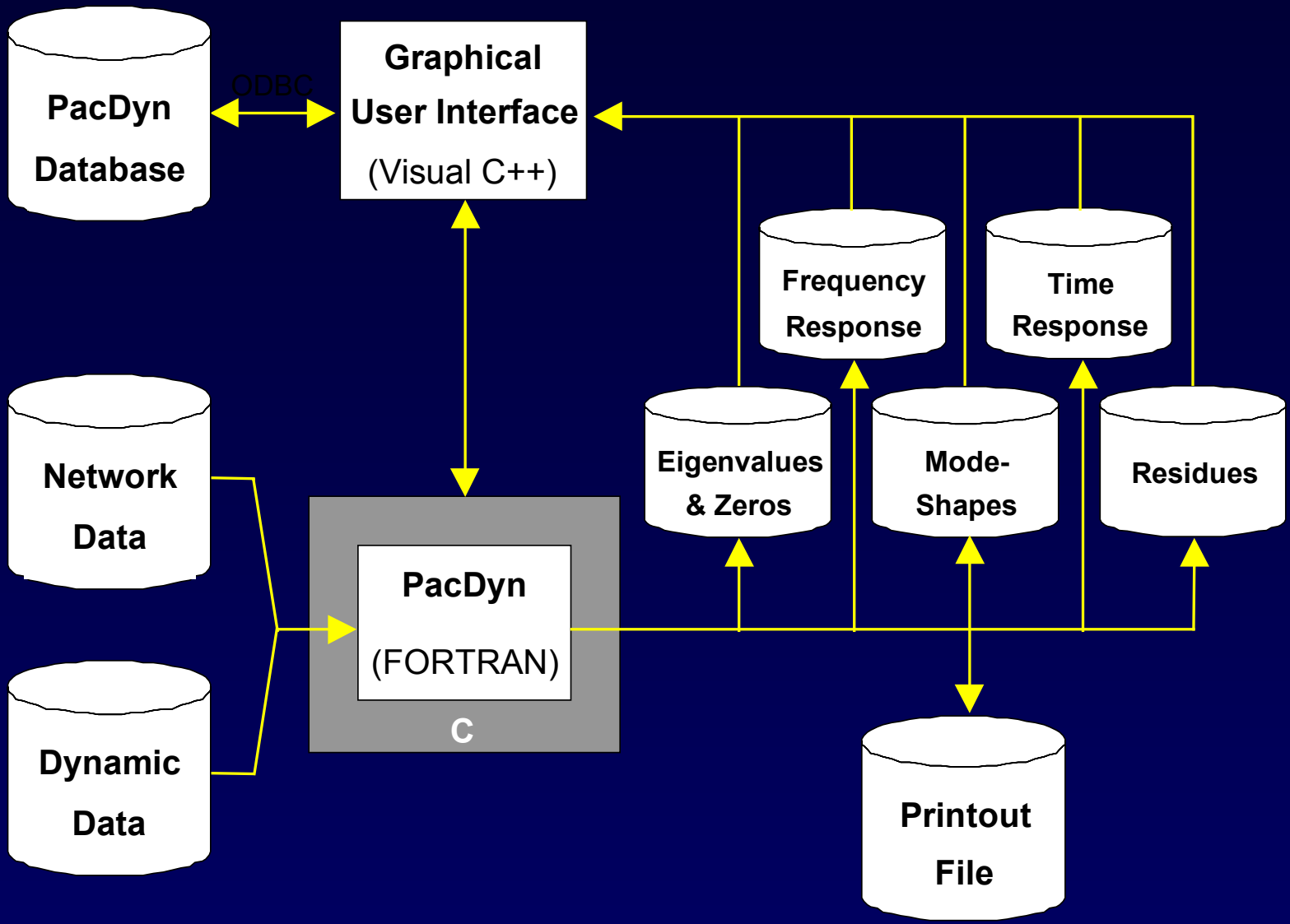
PacDyn Functions



PacDyn DOS Graphical User Interface



PacDyn for Windows Graphical User Interface



PacDyn - Small Signal Stability Analysis & Control - mbinf.pac - New case #1

File Edit View Eigenvalues Zeros Simulation Sensitivities Tools Window Help

mbinf.pac - New case #1 - Transfer Function Mana...

- Time Response
  - Step in Vref
    - Input
      - +VREF 1
    - Output
      - +VB 1
- Frequency Response
  - Pss
    - Input
      - +VREF 1
    - Output
      - +WW 1
- DPSE & Reduced Order Model
- Residues

mbinf.pac - New case #1 - Eigenvalues & T.F. Zeros Management System

Eigenvalues

List | Plot

	Real	Imaginary	Conv.	Damp	Freq.	Complex
1	0.3660	4.9987	c..	-7.30%	0.80	5.01
2	0.3660	-4.9987	c..	-7.30%	0.80	5.01
3	-19.0602	0.0E-01	c..	100.00%	0.00	19.06
4	-7.9263	10.4185	c..	60.55%	1.66	13.09
5	-7.9263	-10.4185	c..	60.55%	1.66	13.09
6	-8.8382	0.0E-01	c..	100.00%	0.00	8.84

Select: All None

Delete: Eigenvalues

Sort: Default

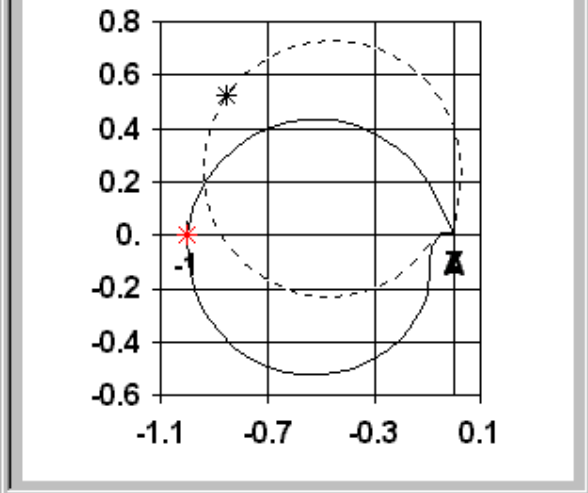
Ascending

Descending

Plot CEPEL - [Frequency Response - D:\S...

File View Tools Window Help

Open About Help



-$1 Module = 0.2629 Phase = -144 Freq. =

Automatic PSS Design

Frequency: 4.992 Get

Lead/Lag Compensation — Inv

Lead to -1 Lag to -1 Custom

Lead to +1 Lag +1 Ang.: 0

Wash-out

Lead - Lag Blocks: 1

Tw: 3

Gain Margin: 1 Gain: 3.548

Td: 0.121 Tn: 0.3318

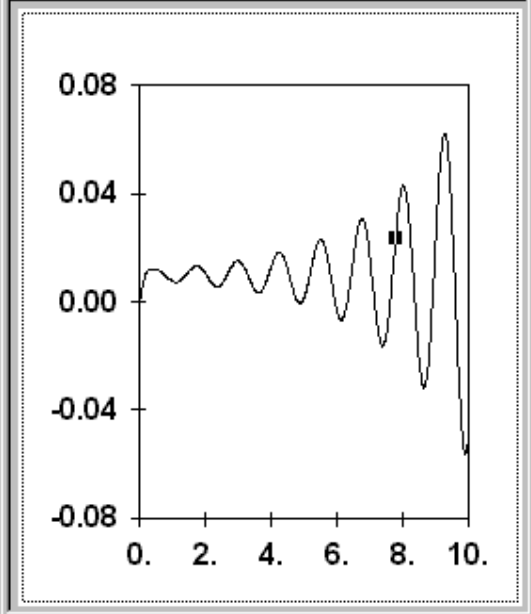
Wc: 4.992 α 2.743

Hold

Save Close

Plot CEPEL - [Time Response - D:\S...

File View Tools Window Help



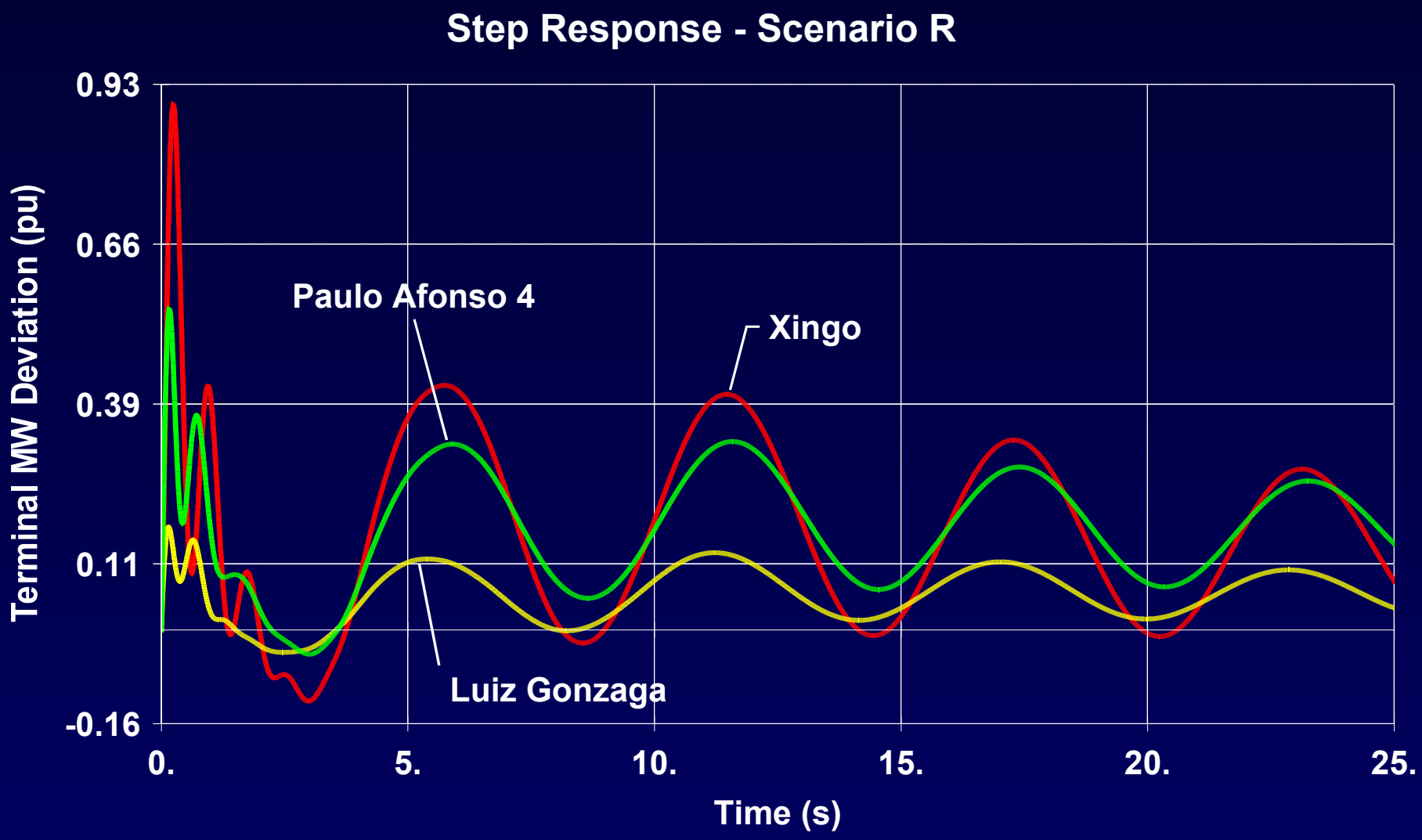
(-3.221609, 0.028772)

Start | HP Status Window | PacDyn - Small Si... | Plot CEPEL - [Fre... | Plot CEPEL - [Ti... | Untitled - Paint | 4:03 PM

Large Power System Applications

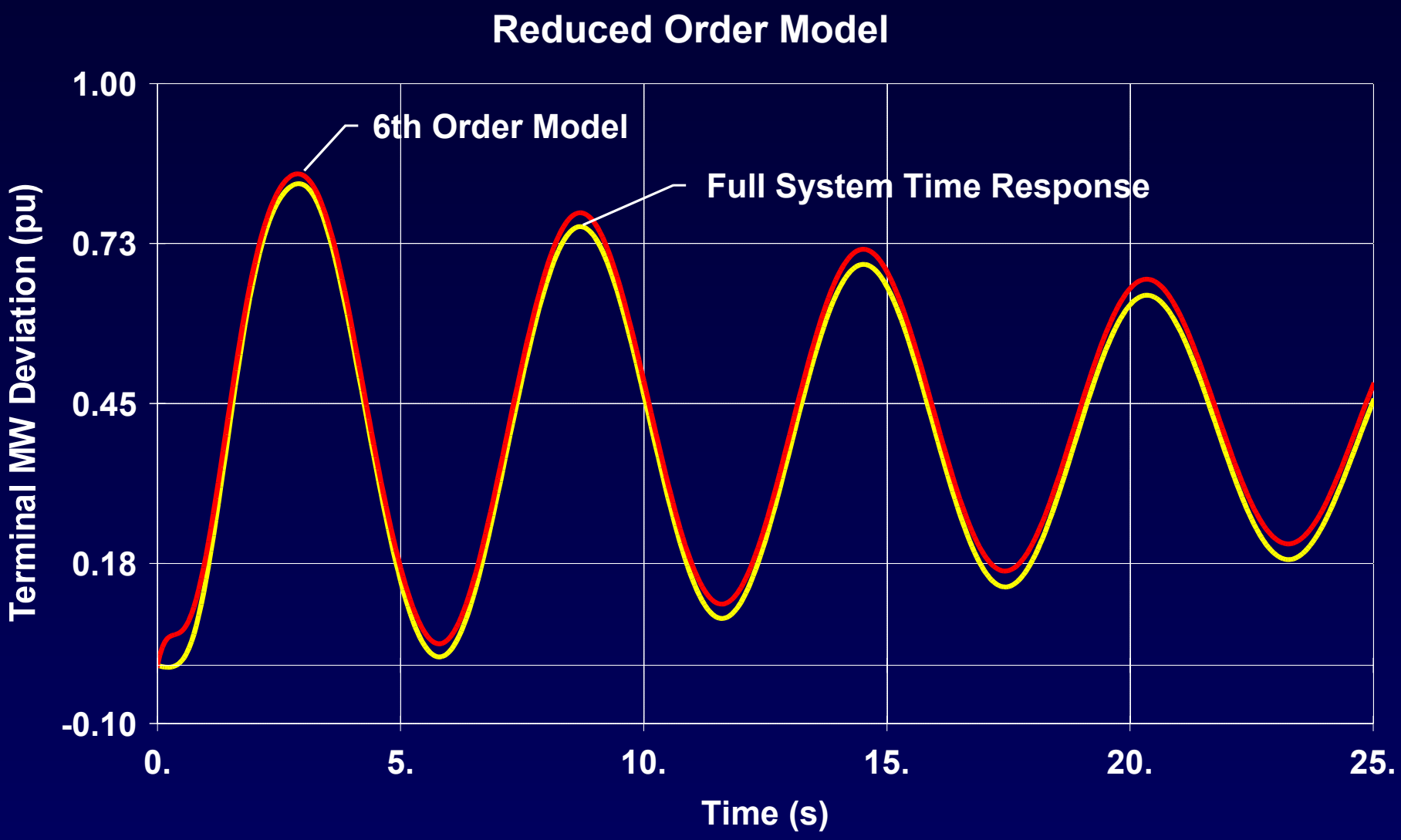
- Brazilian North-South Interconnection
  - 2,380 buses, 3,450 circuits, 120 generators
  - Jacobian Matrix order: 13,000 (1,700 State variables)
- Argentinean Interconnected System (SADI)
  - 1,200 buses, 1,600 circuits, 170 generators
  - Jacobian Matrix order: 9,000 (2,000 State variables)
- Nordic Interconnection (Nordel)
  - 3,000 buses, 4,000 circuits, 1,000 generators
  - Jacobian Matrix order: 55,000 (11,000 State variables)
- UCPTE-CENTREL Interconnection
  - 2,000 buses, 3,200 circuits, 380 generators
  - Jacobian Matrix order: 11,000 (2,200 State variables)

Brazilian North-South Interconnection



Step responses of major system generators for Scenario R (λ = -0.034 $\pm$ j 1.079) (with existing PSSs and without TCSC stabilizer)

Brazilian North-South Interconnection

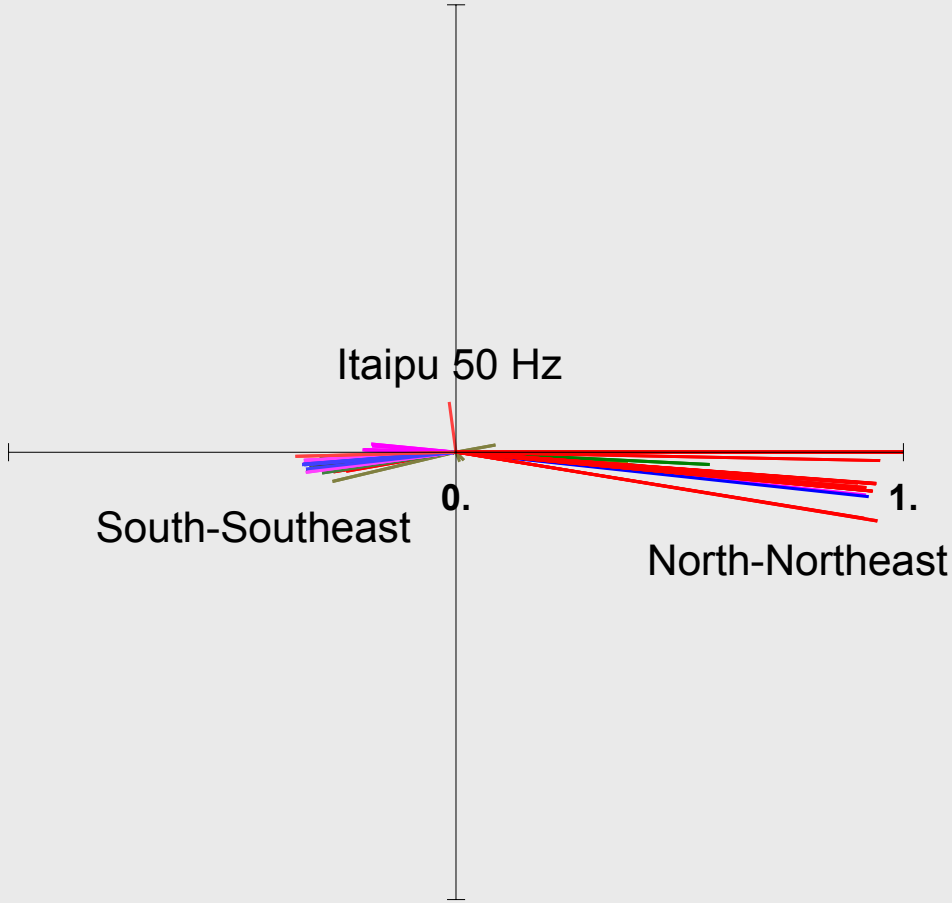


Active power flow in the North-South tie-line. Responses of the full model and the 6th order reduced model

Brazilian North-South Interconnection

Mode-Shape Output: WW
Eigen: -0.033534 + j 1.0787

*** COMPLEXO PAF + UAS ***
*** AREA LESTE ***
*** AREA SUL ***
*** SUDOESTE DA BAHIA ***
*** AREA OESTE ***
*** AREA TUCURUI-BELEM ***
*** AREA MARANHAO ***
********** ITAIPU **********
********** COPEL **********



Mode-shape for North-South inter-area mode (λ = -0.034 $\pm$ j 1.079)

Brazilian North-South Interconnection

Transfer Function Residues
Input: VREF Output: WW
Eigen: -0.033534 + j1.0787

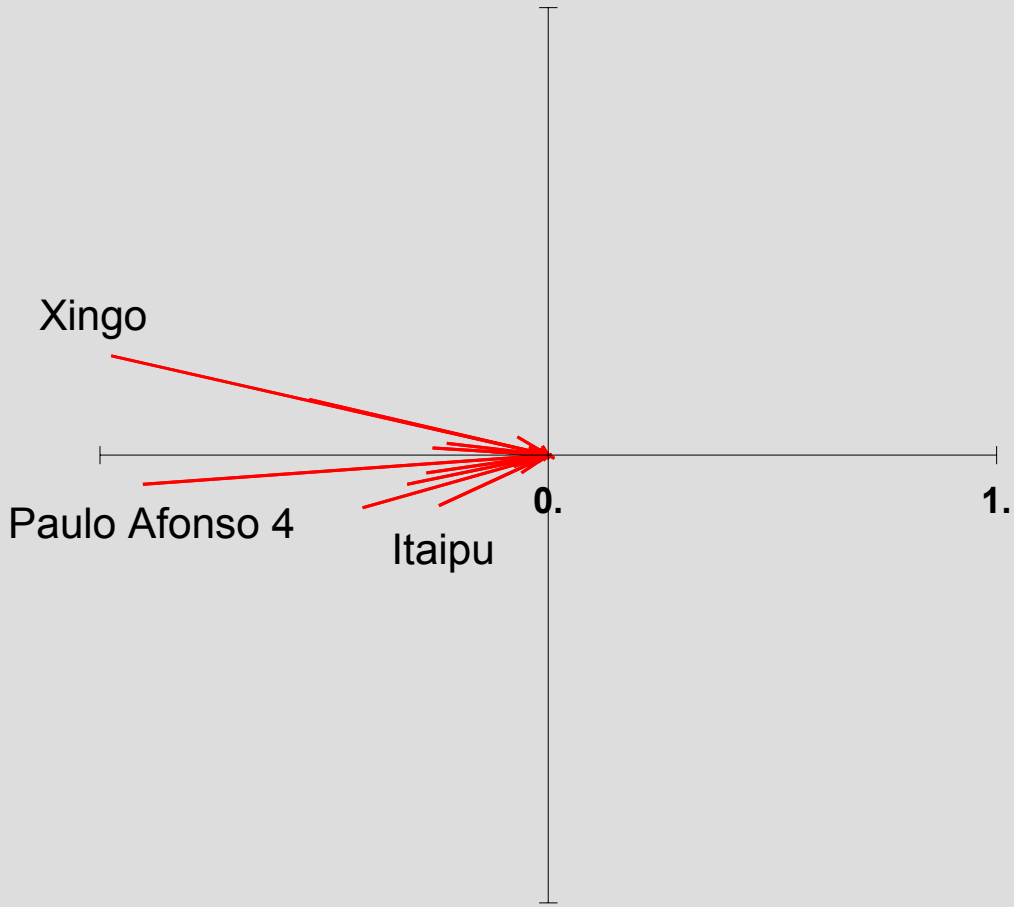
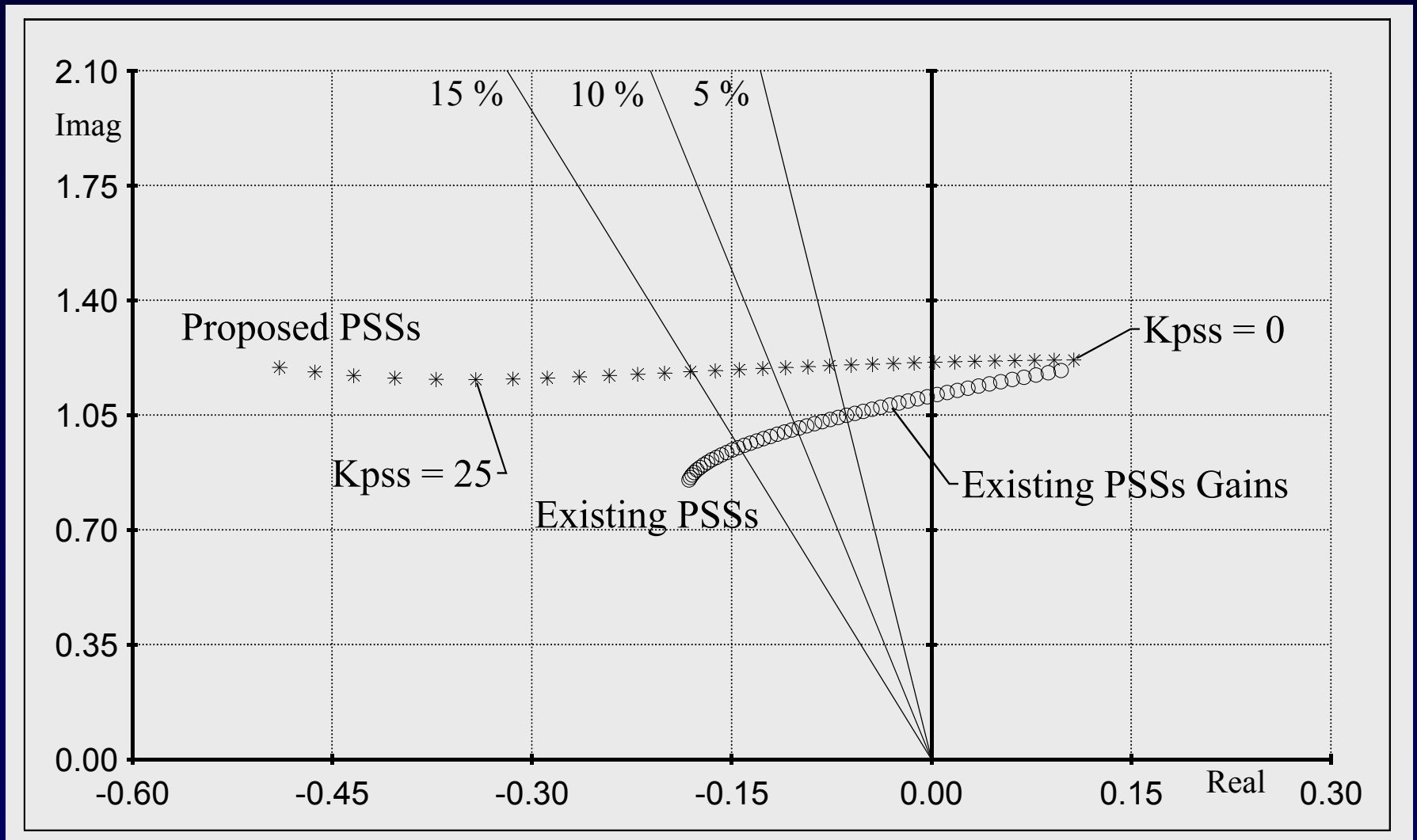


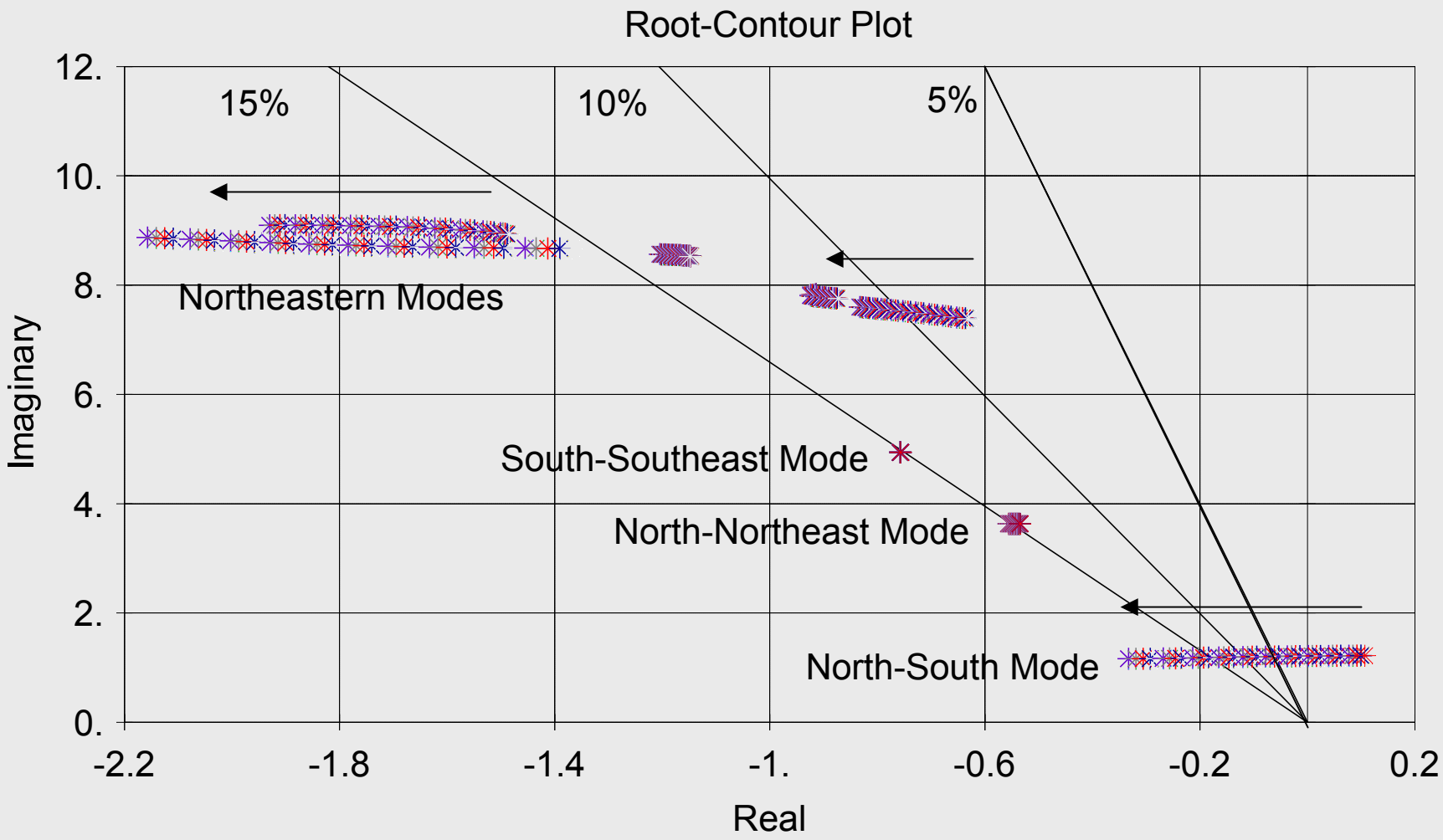
Diagram of transfer function residues, used to determine the most effective generators for installing or retuning existing stabilizers (λ = -0.034 $\pm$ j 1.079)

Brazilian North-South Interconnection



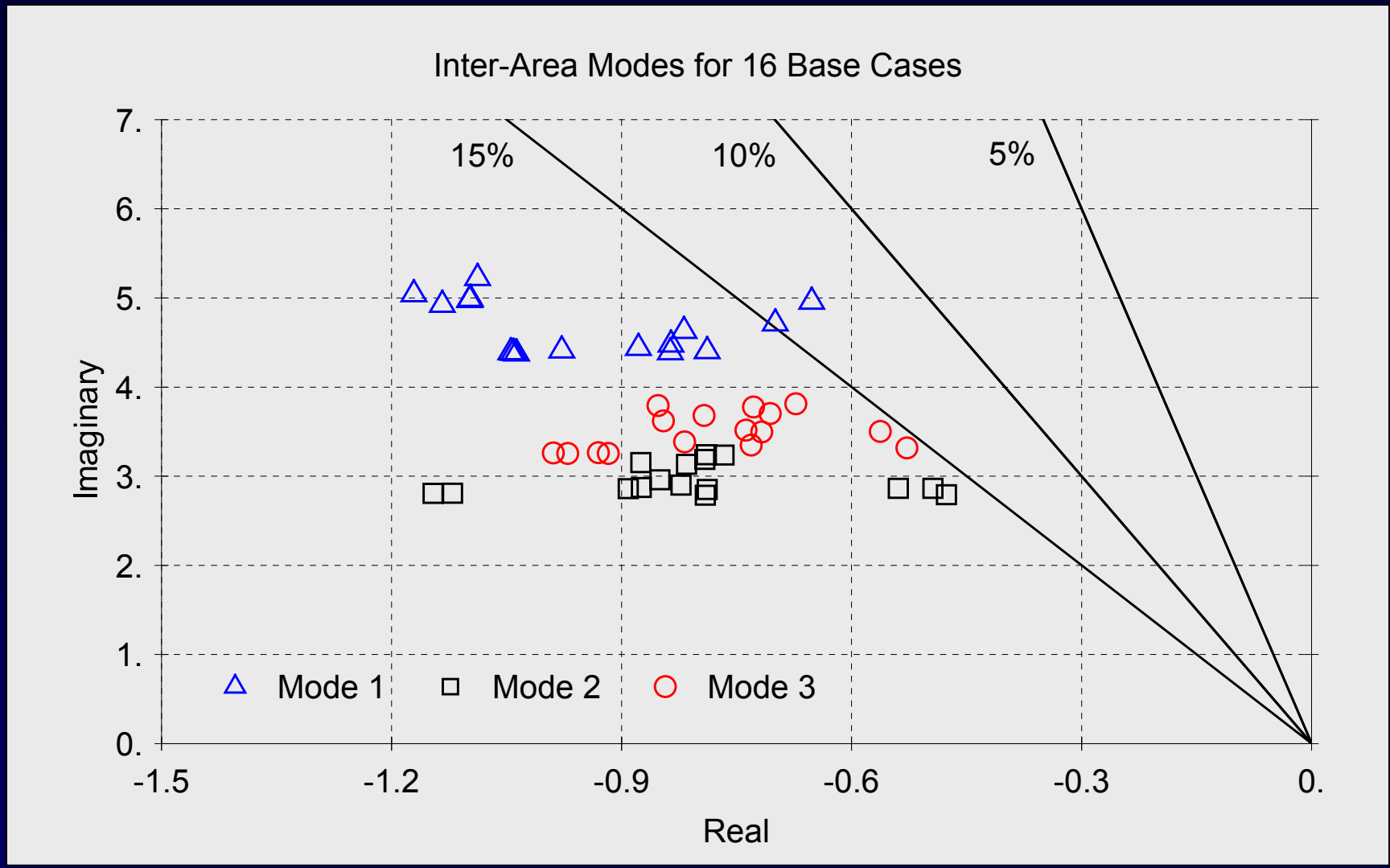
Locus of North-South mode following changes in the PSS gains at Xingó, Paulo Afonso IV and Itaparica power plants

Brazilian North-South Interconnection



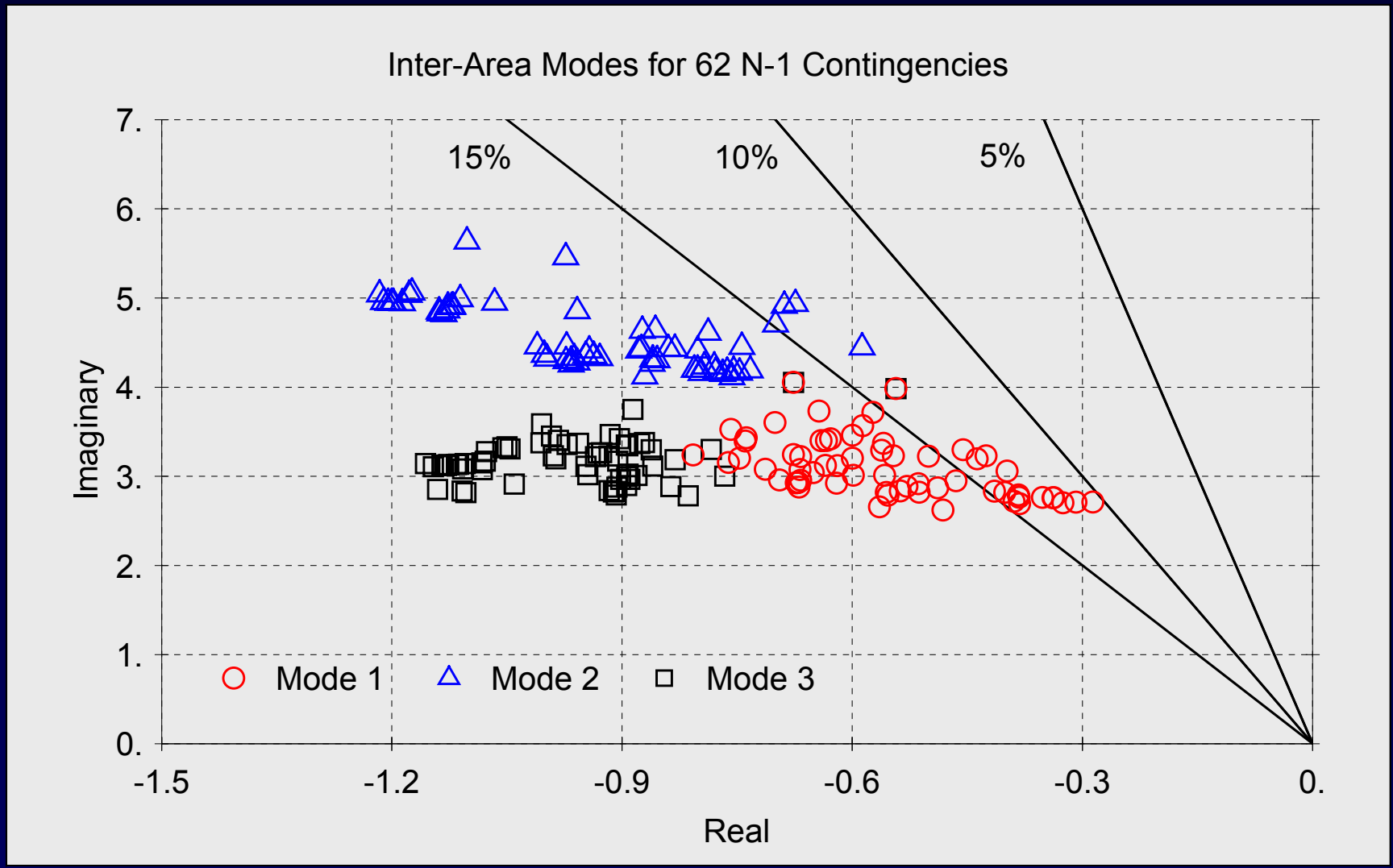
Root-contour plot as the gains of the PSSs at Xingó, Paulo Afonso IV and Itaparica are raised from zero to 25 pu/pu

Argentinean Interconnected System (SADI)



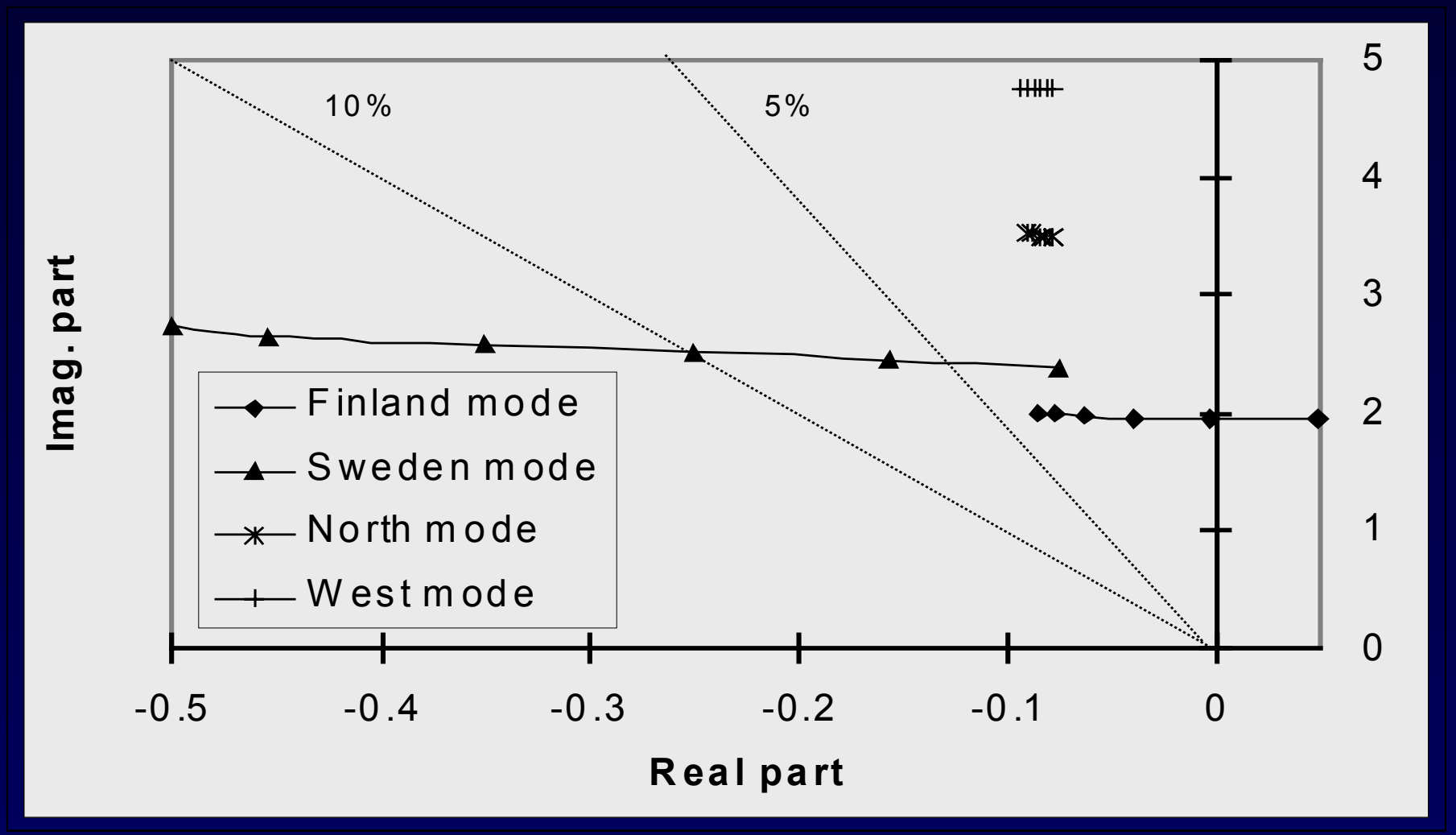
Inter-area modes for 16 base cases

Argentinean Interconnected System (SADI)



Inter-area modes for 62 N-1 contingencies

Nordic Interconnection



Root contour for SVC stabilizer design. Contingency case, 2,050 MW export

Future Developments

- All results stored in a single database.
- Full integration with power flow and transient stability programs.
- Advanced methods for coordinated control design.
- Non-linear search for stability boundaries in the control parameters or loading spaces.
- More extensive use of macro functions.
- Modeling of UPFC devices, etc.

Final Comments

- Small signal stability programs are now used worldwide in the analysis and damping control of inter-area oscillations.
- Engineering study productivity is much enhanced with the use of an advanced GUI.
- Advanced eigensolution methods are vital in this area.