IV International Workshop on PMU Applications

Wide-Area Damping Control Design using Non-Convex Optimization Algorithm

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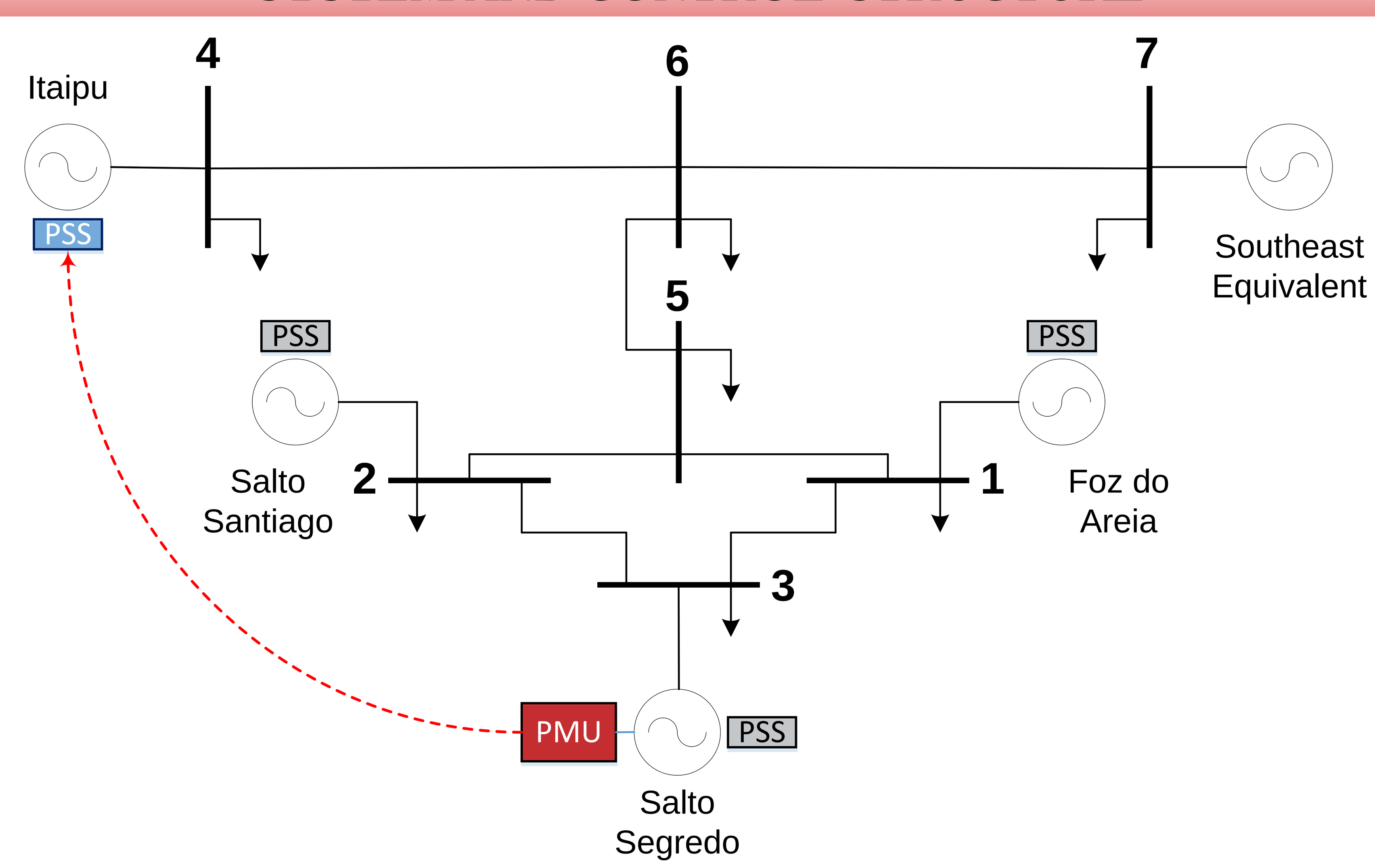
INTRODUCTION

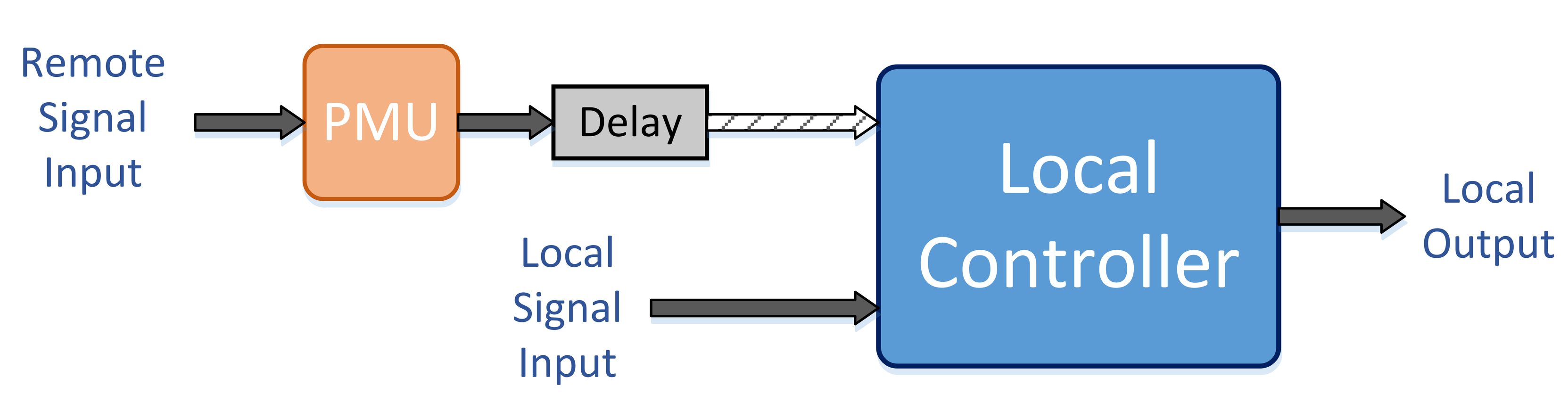
To ensure the minimum damping of the electromechanical modes, local controllers, known as Power System Stabilizers (PSS), are usually implemented. In some cases, this decentralized control approach may not be sufficient to properly damp the inter-area modes.

This project proposes the introduction of PMU signals in the control strategy of a well-known system, aiming a better damping of oscillations and improved Small Signal Stability performance.

A non-convex and non-smooth optimization method was used, via MATLAB package, to project the transfer functions of the desired controller by minimizing the H_∞ norm of selected signals. Additionally, a pole placement restriction function was introduced in the algorithm to force a desired minimum damping to the closed-loop system.

SYSTEM AND CONTROL STRUCTURE





SYSTEM MODEL

Power System

$$\begin{bmatrix} \dot{\mathbf{x}} \\ \mathbf{z} \\ \mathbf{y} \end{bmatrix} = \begin{bmatrix} \mathbf{A} & \mathbf{B_1} & \mathbf{B_2} \\ \mathbf{C_1} & \mathbf{0} & \mathbf{0} \\ \mathbf{C_2} & \mathbf{0} & \mathbf{0} \end{bmatrix} \begin{bmatrix} \mathbf{x} \\ \mathbf{w} \\ \mathbf{u} \end{bmatrix}$$

Time Delay

$$G(s)_P = \frac{6 - 2Ts}{6 + 4Ts + (Ts)^2}$$

Control Structure

$$\mathbf{PSS(s)} = \left[\begin{array}{cccc} PSS(s)_{11} & 0 & 0 & 0 \\ 0 & PSS(s)_{22} & 0 & 0 \\ 0 & 0 & PSS(s)_{33} & 0 \\ \hline 0 & 0 & \color{red}{PSS(s)_{43}} & \color{blue}{PSS(s)_{44}} \end{array}\right]$$

APPLICATION RESULTS

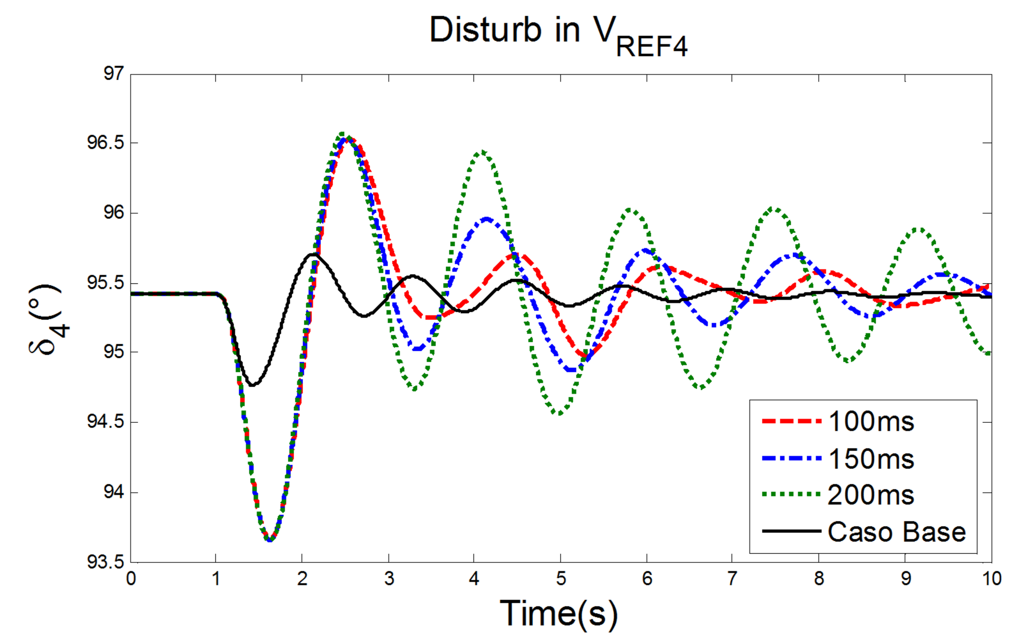
The method was applied to project PSS controllers for the multi-machine Southern/Southeastern Brazil equivalent system. A multi-plant project was made considering 100, 150 and 200 *ms* as values for communication time delay. Two strategies were used:

1. Replace all four PSS by one at machine 4 with a remote input signal (angular speed) from machine 3.
2. Preserve the original PSS and add the PMU signal to the controller installed at machine 4.

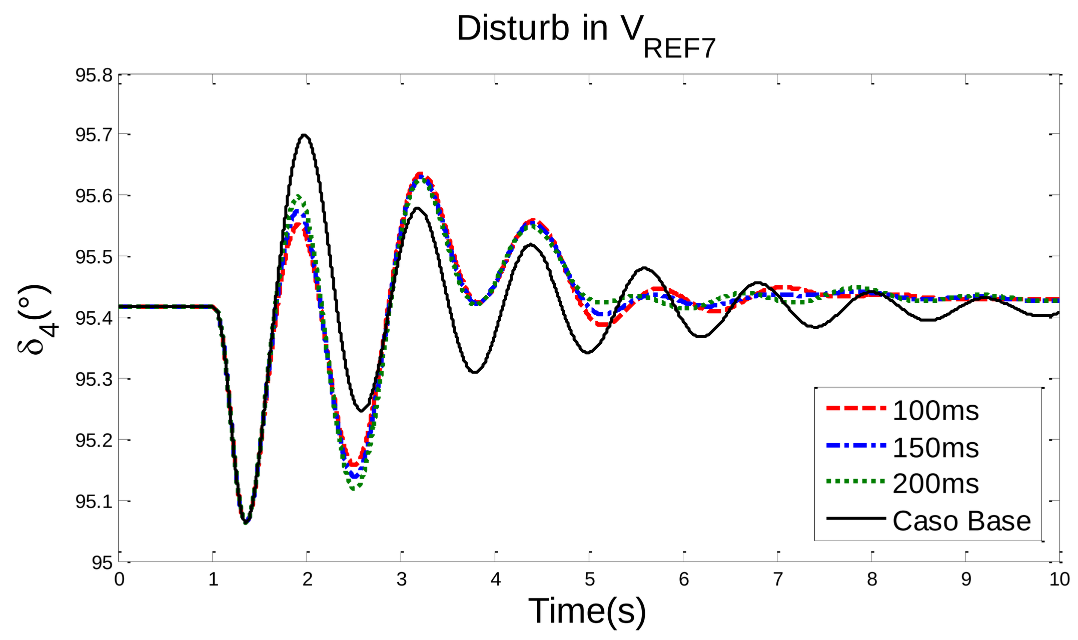
Less damped inter-area modes

Cases			Eigenvalues	Frequency (HZ)	Damping (%)	Part. Factor
Without PSS			$0.64 \pm 5.39i$	0.86	-11.9	δ_4
			$-0.22 \pm 5.87i$	0.93	3.84	δ_3
4 PSS	Benchmark		$-0.33 \pm 5.20i$	0.82	6.39	ω_7
1 PSS + PMU	Delay (ms)	100	$-0.29 \pm 5.48i$	0.87	5.36	δ_3
		150	$-0.74 \pm 6.19i$	0.98	11.88	δ_4
		200	$-0.30 \pm 6.17i$	0.98	5.00	δ_1
4 PSS + PMU	Delay (ms)	100	$-0.61 \pm 5.07i$	0.81	11.87	ω_7
		150	$-0.61 \pm 5.19i$	0.82	11.68	ω_7
		200	$-0.57 \pm 5.27i$	0.84	10.84	ω_7

1 PSS + remote signal:



4 PSS + remote signal:



CONCLUSION /FUTURE WORK

The MATLAB package used presents a good potential in the synthesis of power system controllers. The controllers were able to stabilize the system and achieve the desired minimum damping.

The selection of different signals and introduction of more PMUs will be evaluated during the future research. Further studies in the minimization of the H_∞ norm will be made, with different performance signals and weighting functions. The method will be applied to larger and more complex systems to verify its performance.

COLLABORATING INSTITUTIONS: