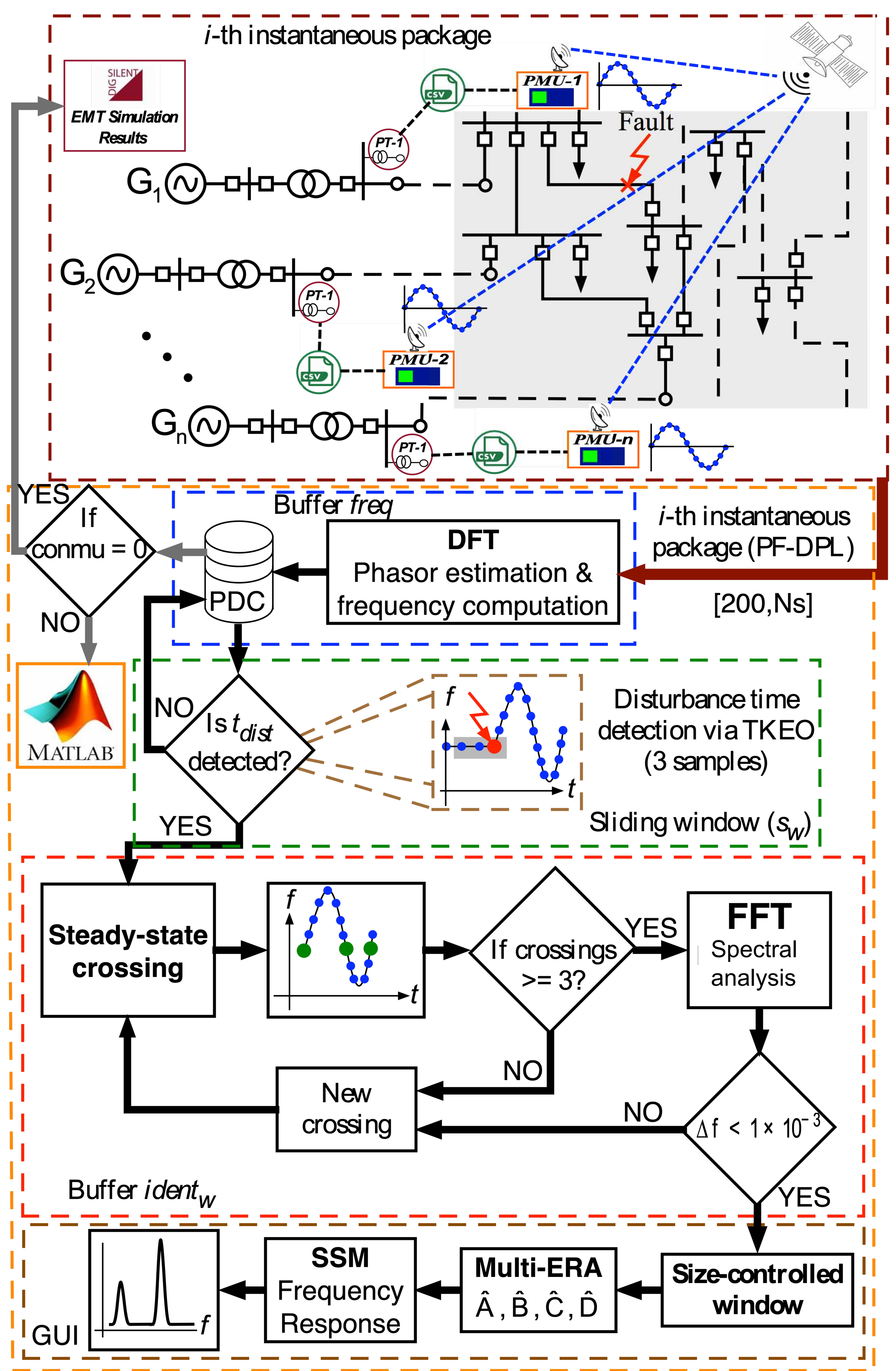
On-line System Identification of Power System Linear Models

J. A. Moreno-Corbea[1], M. R. A. Paternina[1], D. Rodales[2], R. Reyes[3], F. Zelaya[4], A. Zamora[2], C. Toledo[5], C. Castrillón[6] and A. Sánchez[7]
1. UNAM, Mexico City, 2. U. Michoacana, Morelia, Mexico, 3. U. Nuevo León, 4. UTK, Knoxville, TN, USA, 5. UIS. Bucaramanga, Colombia, 6. UNAL, Medellín, Colombia, 7. Cinvestav, Guadalajara, Mexico.

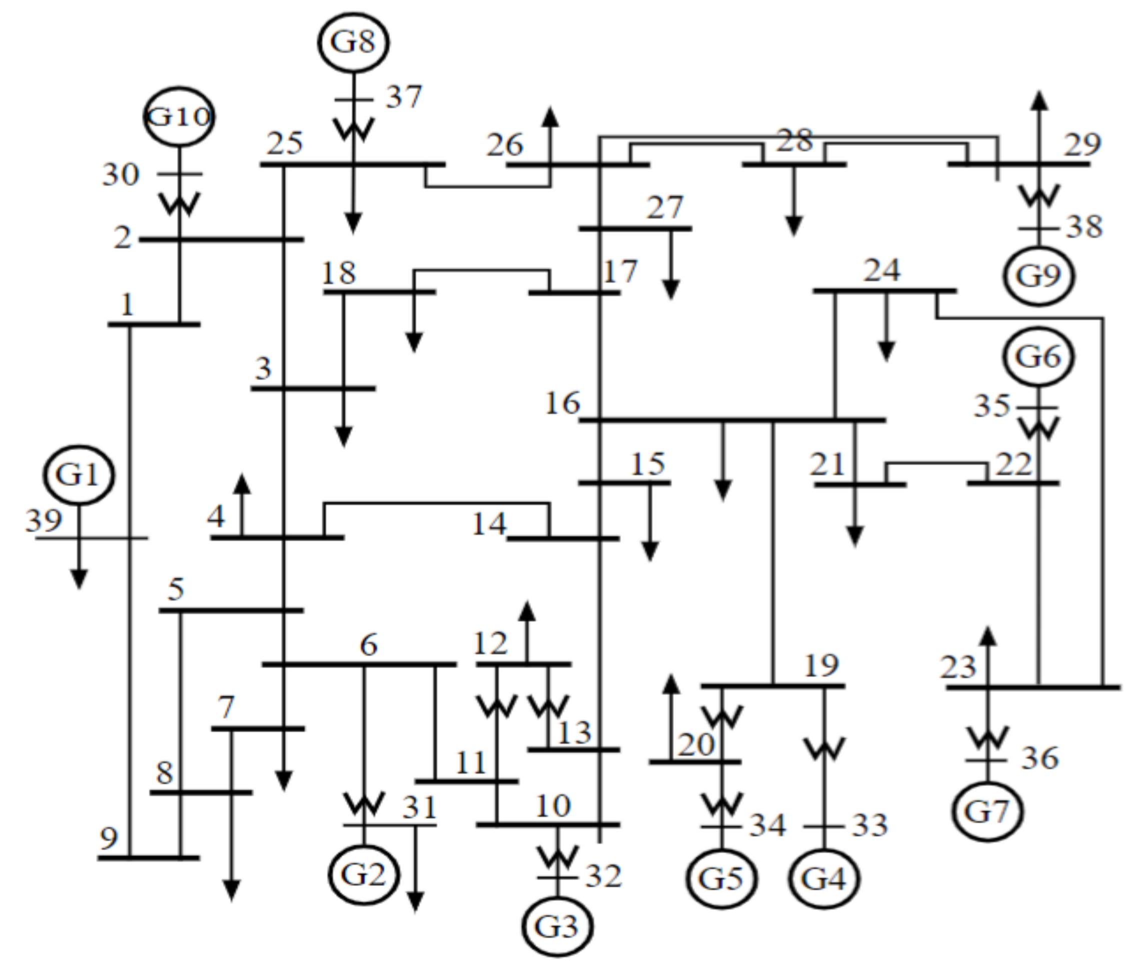
Abstract

This paper deals with the provision of adequate testing simulation environments to facilitate the evaluation of new system identification techniques to enhance power system stability. It develops and implements a testing architecture for on-line system identification approaches, taking advantage of the use of two well-known computational programs (Matlab and DIgSILENT PowerFactory). To ensure a reliable and optimal system identification, this platform exploits a mutually beneficial relationship among four well-established mathematical techniques (discrete Fourier transform, Teager-Kaiser energy operator, the fast Fourier transform, and eigensystem realization algorithm). The proposed architecture can deal with any system identification technique to be tested.

Real-time Simulation Architecture



Test System



The 39-bus New England power system.

Architecture stages

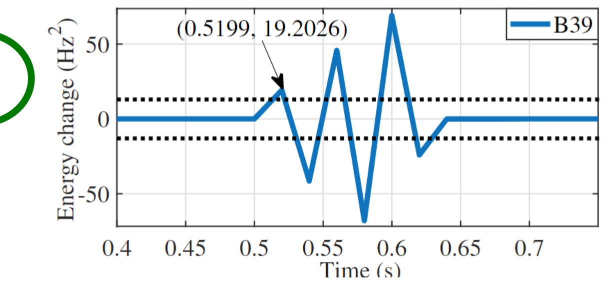
1. Phasor estimation & frequency computation.
2. Disturbance time detection via Teager-Kaiser energy operator.
3. Optimal data-window computation: Steady-state crossing detection, spectral analysis via fast Fourier transform and dominant frequency convergence criterion analysis.
4. On-line optimal-based power system identification via eigensystem realization algorithm (ERA).

①

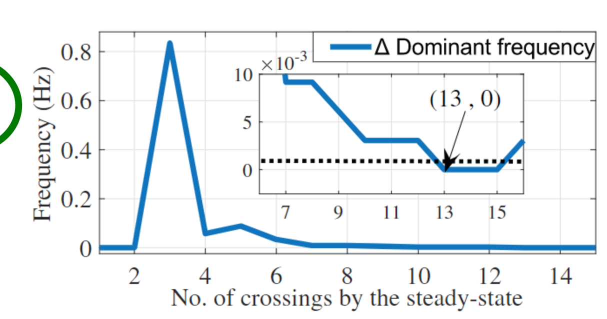
$$f(t) = f_0 + \Delta f(t)$$

$$\Delta f(t) = \frac{1}{2\pi}\left[\frac{\hat{\varphi}_{a_1,k} - \hat{\varphi}_{a_1,k-1}}{\Delta t}\right]$$

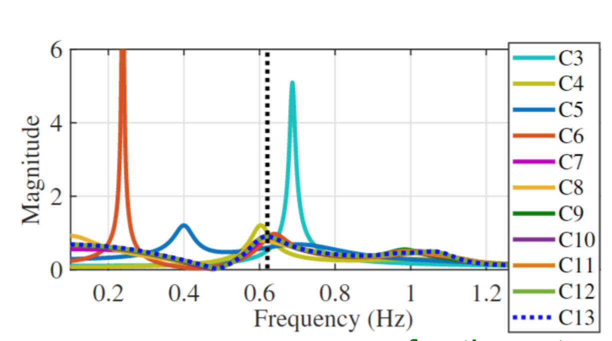
$\hat{\varphi} = \angle\hat{\xi}$ $\quad\hat{\xi}$: Fourier coefficients

② 

Energy change of the frequency at bus 39 for a three-phase short circuit.

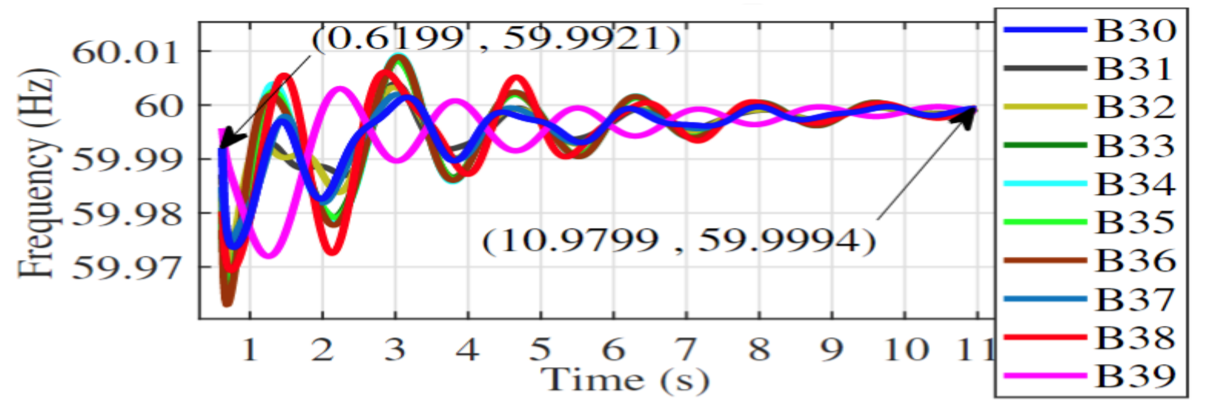
③ 

Convergence criterion of the dominant frequency variation for finding the optimal steady-state crossing.



Frequency response of the transfer function O1/I1 associated with G1 until the 13-th crossing.

Optimal data-window

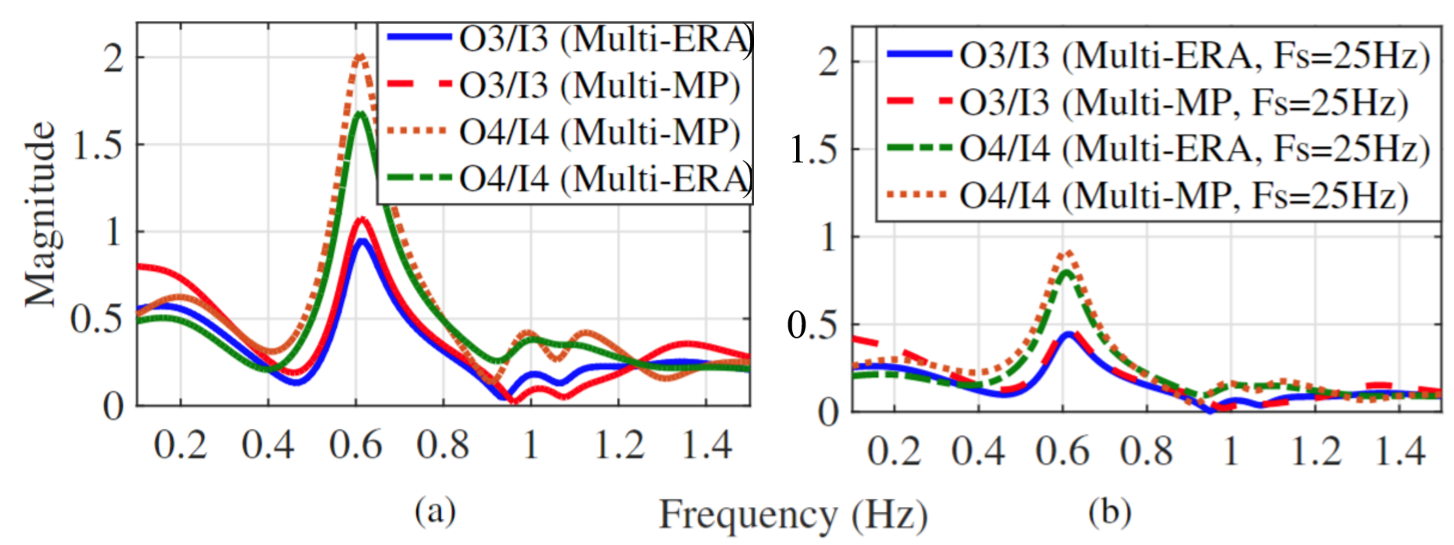


Frequency signals over the identification window with 13 crossings by the steady-state in the frequency signal at bus 30.

④ On-line power system identification via ERA

Power system linear model

$$\dot{\mathbf{x}} = \hat{\mathbf{A}}\mathbf{x} + \hat{\mathbf{B}}\mathbf{u}$$
$$\mathbf{y} = \hat{\mathbf{C}}\mathbf{x} + \hat{\mathbf{D}}\mathbf{u}$$



Comparisons of frequency responses of the transfer functions between Multiple-ERA and Multiple-Matrix Pencil methods for 2-Outputs and 2-Inputs in the New England power grid: (a) O3/I3 and O4/I4 using a sampling frequency of 50Hz; (b) O3/I3 and O4/I4 using a sampling frequency of 25Hz.

On-line System Identification of Power System Linear Models GitHub

Conclusions

This research platform profits from the use of two well-known computational programs to demonstrate its performance and effectiveness for optimally identifying a large-scale power system. To ensure a reliable and optimal system identification, this platform takes advantage of a mutually beneficial relationship among four well-established mathematical techniques, this symbioses guarantees the estimation of synchrophasor information, the correct detection of the right disturbance instant, the optimal extraction of the dominant frequency, and the proper identification of the Markov parameters that assemble the descriptor form of Multiple-Input and Multiple-Output (MIMO) linear systems for modeling modern power grids. The proposed architecture can deal with any system identification technique to be tested.

Paper Number: 23PESGM0279 by J.A. Moreno-Corbea, jamcorbea@comunidad.unam.mx