Application of Real-Time Digital Twin Simulation with WAMS for Dynamic Security Improvement of Power Systems

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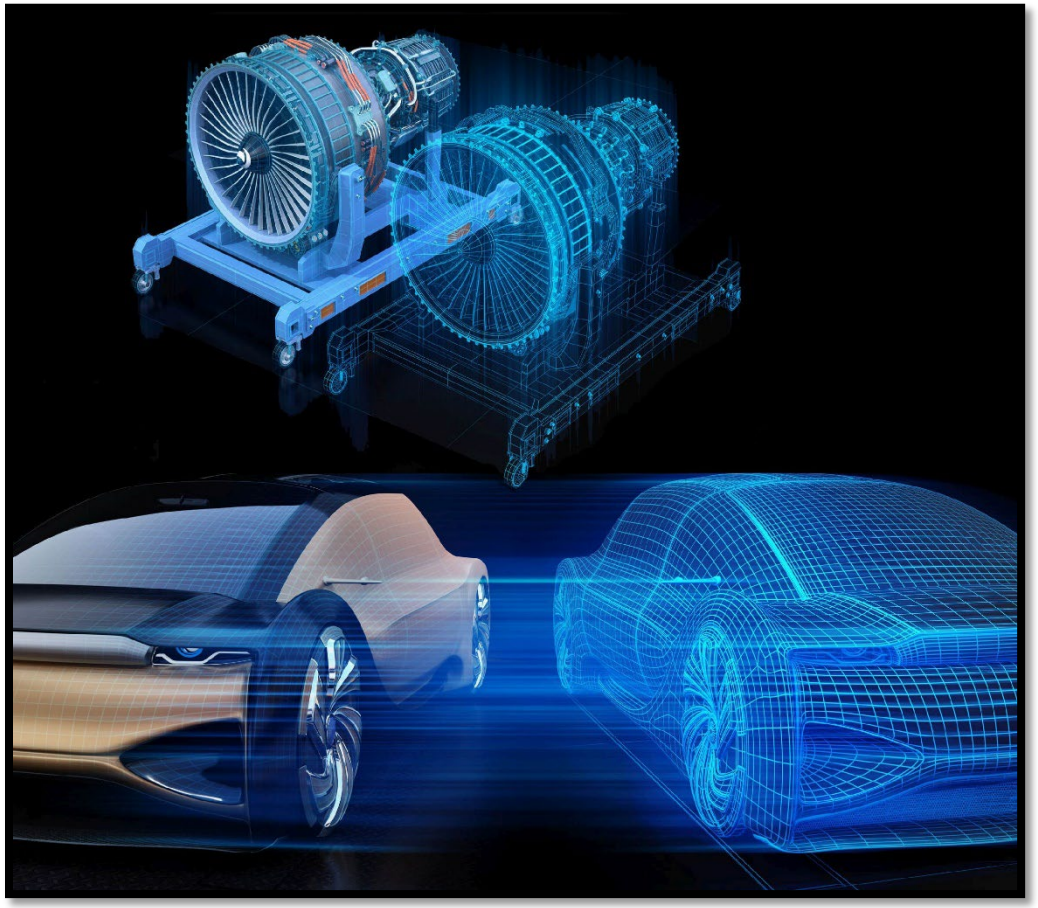
Digital Twin Concept



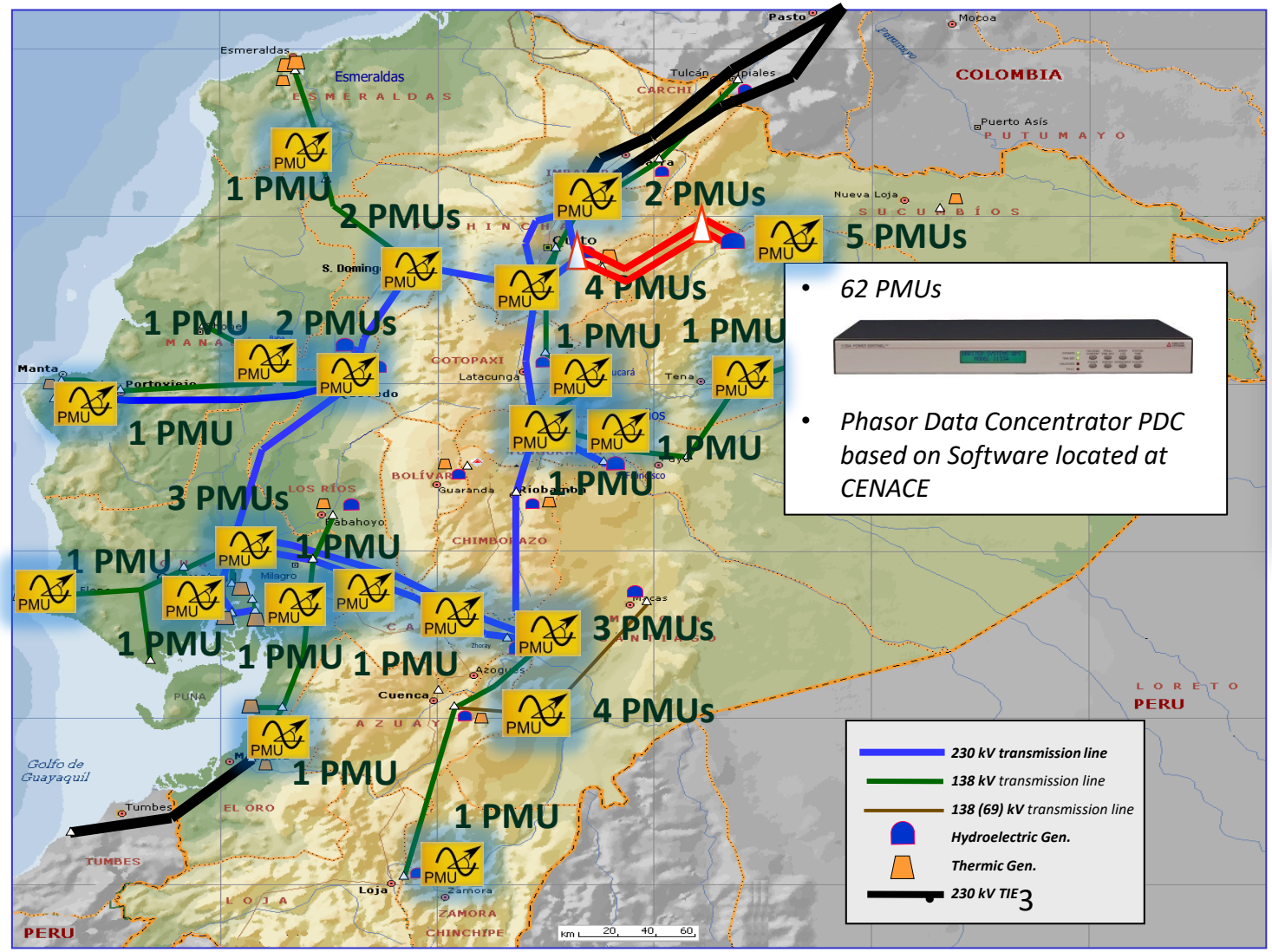
A digital twin is a virtual representation that serves as the real-time digital counterpart of a physical object or process.

Digital twins are the result of continual improvement in the creation of product design and engineering activities.

The digital twin concept consists of three distinct parts: the physical product, the digital/virtual product, and connections between the two products.

The connections between the physical product and the digital/virtual product is data that flows from the physical product to the digital/virtual product and information that is available from the digital/virtual product to the physical environment.

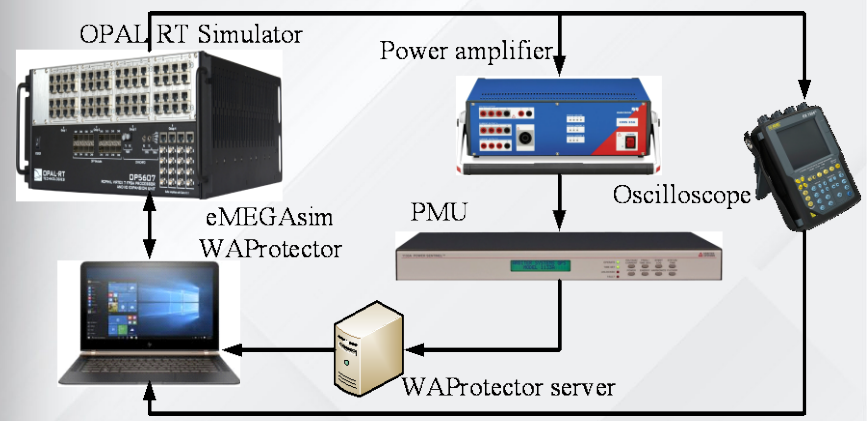
Ecuadorian WAMS

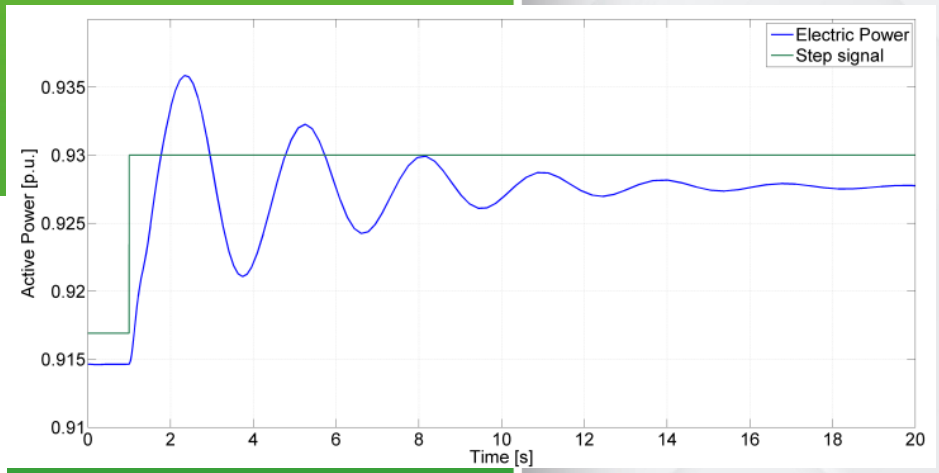


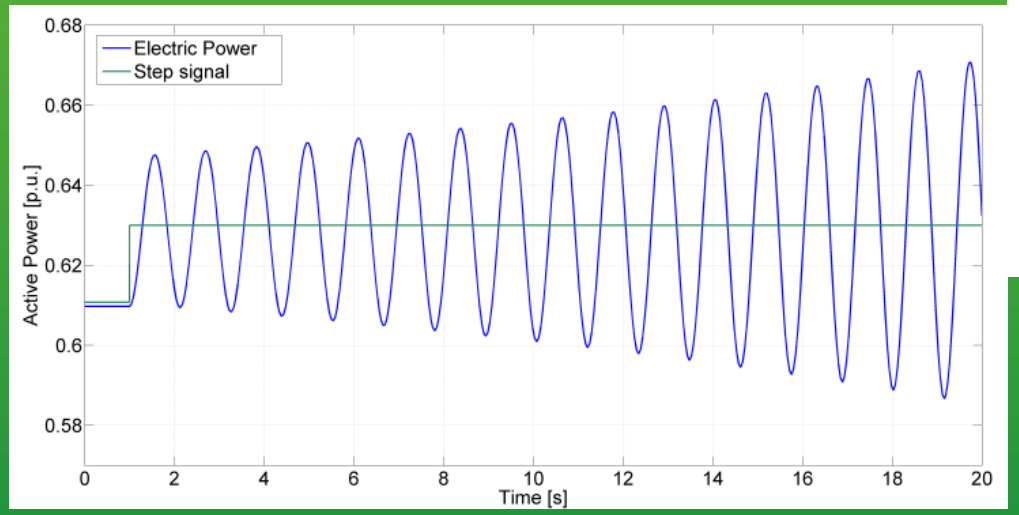
- *62 PMUs*

- *Phasor Data Concentrator PDC based on Software located at CENACE*

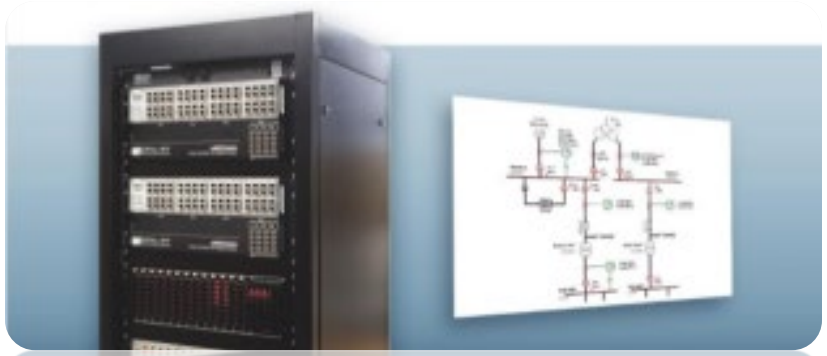
PSS Tuning using eMEGAsim and WAMS







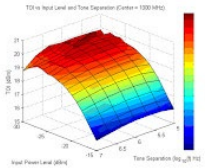
PSS Tuning Metodology



Installation of monitoring devices in the Generation power Plant: PMUs

Modeling of key system elements: generator, AVR and simplified network.

Model validation through field tests and real-time records (WAProtector)



Probabilistic Oscillatory analysis:

Modal Analysis

Frequency response

Time domain Simulation

Multiple scenarios (Monte Carlo)

MATLAB SIMULINK

PSS Tuning.- Robust Methodology:

- Multiple scenarios (Monte Carlo)

- Heuristic optimization algorithm

- Frequency response (constraints)

- TestBed for PSS Tuning (Laboratory)

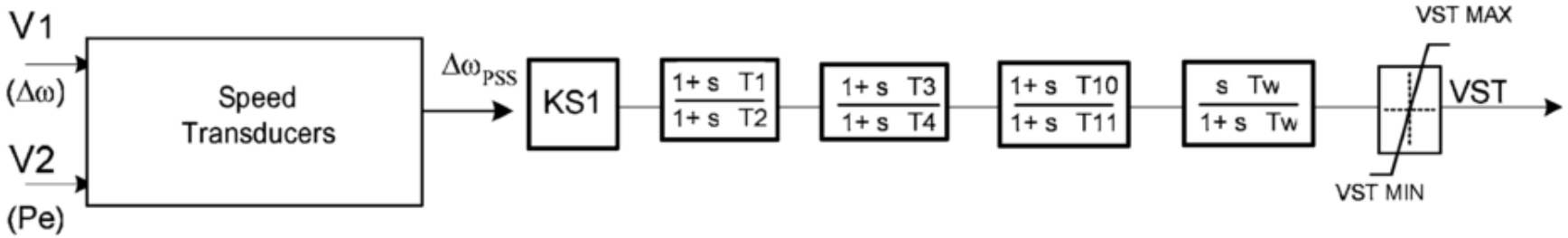
Field PSS tuning

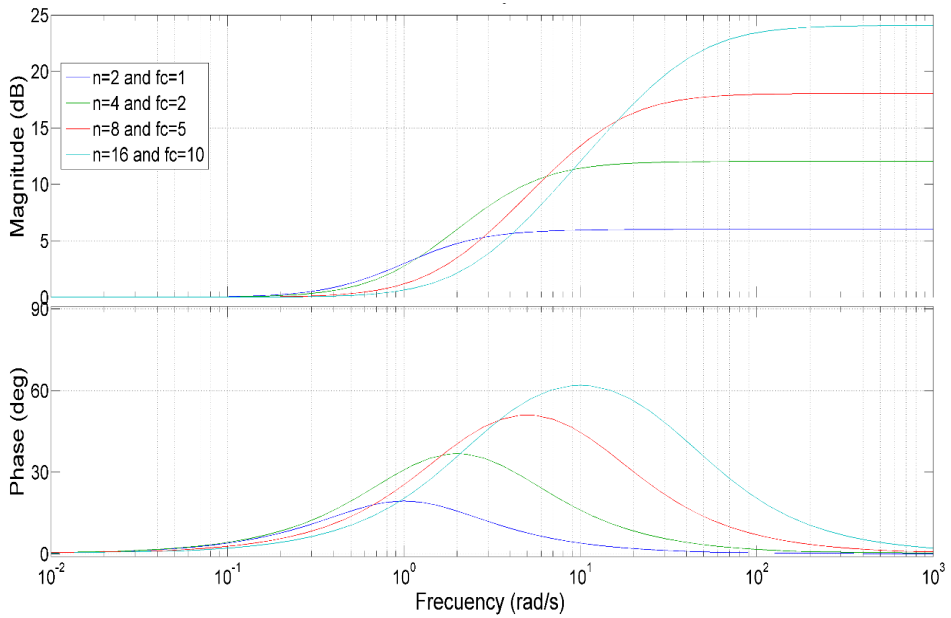
Tuning validation tests

(WAProtector)

eMEGAsim

PSS Tuning Metodology



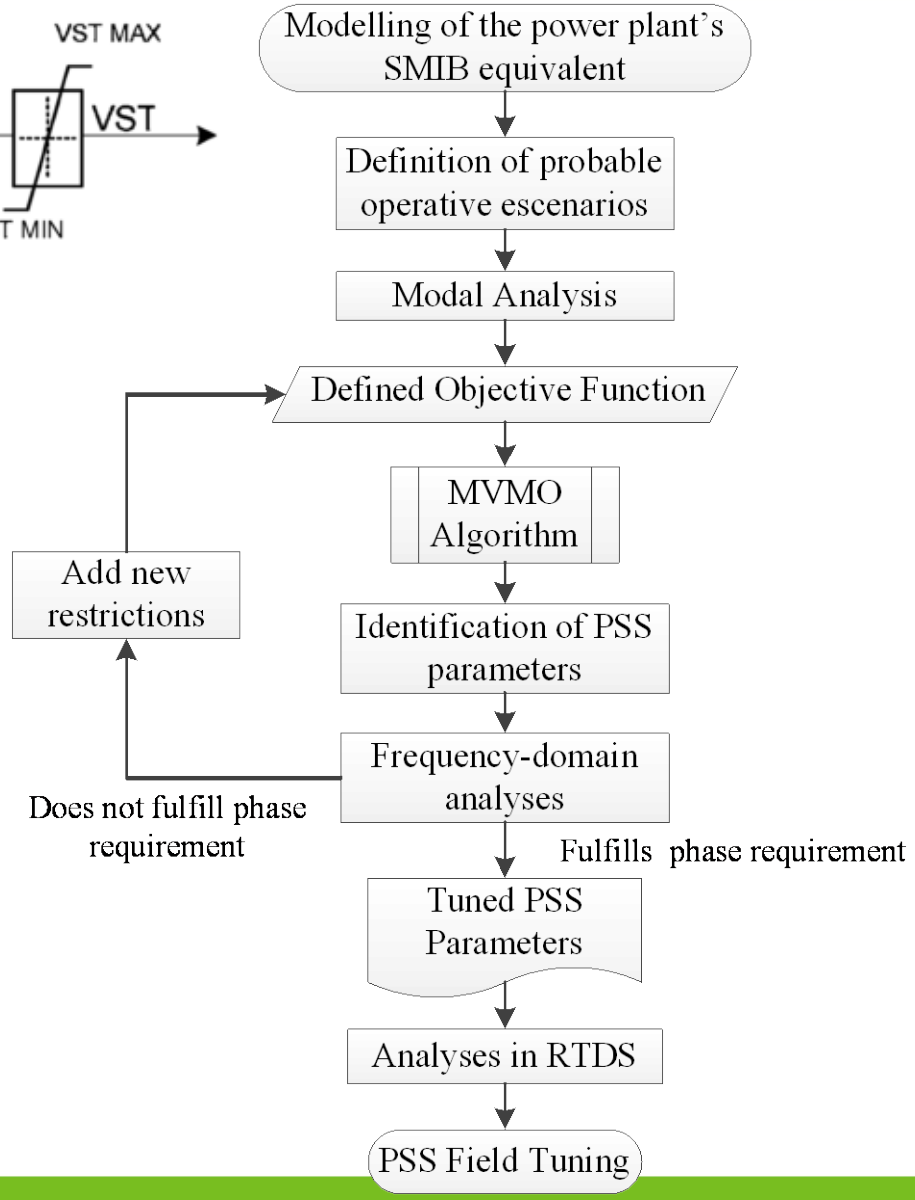


$$\min OF = \left| \xi_{th} - \xi_{sys} \right|$$

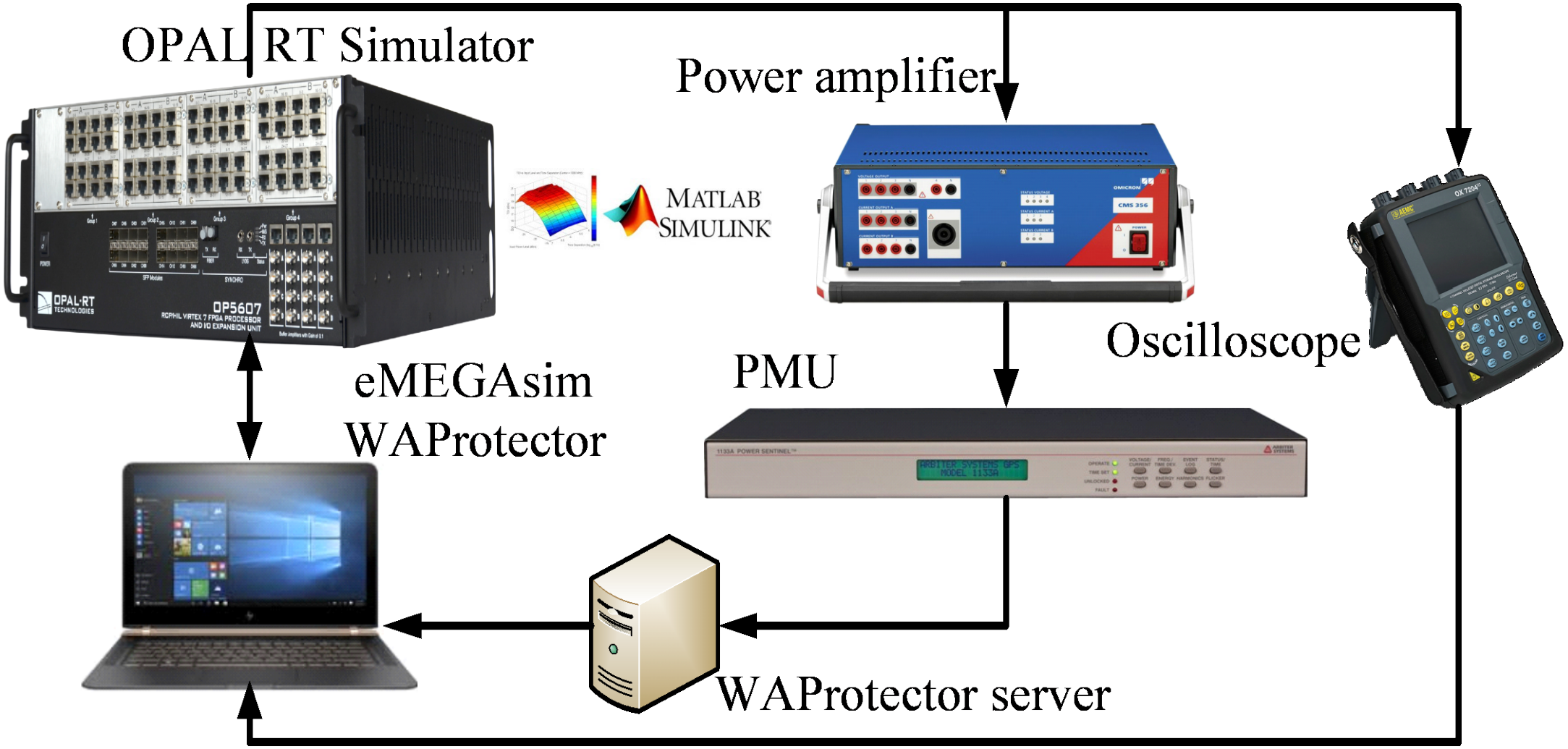
$$\xi_{sys} = \min_{p=1\ldots nm} \left(\xi_p \right)$$

$$\mathbf{x}_{\mathrm{j-min}} \leq \mathbf{x}_{\mathrm{j}} \leq \mathbf{x}_{\mathrm{j-max}}$$

$$fc = \frac{1}{2\pi} \frac{1}{\sqrt{T_1 T_2}} \qquad n = \frac{T_1}{T_2}$$



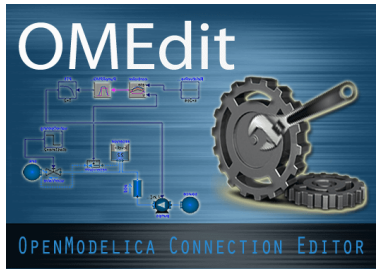
Testbed for PSS Tuning



Operators’ training Environment using ePHASORsim and WAMS

Training Environment

Implemented Training Environment



Power System

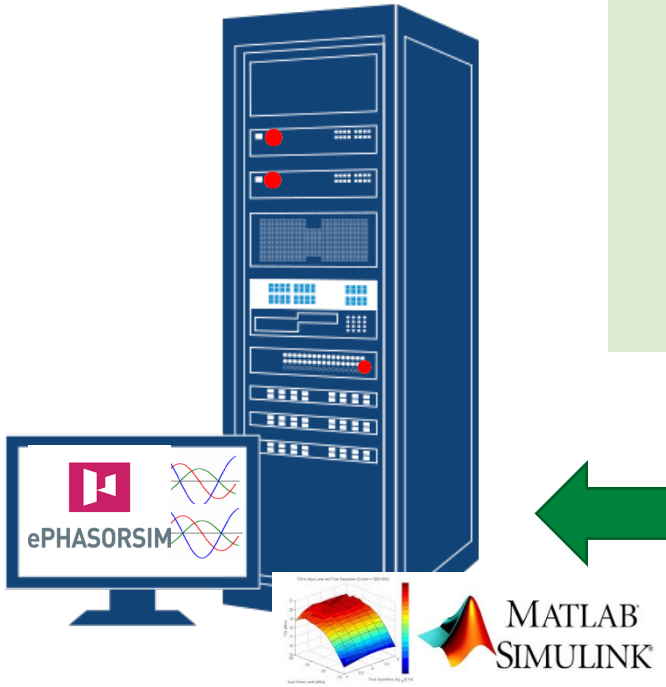
Dynamic Modelling

- Generator
- Automatic Voltage Regulator (AVR)
- Power System Stabilizer (PSS)
- Governor (GOV)

Static Modelling

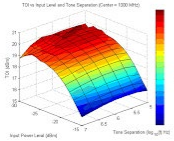
- Load
- 2W, 3W Transformer
- Transmission lines

FMU



DGS

Implemented Training Environment

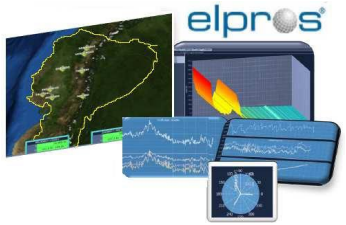


MATLAB SIMULINK

Real-Time Digital Simulator

Virtual PMU

C37.118

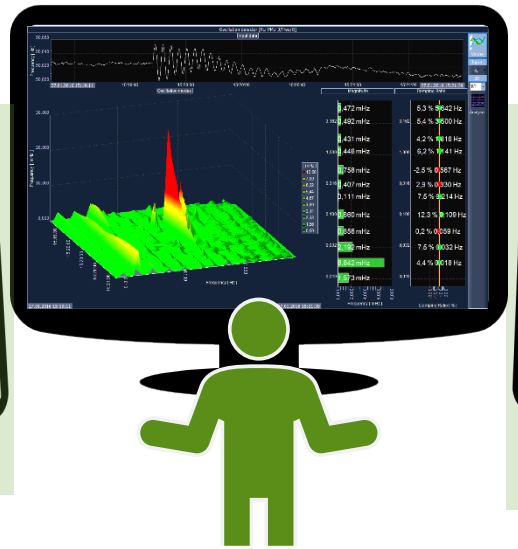


Wide Area Monitoring System

WAMS' APPLICATIONS

- Angular Difference
- Oscillatory Stability
- Voltage Stability of Transmission Corridors
- Frequency Monitoring

- Dynamic Simulation (Operation Commands)
- Load Flow Simulation



- Study Cases
- Generation and Demand

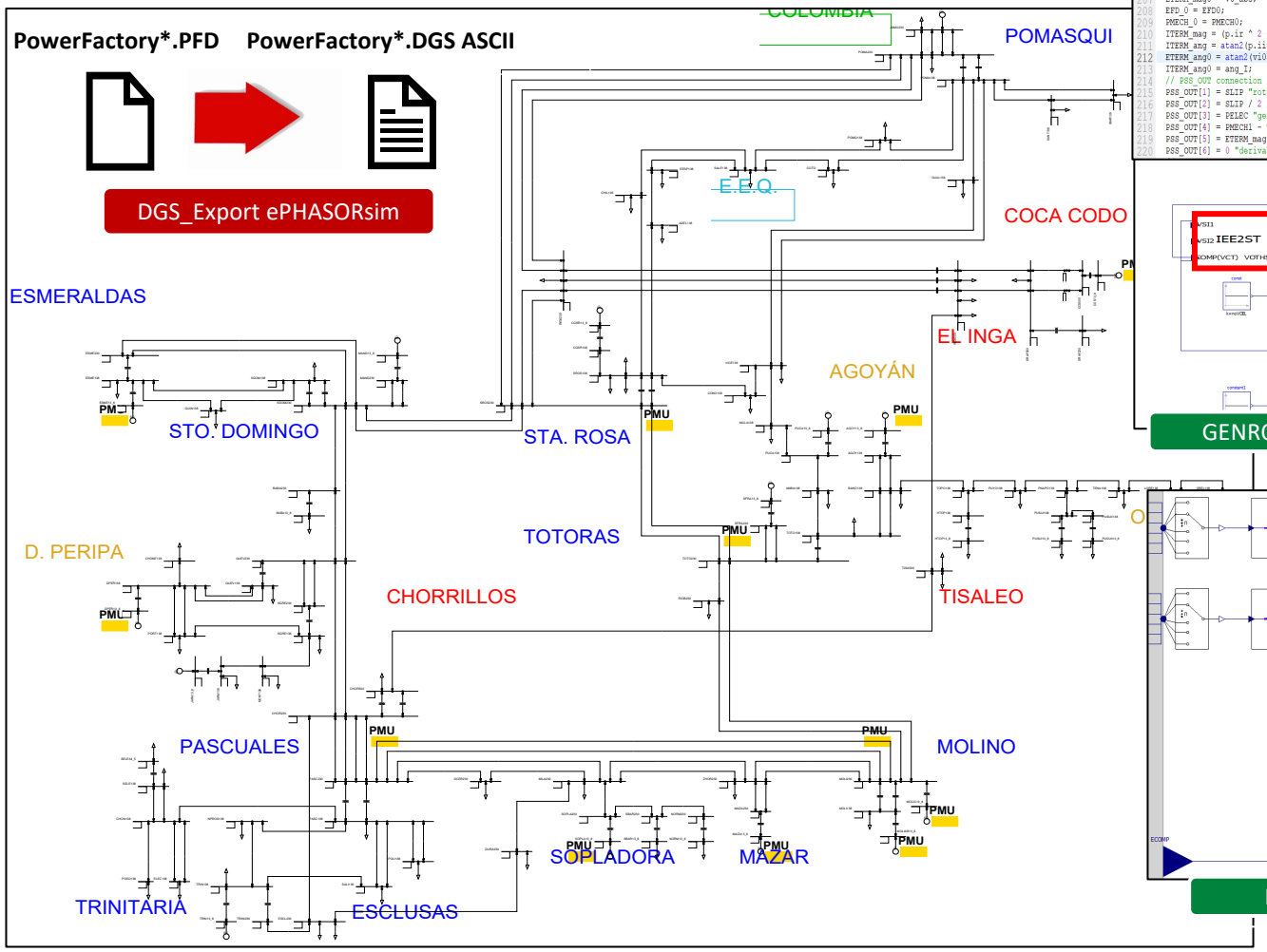
Training Environment

Implemented Training Environment

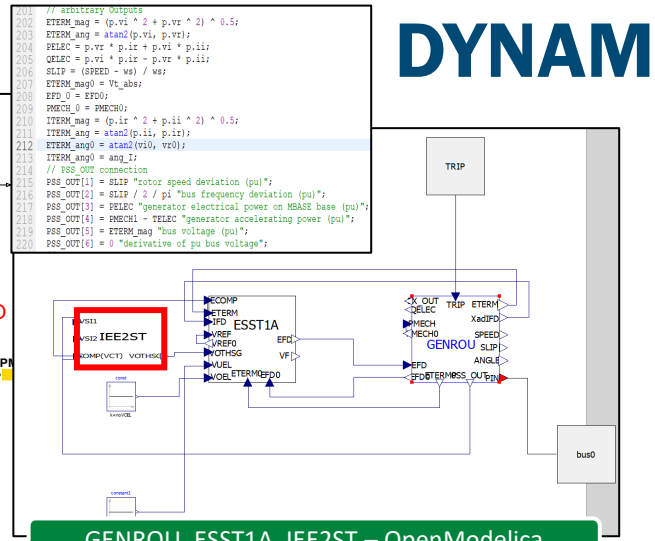
STEADY-STATE MODELS

PowerFactory*.PFD PowerFactory*.DGS ASCII

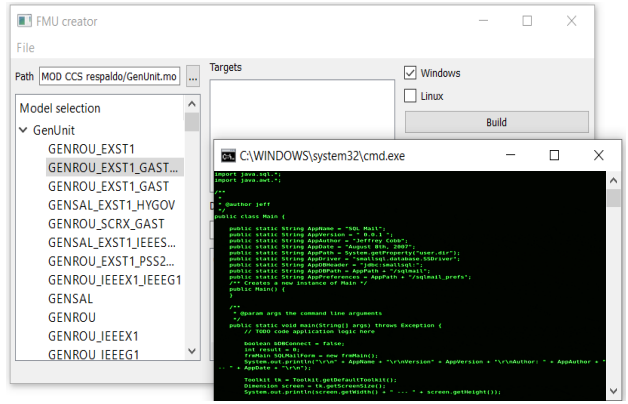
DGS_Export ePHASORsim



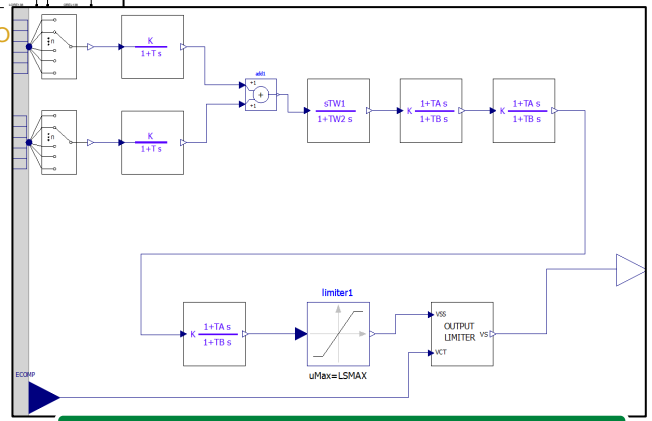
DYNAMIC MODELS



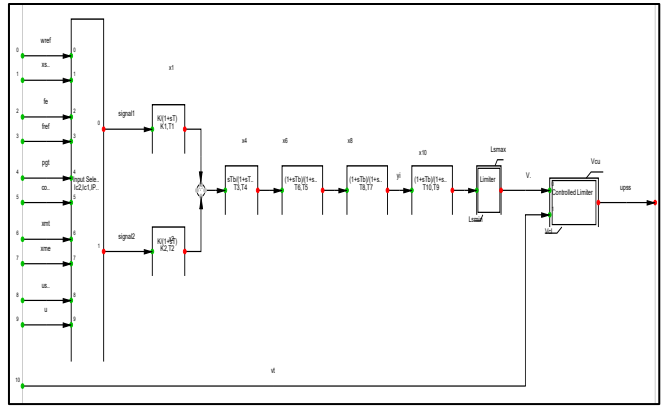
GENROU_ESST1A_IEE2ST – OpenModelica



FMU Creator

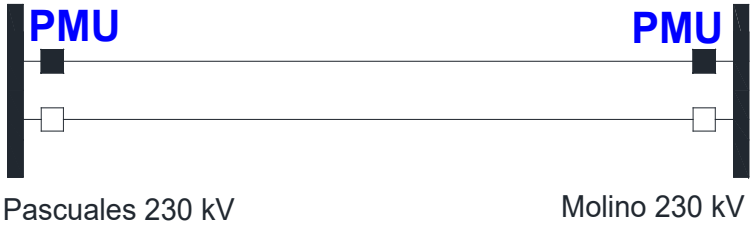


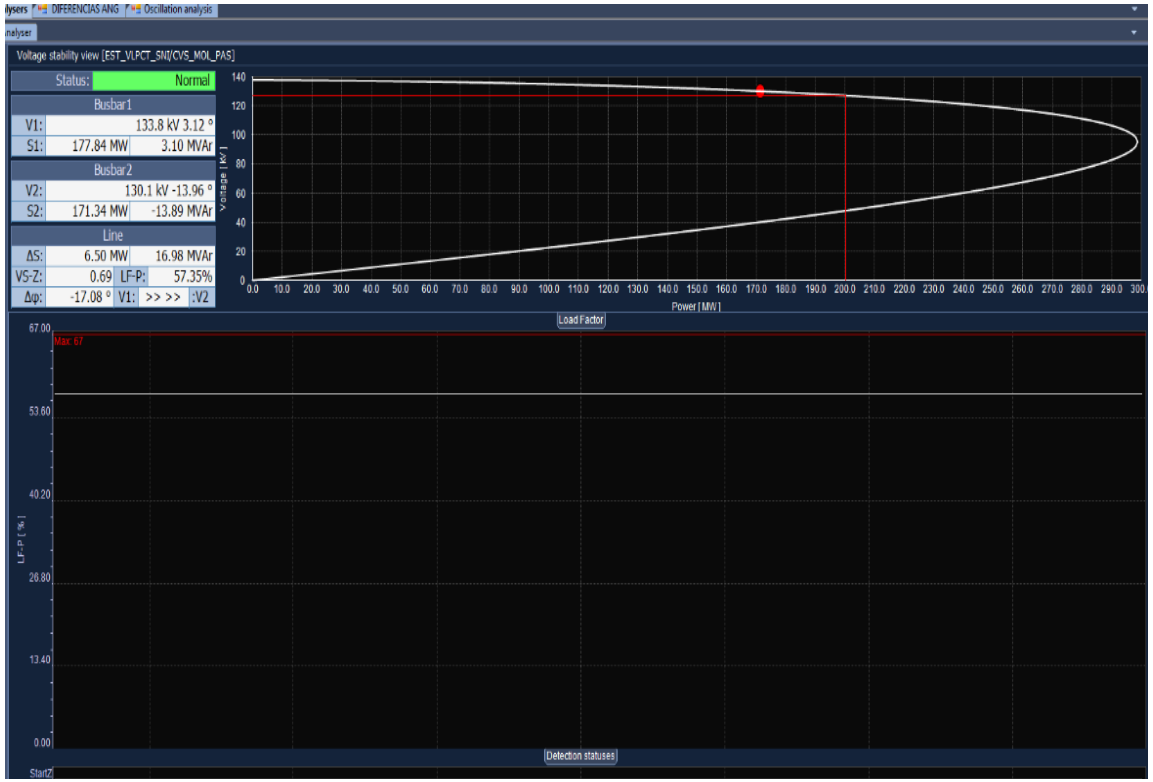
IEE2ST Block Diagram - OpenModelica

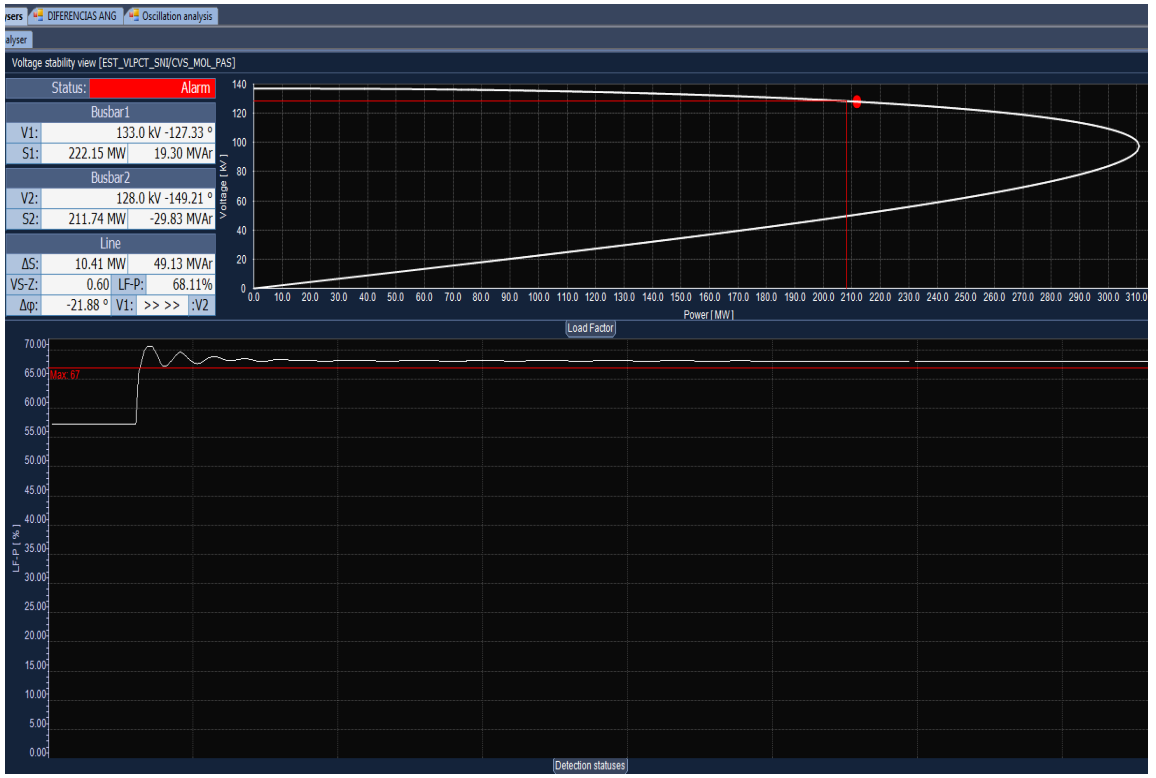


IEE2ST Block Diagram – DIgSILENT Simulation Language

Real-Time Simulation Results







THANK YOU

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