Role and Use Cases of the RTDS Simulator Towards Advancing and Deploying Synchrophasor based WAMPAC Systems

Dinesh Rangana Gurusinghe

RTDS Technologies

RTDS.COM

Outline

- Introduction
- Synchrophasor Test Setup with RTDS Simulator
- RTDS PMU Models
- Use Cases
    1. Real-Time Assessment of Voltage Stability
    2. PMU Performance Testing
    3. Synchrophasor Training
- Conclusion

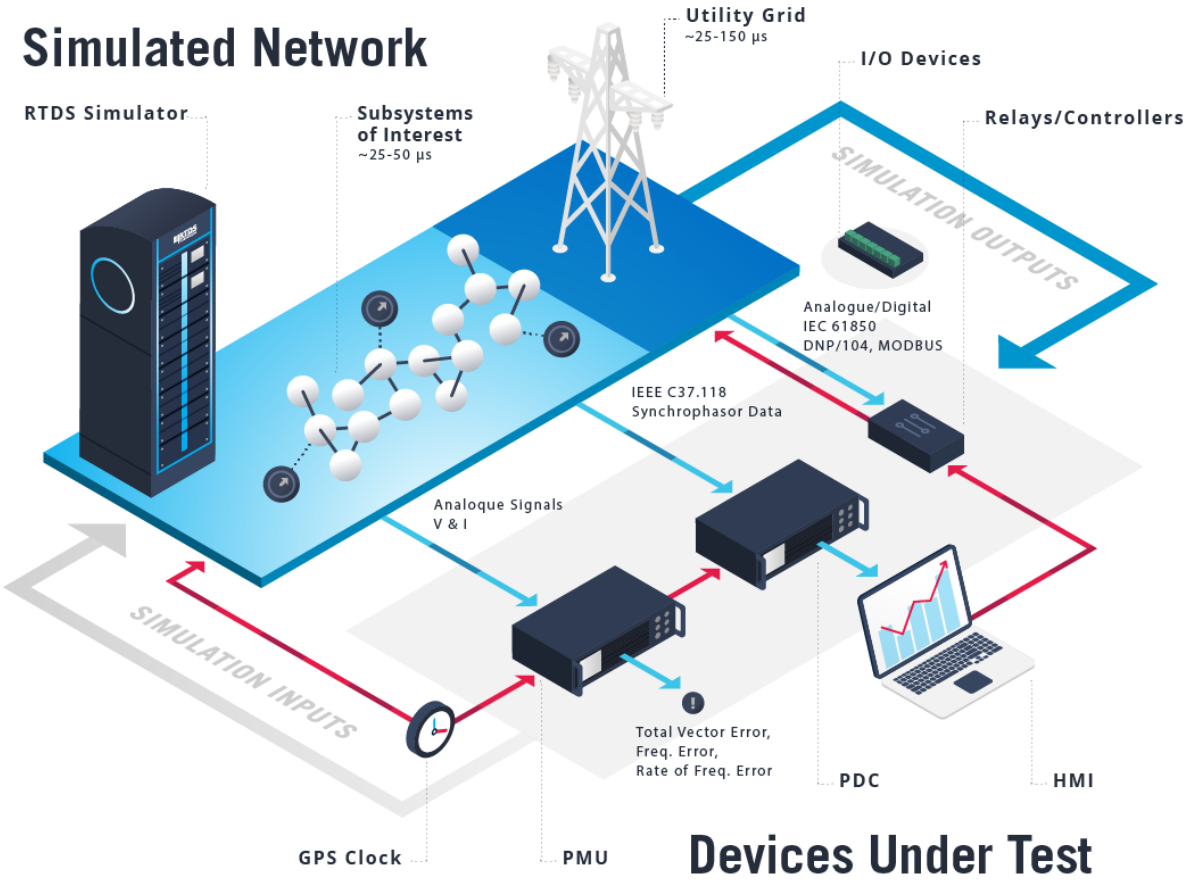
RTDS Technologies

- 500+ customers
- 2000+ units
- 50+ countries
- Our clients are leading…
  - ✓ Electrical power utilities
  - ✓ Electrical equipment manufacturers
  - ✓ Research and learning institutions
  - ✓ Consultants

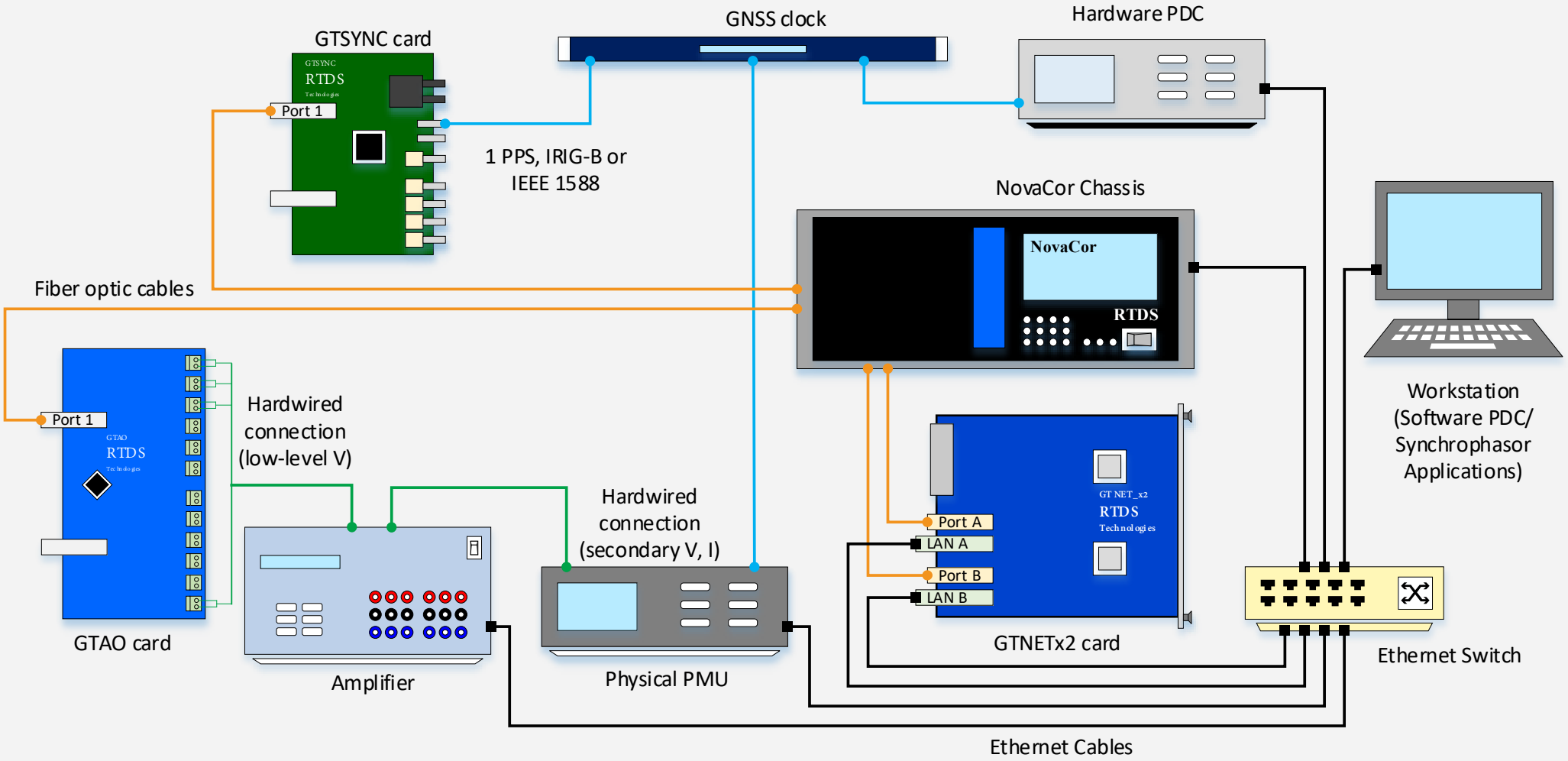
Introduction

- To recognize,
  - ✓ Development issues
  - ✓ Technical hitches in real implementation
  - ✓ Issues related to communication

- Advantages,
  - ✓ Interfaced actual hardware such as PMUs
  - ✓ Testing of individual components as well as the integrated system



Synchrophasor Test Setup with RTDS Simulator



RTDS PMU Models

- Streams Phasor Measurement Unit (PMU) data as per IEEE C37.118 format using GTNETx2 and GTSYNC hardware
- Supports,
  - ✓ IEEE C37.118 : 2005 (Config 2)
  - ✓ IEEE C37.118.2 : 2011 (Config 3)
- Measurements comply to IEC/IEEE Std. 60255-118-1 : 2018
- Two components,
  - ✓ GTNET-PMU8
  - ✓ GTNET-PMU24

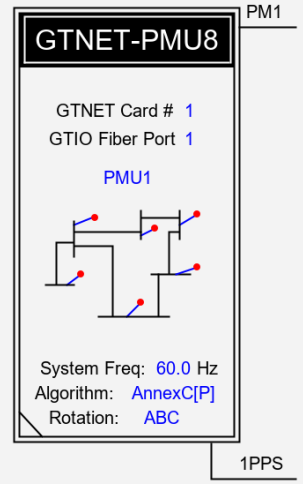
GTNET - PMU

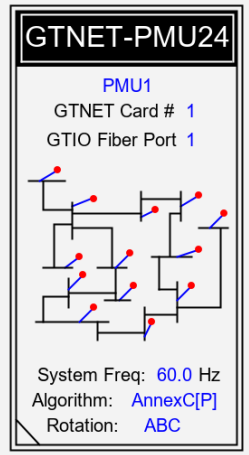
GTNET-PMU8

- Simulates up to 8 PMUs
- Up to 12 phasors per each PMU
  - ✓ Individual phase voltages and currents
  - ✓ +ve, -ve and zero sequence quantities
- Provides frequency and ROCOF measurements
- Complies to both P and M service classes
- Supports reporting rates,
  - ✓ up to 240 frames/s for 60 Hz systems
  - ✓ up to 200 frames/s for 50 Hz systems

GTNET-PMU24

- Simulates up to 24 PMUs
- Up to 2 phasors per each PMU
  - ✓ +ve sequence voltages and currents
- Provides frequency and ROCOF measurements
- Complies to P service classes
- Supports reporting rates,
  - ✓ up to 60 frames/s for 60 Hz systems
  - ✓ up 50 frames/s for 50 Hz systems





Use Case 1

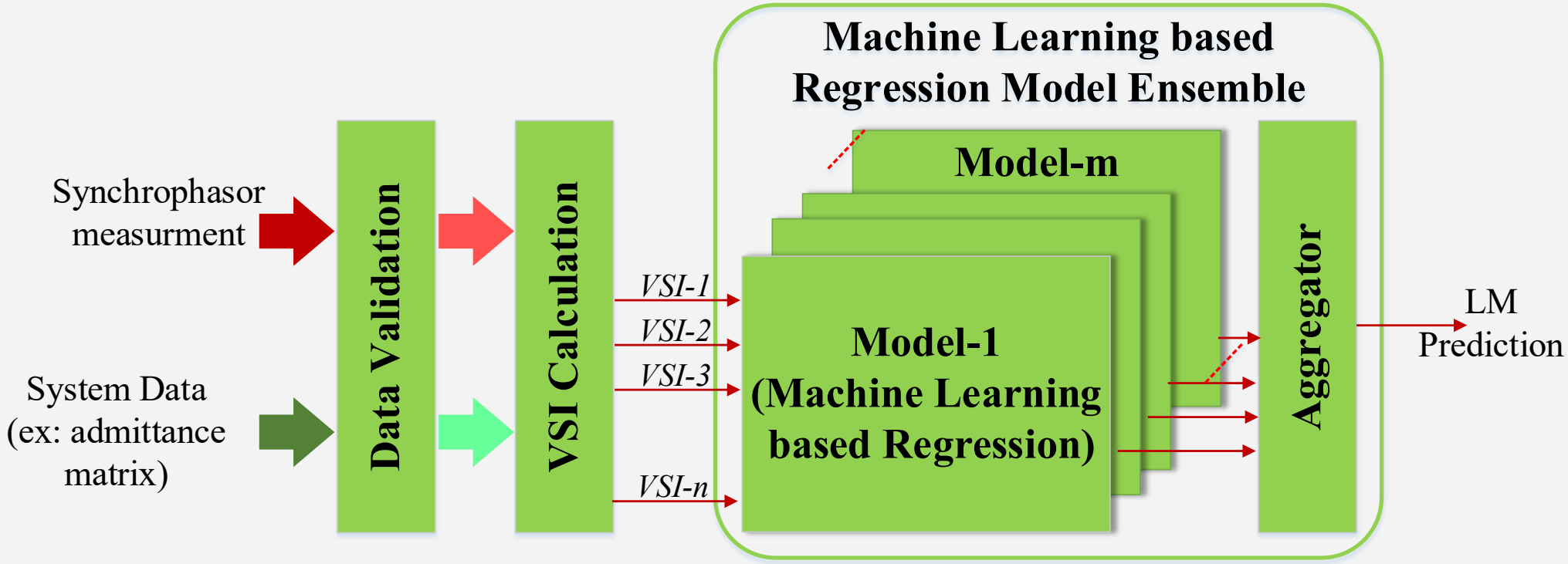
Real-Time Assessment of Long-Term Voltage Stability

K. D. Dharmapala, “Machine learning based real-time monitoring of long-term voltage stability using voltage stability indices,” M.Sc. thesis, Dept. Electrical & Computer Engineering, University of Manitoba, Winnipeg, MB, Canada, 2020.

Real-Time Voltage Stability Margin Prediction

- Voltage Stability Indices (VSI) provide real-time quantitative parameters to determine the proximity to voltage instability.
- Levels of accuracy and sensitivities of VSIs varies with the power system conditions.
- Combining different VSIs based on regression principles can accurately predict voltage stability margin or so called loadability margin.

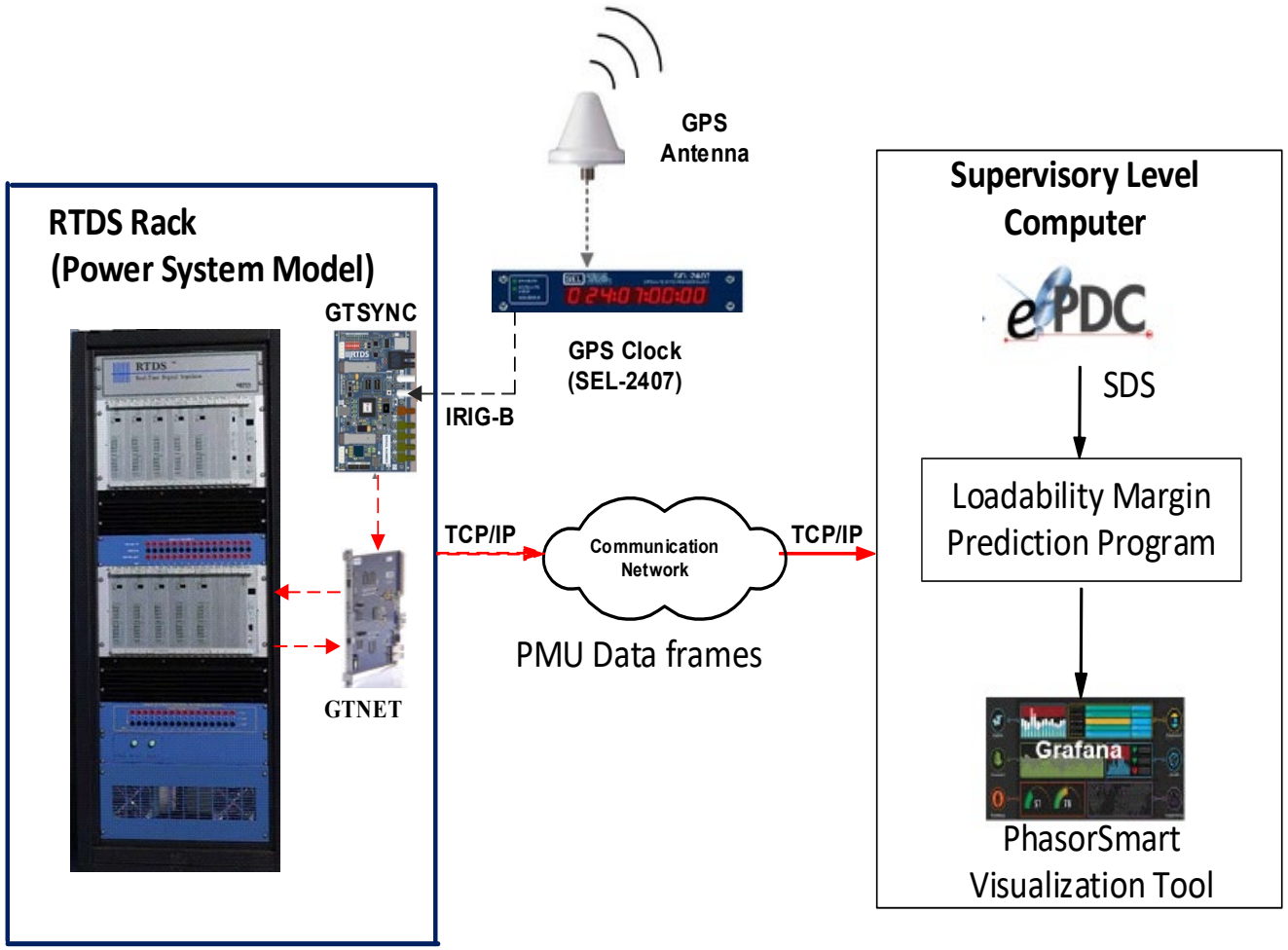
Framework



[Source] : K. D. Dharmapala, "Machine learning based real-time monitoring of long-term voltage stability using voltage stability indices," M.Sc. thesis, Dept. Electrical & Computer Engineering, University of Manitoba, Winnipeg, MB, Canada, 2020.

Voltage Stability Monitoring Test Setup

- Test setup comprises,
  - ✓ RTDS Simulator
  - ✓ PhasorSmart® application framework
- IEEE 14-Bus system was simulated in the RTDS Simulator.
- Application framework was implemented in the supervisory level computer using a C++ program.



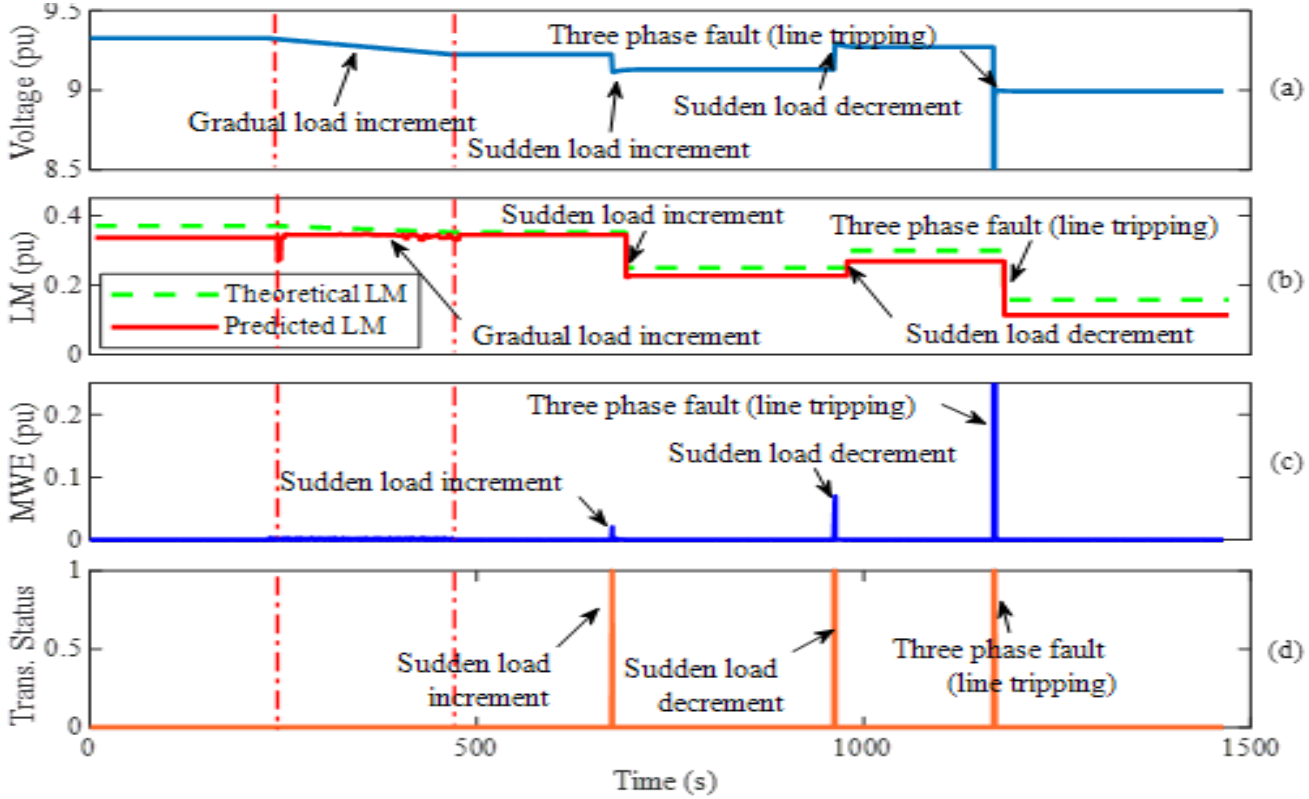
Voltage Stability Monitoring Dash-Board

- PhasorSmart® dash-board provides a simple overview of the current status of the system voltage stability
- Real-time voltage magnitudes of the most critical buses
- Here, LM predictions are visualized for the two most critical buses (i.e. Bus 14 and Bus 8).

[Source] : K. D. Dharmapala, “Machine learning based real-time monitoring of long-term voltage stability using voltage stability indices,” M.Sc. thesis, Dept. Electrical & Computer Engineering, University of Manitoba, Winnipeg, MB, Canada, 2020.

Real-Time Monitoring Results

1. Gradual load increment
2. Sudden load increment at bus 9
3. Sudden load decrement at bus 9
4. Three phase fault on a line



(a) Voltage profile of bus-14 of the IEEE 14 bus system
(b) LM prediction form the ensemble ML model
(c) MWE variation
(d) Transient status under different power system operational situations

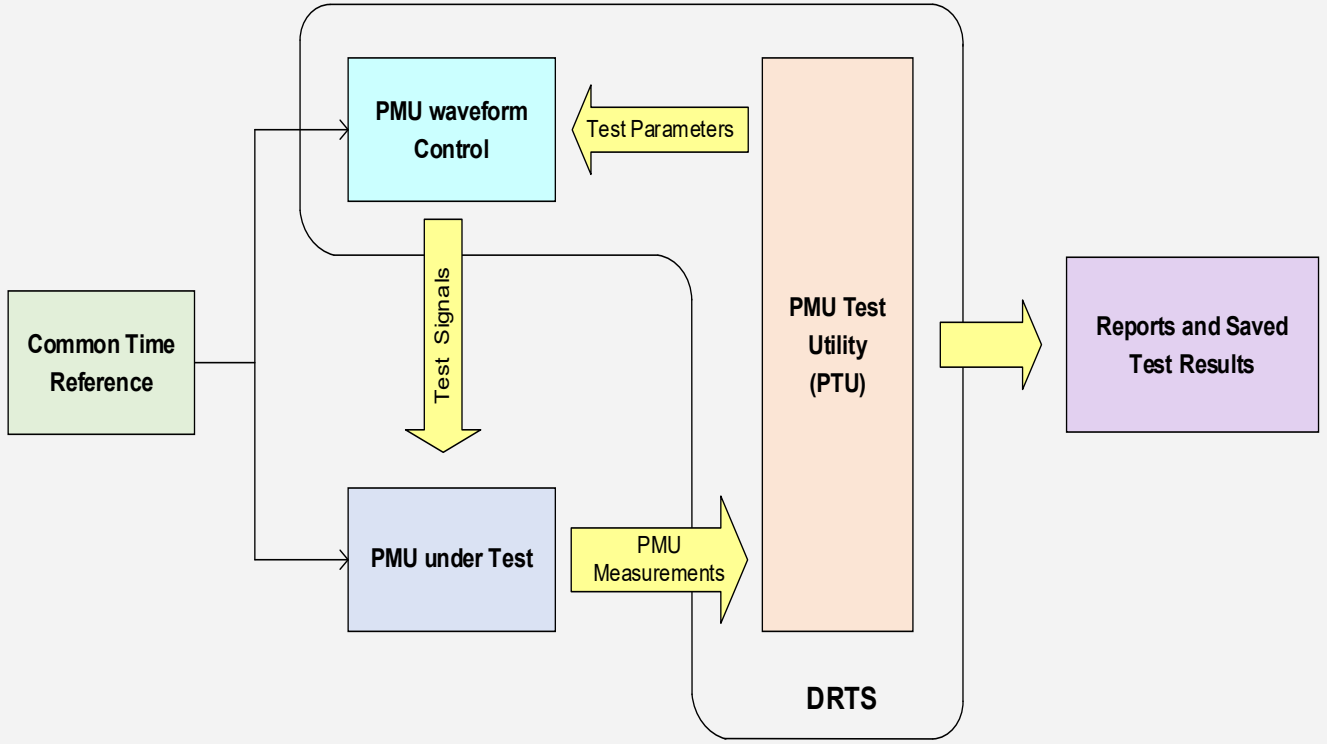
Use Case 2

PMU Performance Testing

D. R. Gurusinghe, S. Kariyawasam, and D. S. Ouellette, “An advanced automation tool for testing electrical performances of phasor measurement units ,” in proceedings of Protection, Automation & Control World Conference (PAC World 2021), Aug. 2021.

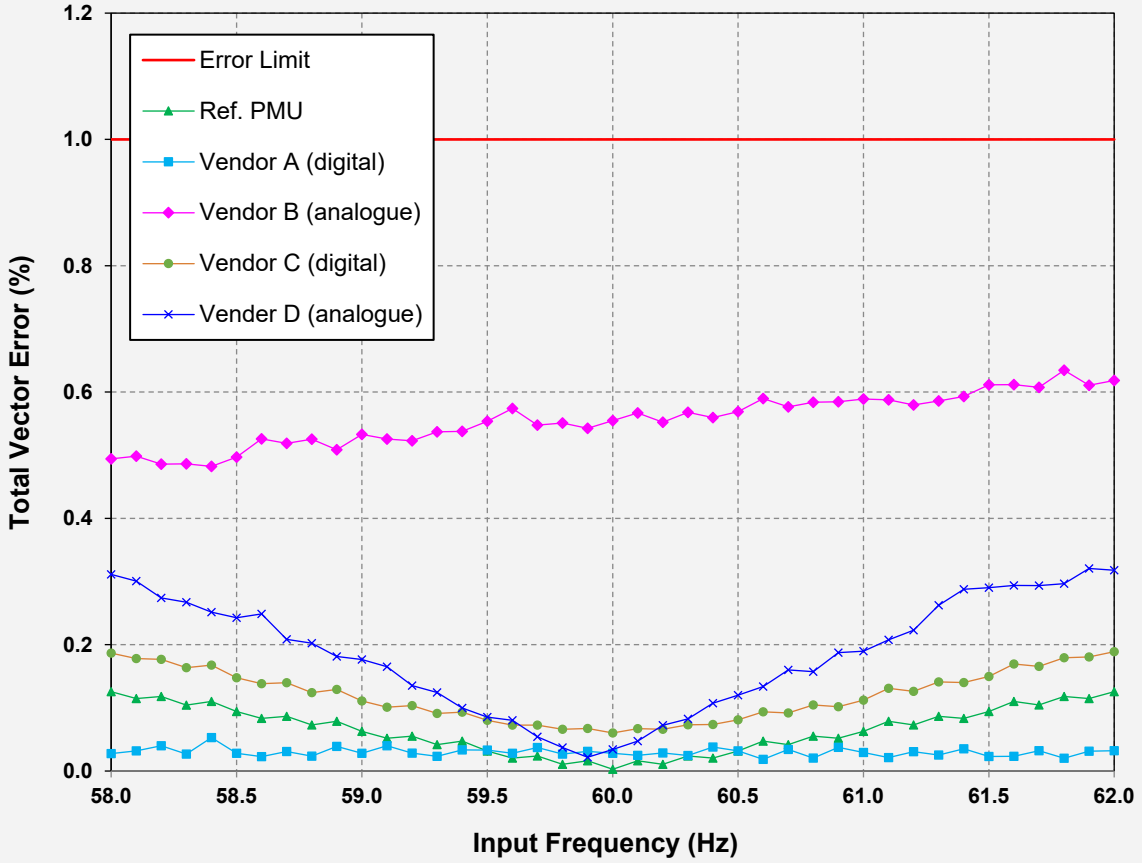
Overview and Features of PMU Test Utility

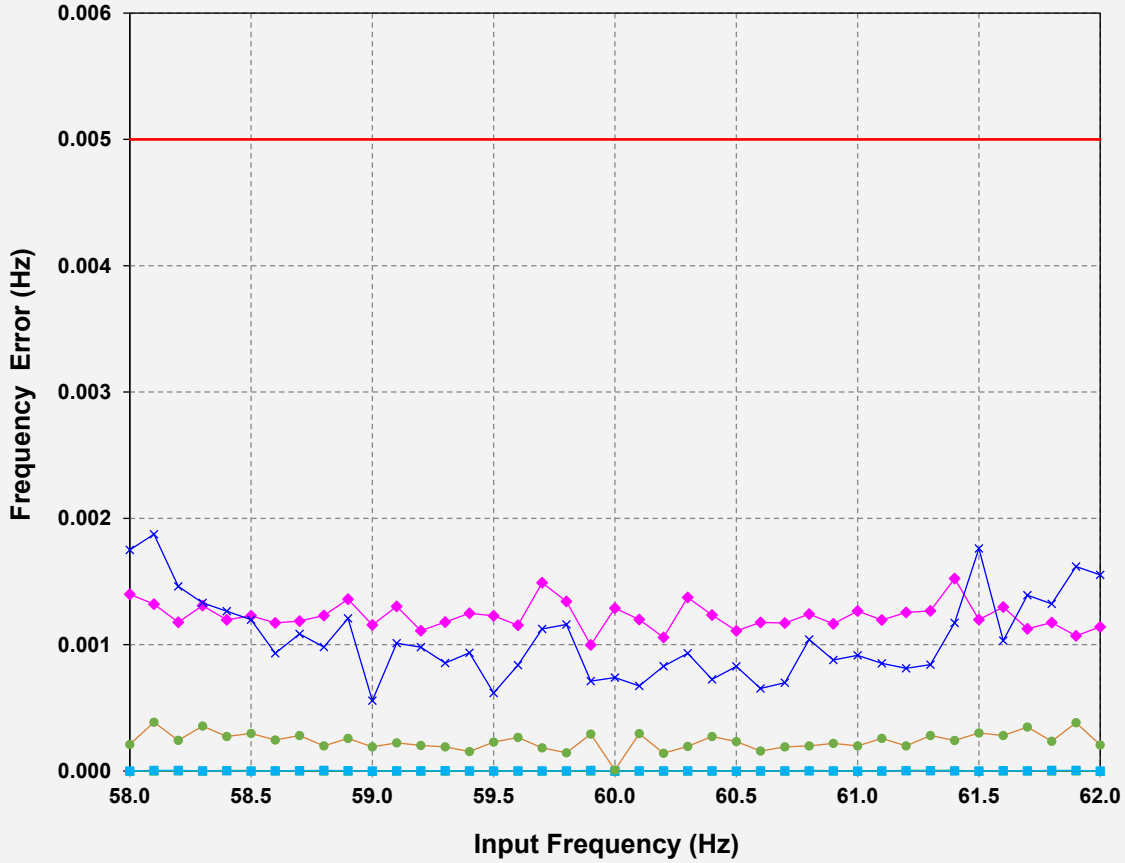
- Waveform control block is a signal generator component in the RTDS Simulator.
- PTU application provides necessary input parameters to the waveform control block
- The PTU collects measurements from the DUT, compare them against the theoretical values to determine error quantities



[Source] : D. R. Gurusinghe, S. Kariyawasam, and D. S. Ouellette, "An advanced automation tool for testing electrical performances of phasor measurement units ," in proceedings of Protection, Automation & Control World Conference (PAC World 2021), Aug. 2021.

Test Results of Multiple PMUs





TVE and FE Variation of Multiple PMUs for the Frequency Range Test

Use Case 3

Synchrophasor Training

K. D. Jones, E. B. Cano, H. K. Chen, F. Robinson, K. Thomas and R. M. Gardner, "Strategies for success with synchrophasors: Poised to shine in the Eastern Region of the United States," in IEEE Power and Energy Magazine, vol. 13, no. 5, pp. 29-35, Sept.-Oct. 2015.

Synchrophasor Training

DVP engineers at work on a real-time synchrophasor training simulator in DVP's real-time digital simulator lab

[Source] : D. Jones, E. B. Cano, H. K. Chen, F. Robinson, K. Thomas and R. M. Gardner, "Strategies for success with synchrophasors: Poised to shine in the Eastern Region of the United States," in IEEE Power and Energy Magazine, vol. 13, no. 5, pp. 29-35, Sept.-Oct. 2015.

- It is essential that engineers and operators to understand the wide-area synchrophasor technology.
- Dominion Virginia Power (DVP) has included synchrophasors as a part of their relay training.
- RTDS Simulator is used to simulate the electric grid in real-time and then, stream PMU measurements to a PDC and to EPG's RTDMS platform.
- Engineers and operators can then visualize the effects of simulated events in real-time

Conclusion

- Synchrophasor technology has progressed tremendously over the last decade.
- Digital Real-Time Simulators play an important role towards advancing and deploying synchrophasor Technology.
  - ✓ Digital Real-Time Simulators offer a cost-effective and safe method to test synchrophasor applications under real-time operating conditions.
  - ✓ Various contingency scenarios can be tested in a controlled environment to evaluate performances before deploy to an actual system.

Thank You!

(dinesh@rtds.com)

RTDS Technologies

RTDS.COM