Wide-Area Synchrophasor based Transient Instability Prediction and Control

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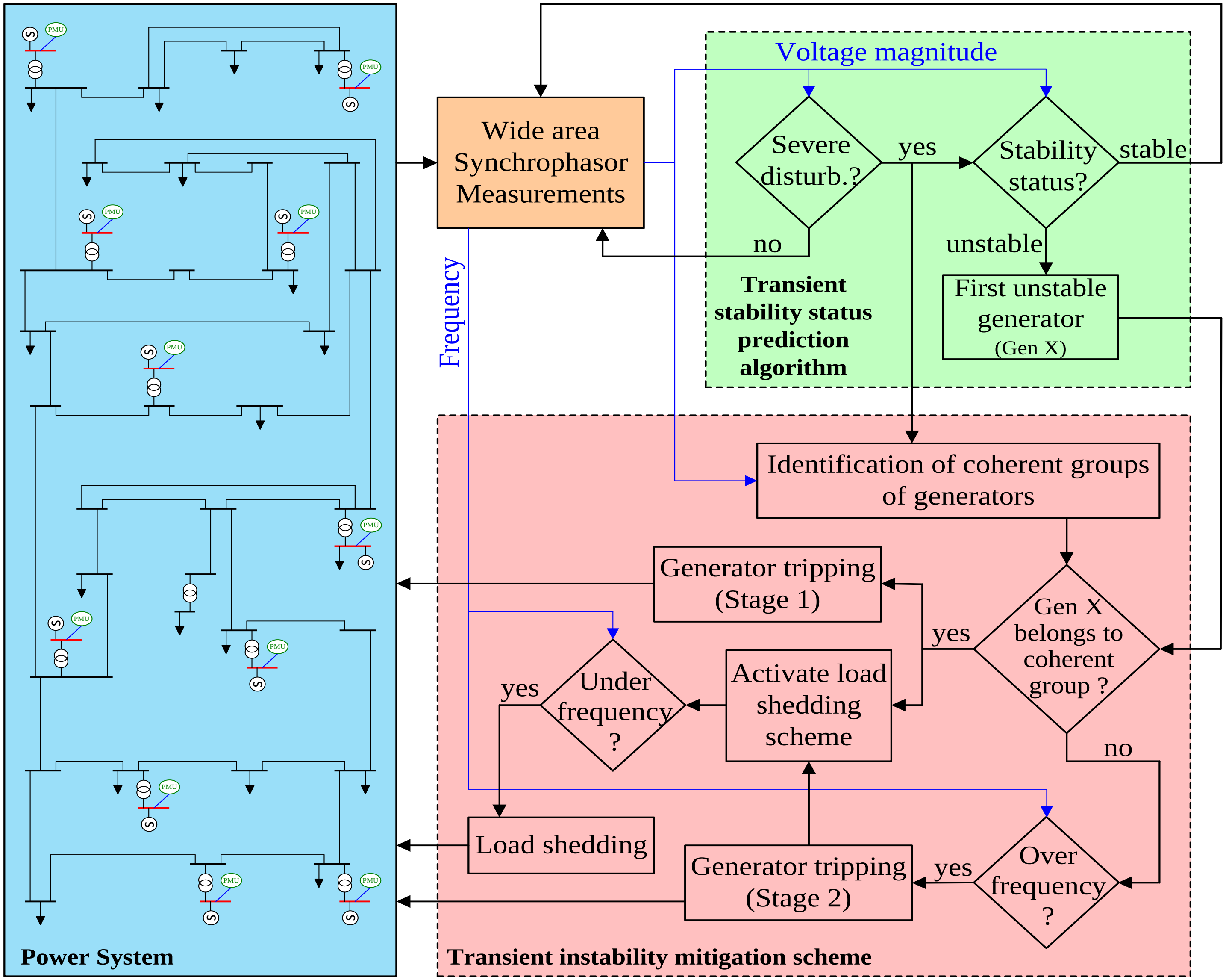
Introduction

- Transient instability is a fast phenomenon and a generator or group of generators potentially lose the synchronism within a few seconds after a severe disturbance.
- Fast recognition of such instabilities provides opportunity to initiate appropriate emergency control actions.
- In literature, it is common practice to provide controls referred as special protection systems (SPSs), which are rather complicated and expensive.
- Response based wide area protection and control systems are the best option as they are more simple, effective and can be implemented using wide area synchrophasor measurements of a network.

Objective

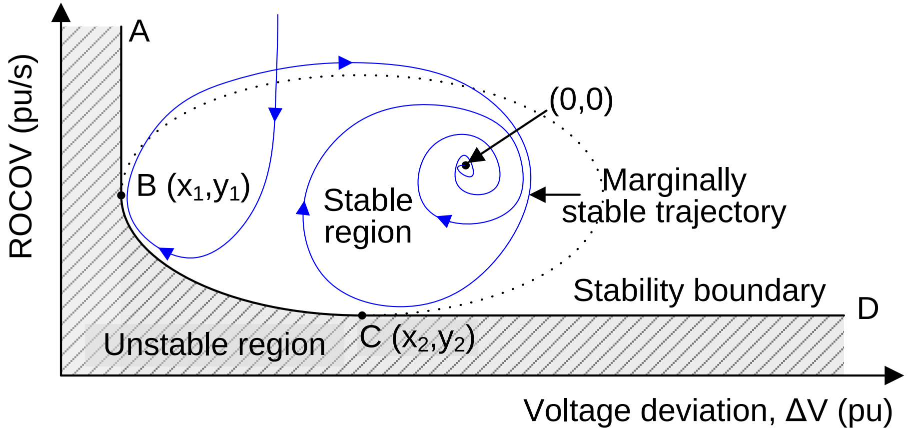
Developing a response based novel technique to predict and control impending transient instability conditions following a severe disturbance using wide area synchrophasors.

Overall Structure of the Proposed Method



Transient Stability Status Prediction Algorithm

- This algorithm classifies the transient swings as stable or unstable, based on rate of change of voltage (ROCOV) vs. voltage deviation (ΔV) characteristics of the post-disturbance voltage magnitudes.
- Implementation involves three-steps:
  1. Identification of contingencies that makes generator marginally unstable through off-line dynamic simulations.
  2. Determination of stability boundary for each generator.
  3. Detection of severe disturbances and triggering the transient stability status prediction algorithm.

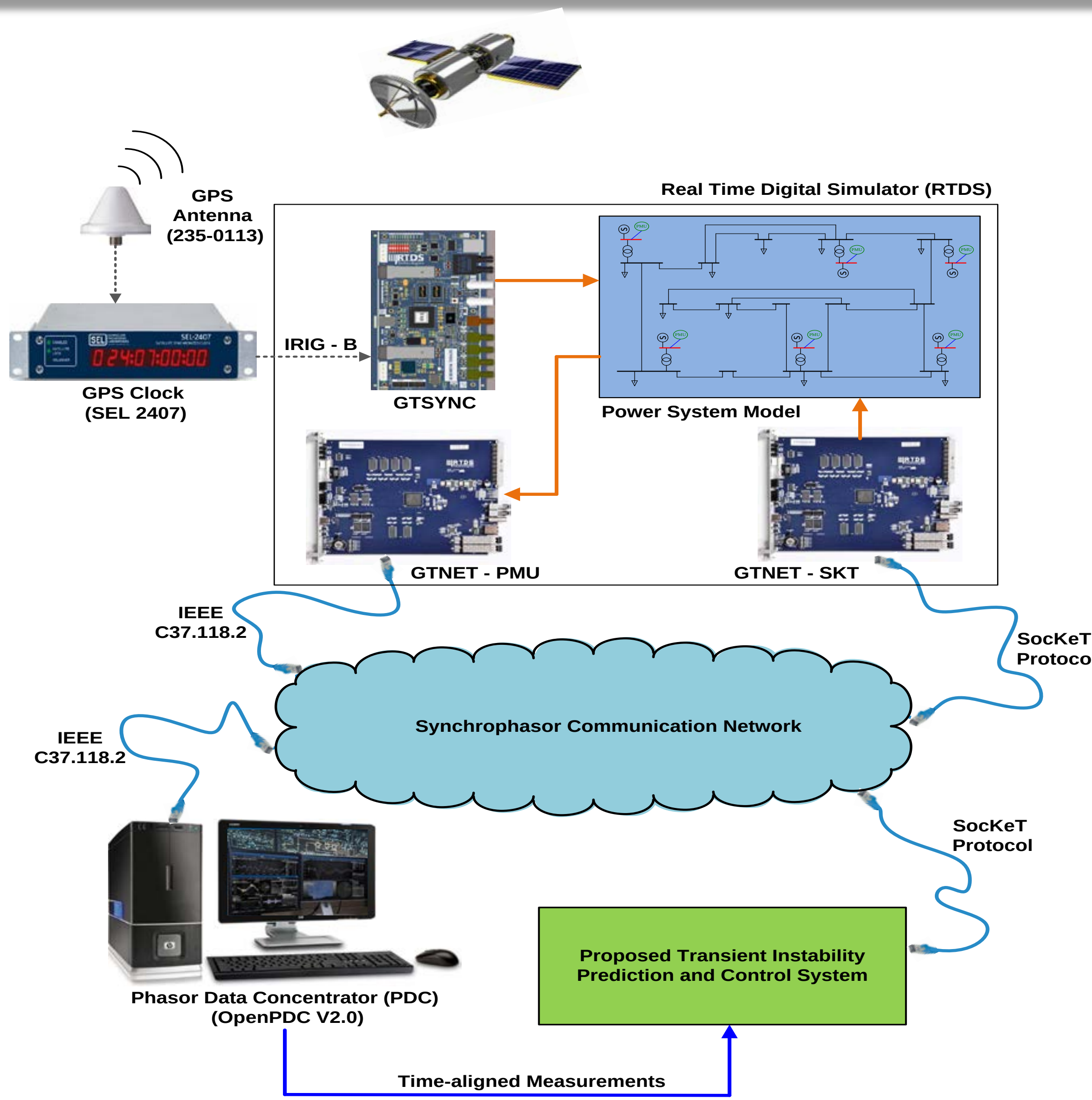


Stability boundary on ROCOV-ΔV plane

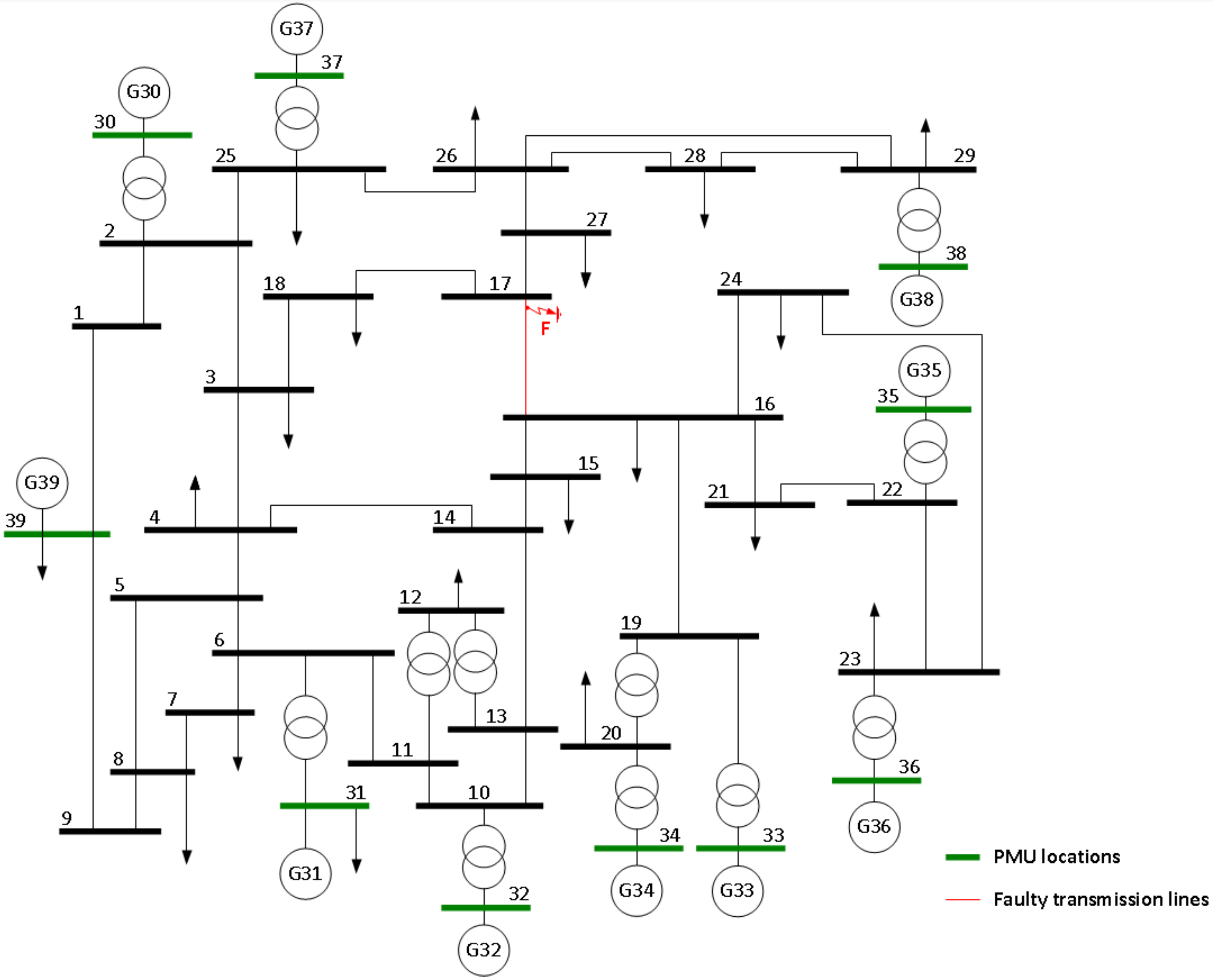
Transient Instability Mitigation Scheme

- The mitigation scheme identifies coherent groups of generators from post-disturbance voltage magnitudes.
- The generators which is becoming unstable first is tripped together with all other generators in the same coherent group.
- A priority based load shedding scheme is activated to trip loads to retain generation-load equilibrium.
- Frequencies at the generator terminals are monitored and the generators violating under/over frequency limits are tripped.

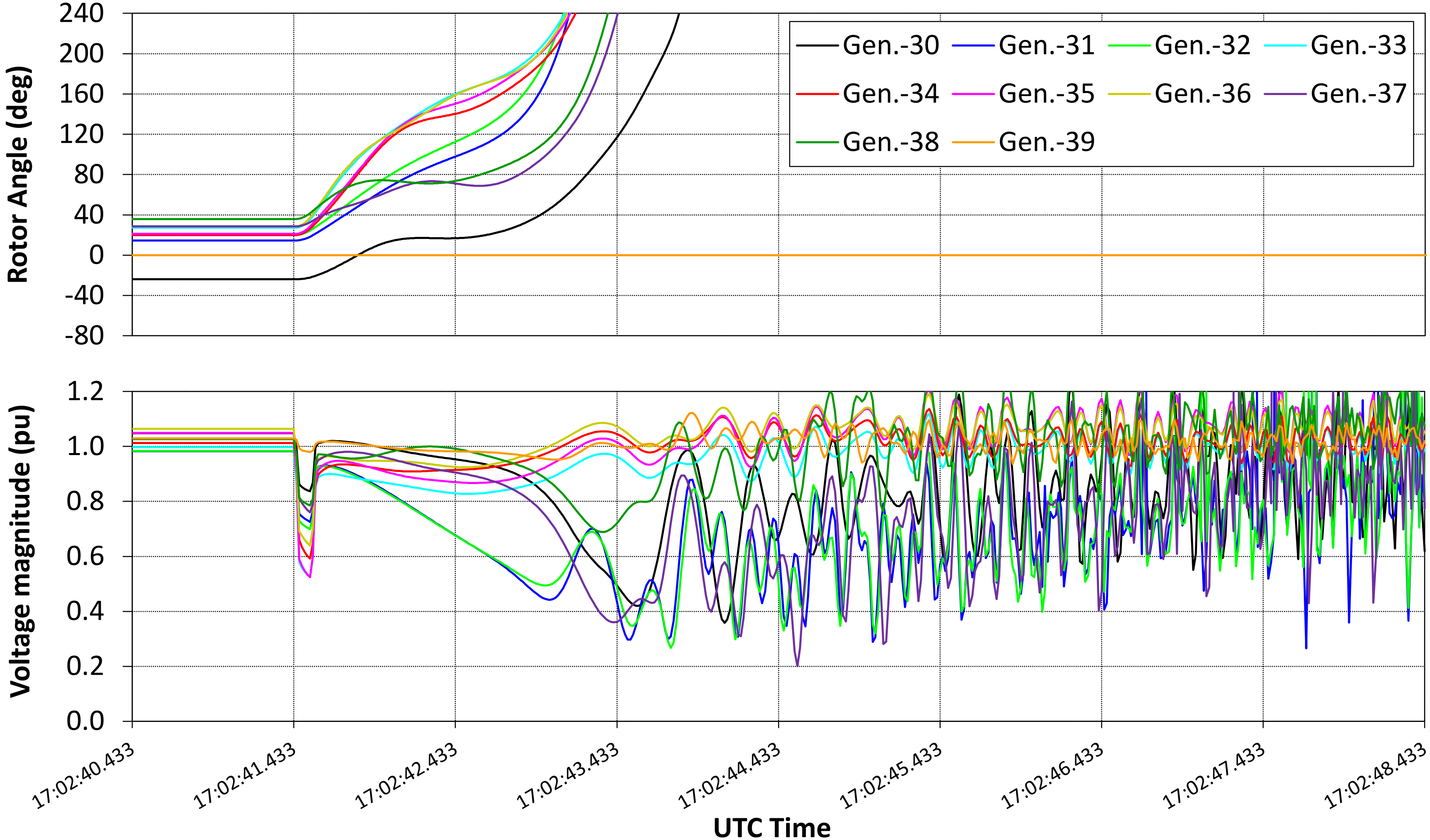
Laboratory-Scale Hardware Setup



Simulation Results : IEEE 39-Bus Test System



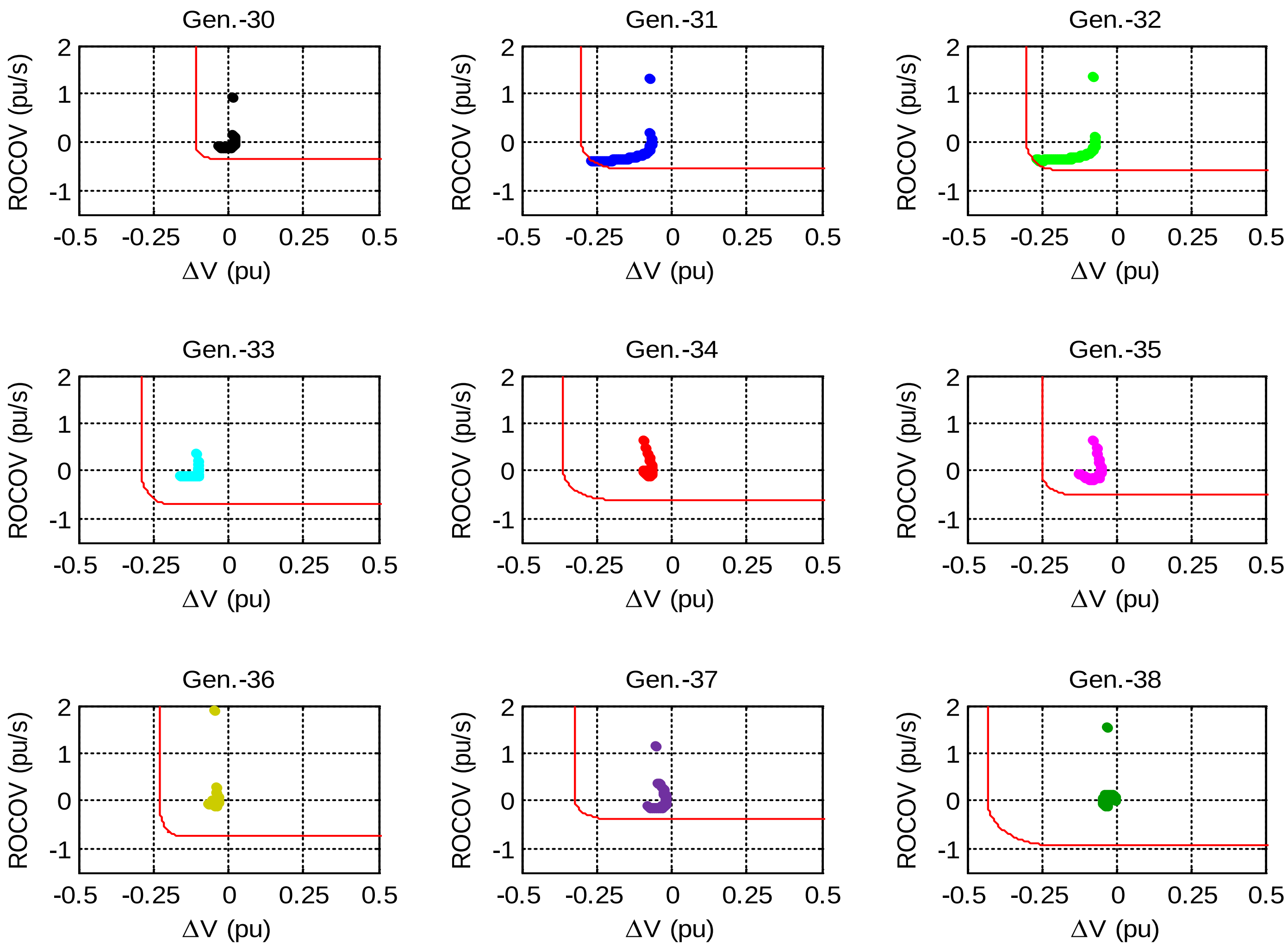
Real Time Simulation Results



Variations of rotor angle and voltage magnitude

Fault on line 16-17 (95% of the length) cleared by removing the line after 6 cycles

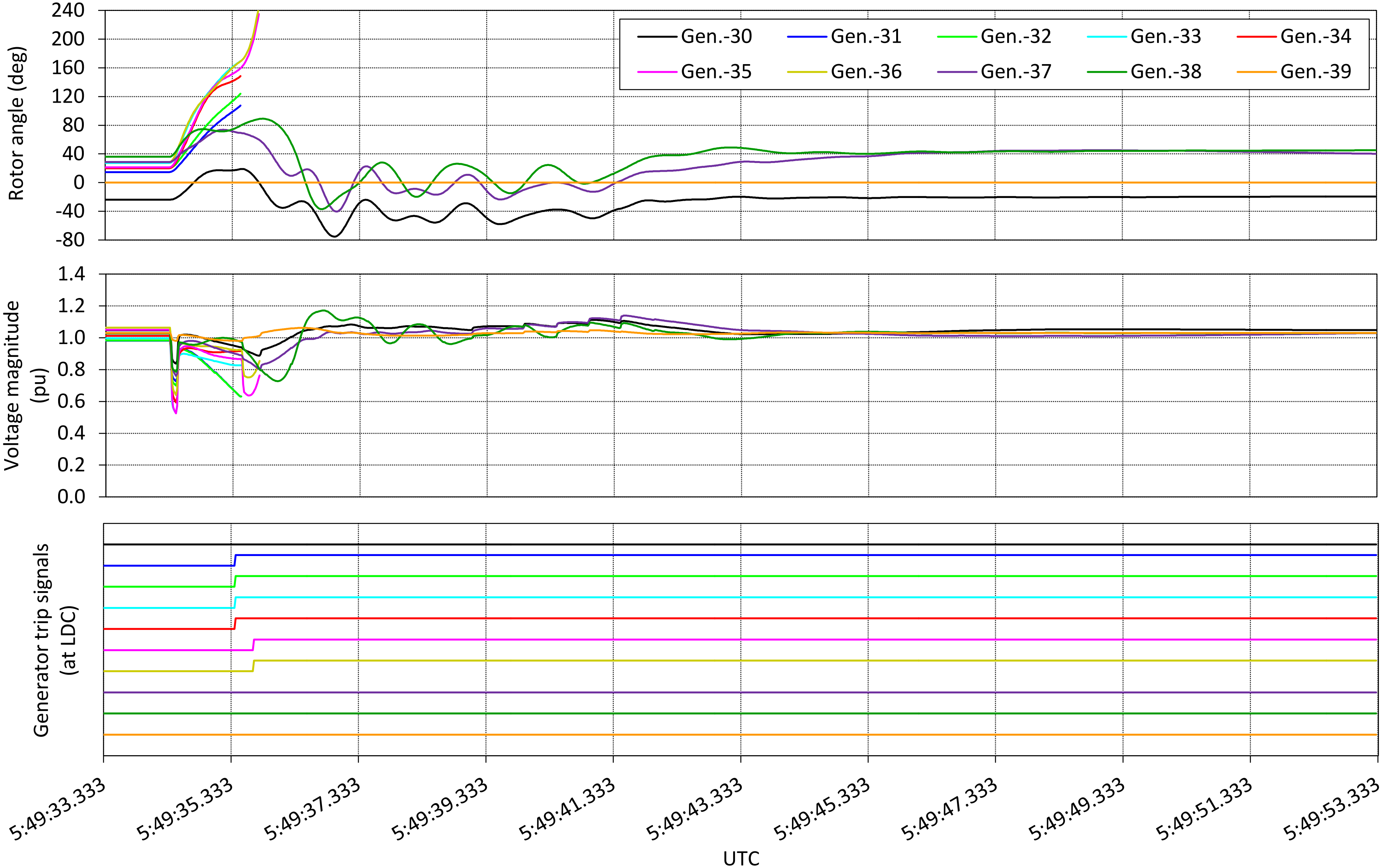
Real Time Simulation Results



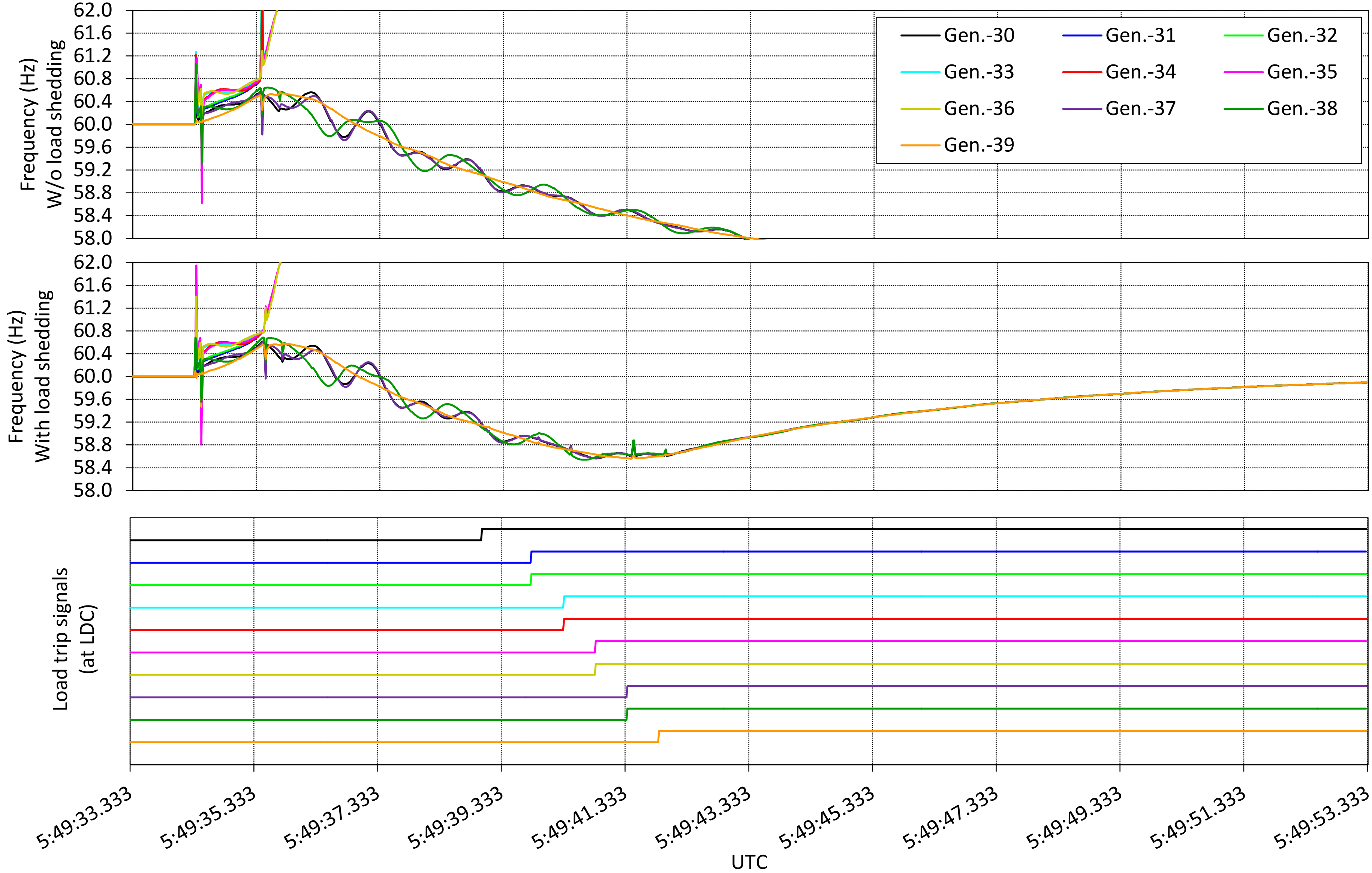
Variations of ROCOV vs. voltage deviation

Fault on line 16-17 (95% of the length) cleared by removing the line after 6 cycles

Real Time Simulation Results



Real Time Simulation Results



Conclusion

- Based on the results of numerous experiments, it can be concluded that using the post-disturbance trajectories of generator terminal buses on ROCOV-ΔV plane, stability status of the system can be determined.
- The proposed prediction algorithm pinpoints the unstable generator, which is very important in determining emergency control actions.
- A generator tripping and load shedding scheme implemented in the RTDS and a laboratory scale communication network demonstrated the effectiveness of the proposed approach.

Thank you