A Software Tool for Real-Time Prediction of Potential Transient Instabilities using Synchrophasors

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Outline

- Introduction
- Transient Stability Status Prediction Algorithm
- PhasorEye Software Tool
- Laboratory-Scale Hardware Setup
- Test Results
- Conclusion
Introduction

- Transient instability: Loss of synchronism of a generator or group of generators after a severe disturbance.
- A very fast phenomenon - Generators can potentially lose the synchronism within a few seconds after the disturbance.
- If transient instability can be recognized in advance, emergency control actions can be initiated to prevent it or minimize its impact.
- Common practice is to provide controls referred as special protection systems (SPSs),
  - Event based control actions designed through offline system studies
  - Could become complicated as the power system expands
- Alternative is the response based emergency control based on synchrophasor measurements.
Preceding work

- Rotor Angle Instability Prediction using Post-Disturbance Voltage Trajectories
  - Fuzzy C-means clustering, template matching & support vector machine classification

- Support Vector Machine-Based Algorithm for Post-Fault Transient Stability Status Prediction using Synchronized Measurements
  - Support vector machine classification

- Post-Disturbance Transient Stability Status Prediction using Synchrophasor Measurements
  - Phase plane of voltage magnitudes
Objective

Implement the recently developed transient stability status prediction algorithm [1], [2] in a real-time software tool (PhasorEye) and validate its performance through hardware in the loop simulations.


One machine to infinite bus (OMIB) system with the initial steady-state power flow solution
Concept of the Proposed Technique

Variations of rotor angle and voltage magnitude following a fault
Concept of the Proposed Method

Plot of ROCOV vs. \( \Delta V \) following a fault

- Stable region
- Unstable region

 ROCOV (pu/s) vs. Voltage deviation, \( \Delta V \) (pu)
Implementation of Algorithm

- **Off-line design**
  1. Identification of contingencies that makes generator marginally unstable through off-line dynamic simulations.
  2. Determination of stability boundary for each generator

- **Real-time operation**
  1. Detection of severe disturbances and triggering the transient stability status prediction algorithm.
  2. Prediction of transient stability status, and trigger emergency control actions

![Diagram](image)
Software Tool

- Developed at the intelligent Power Grid Laboratory of the University of Manitoba, Canada as a tool for testing synchrophasor applications
  - Implement synchrophasor application programs using an output data stream from a PDC
  - Check the availability of real-time data stream, determine the data configuration and connect.
  - Display/plot selected phasors with geographical information.
  - Record an event log, and save data for a specified duration upon triggered by an event specified by the user.
  - Retrieve and plot recorded data
  - Applications: Transient stability monitoring, line parameter estimation, oscillation monitoring
Features of PhasorEye

PhasorEye

Synchrophasor Applications
For Monitoring & Control of Power Systems

Intelligent Power Grid Laboratory
University of Manitoba
Features of PhasorEye Graphic Console

PMU Components Decks:
- Lock Components
- Reset Position
- PMU 2 connect to PMU 7
- Add Connection
- Clear Connection

Station Name: Gen30
ID Code: 1
Phasor 0 Name: PHASOR CH 1v1
Phasor 1 Name: PHASOR CH 2v1
Phasor 2 Name: ANALOG CH 0

Connection Information (Observability Matrix):

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Version 1.5
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PhasorEye Software Tool
Laboratory-Scale Hardware Setup
### Features of PhasorEye Software Tool

#### Log Data

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Laboratory-Scale Hardware Setup

- **GPS Antenna (235-0113)**
- **GPS Clock (SEL-2407)**
- **Real Time Digital Simulator (RTDS)**
- **GPS Clock (SEL-2407)**
- **Phasor Data Concentrator (PDC) (SEL-5073)**
- **IEEE C37.118.2**
- **IEEE C37.118.2**
- **IRIG-B**
- **GTSYNC**
- **Synchrophasor Communication Network**
- **PhasorEye Software Tool**
- **Power System Model**
- **Stability Status**
- **Unstable Generator (s)**
- **Time-aligned Measurements**
Simulation Results: IEEE 39-Bus Test System

Real-Time Simulation Results

Conclusion

IEEE 39-Bus Test System
Simulation Results: Stable Case

Simulation Results:

Stable Case
Simulation Results : Stable Case
Simulation Results: Unstable Case

Real-Time Simulation Results

iPGLSynchro Software Tool

Conclusion

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Simulation Results: Unstable Case
A synchrophasor based transient stability status prediction algorithm was implemented in a standalone software tool.

The effectiveness and practical implementation aspects of the transient stability prediction algorithm was evaluated in a laboratory scale test setup with the RTDS™ simulator.

We hope to present how the transient stability predictions can be used to initiate emergency control actions in a future NASPI meeting.

- Load shedding
- Generator shedding
- HVDC control
Thank you

Q & A