Voltage Security Applications utilizing Synchronized Sampling

Principal Investigator: Prof. G. Huang, Texas A&M University

Background: This proposal is written as an expansion of Task 2A in the description of the project titled *Use of synchronized sampling in substations and system-wide applications* ".

Problem to be solved: Restructuring of the electrical power industry, motivated by the need to induce competition and efficiency, has led to the need for developing viable technical procedures addressing system operation, system security and commercial arrangements all together. The transmission provider assumes the obligation to optimally transfer the power as per the economic agreements except under an emergency situation. There is a need to evolve methods to account for responsibility, amongst the participating power transactions, during an emergency or potential security violation situation. The system operator is responsible for monitoring system operation and ensuring system security and therefore must act whenever security is threatened, and such action must be technically sound and commercially equitable. This proposal takes advantage of the synchronized sampling measurements such as available from IEDs, to facilitate the voltage stability monitoring and its use for transaction curtailment evaluation if needed.

In this proposal, we present a simple procedure to estimate the voltage stability margin and the usage of steady state voltage stability margin by transactions in the deregulated energy markets. This procedure has been developed for the composite market model that consists of both the pool market and several bilateral transactions. The voltage stability indicator used in this method is simple to estimate and can be used for online monitoring of the whole system. In an earlier work, this indicator was used to formulate a voltage stability constrained optimal power flow formulation for reliability studies. Load Curtailment is a disruptive, but sometimes necessary, solution to prevent wide-spread blackout. The estimates proposed in this proposal can lead to methods to allocate curtailment amount, and do it equitably amongst the transactions.

In particular, we take advantage of the synchronized sampling data to avoid unwanted computation burden to estimate the stability margin using a decoupled local equation at the monitoring bus. We also evaluate how a transaction would occupy the available stability margin based on the online synchronized measurement data and simple analysis.

Approach to be used: From real and reactive power load measurements at a voltage controlled bus and synchronized IED measurements (IED time stamped instantaneous phasor data are used to estimate the time stamped steady state quantities such as voltage magnitude and phasor measurements through low pass filters) from neighboring buses, we can calculate the stability margin for the bus. Its trend through loading changes can also be estimated. The voltage stability index for each bus that has reactive power resources will be in a per unit form. The Index having a value of one will indicate a full utilization and further loading may jeopardize the system security. As the load and transactions are increasing, the indices will be increased since its reactive power resource will be consumed.

Task 1: Voltage Stability Monitoring and Stability Margin Estimation

- IED time stamped instantaneous phasor data are used to estimate the time stamped steady state quantities such as voltage magnitude and phasor measurements through low pass filters.
- For a measured loading of the monitored bus and the above synchronized sampling data from neighboring buses, static stability margin for the voltage controlled buses will be calculated and displayed
- Demonstration of its use for stability monitoring in the ERCOT system
- Field data testing on the ERCOT system
- Visual implementation of the margin information

Task 2: Associate transactions with stability margin usages

- For a transaction pattern data and synchronized sampling data from neighboring buses and the local bus, we evaluate transactions and their impacts on the stability margin indices
- Demonstration using examples based on ERCOT data
- Field data testing on the ERCOT system
- Visual implementation of the transaction usages of the margin

Deliverables :

- Detailed voltage stability index and demonstration examples to evaluate voltage stability margin for voltage regulated buses for the ERCOT system
- For a given loading and synchronized sampling data from neighboring buses and the local bus, static stability margin for the voltage controlled buses will be calculated and displayed
- A warning signal will be flashed to warn about potential stability crises as load increases
- The software (initially developed in Matlab) that couples with state estimator for voltage stability monitoring can be part of EMS
- For a given transaction pattern and synchronized sampling data from neighboring buses and the local bus, static stability margin usages of the transactions for the voltage controlled buses will be calculated and displayed
- The software (initially developed in Matlab) that couples with state estimators to demonstrate transaction flow patterns and stability margin usages can be part of EMS.

Expected benefits to ERCOT:

- Monitoring voltage stability margin using IED measurement and calculations to give warnings for potential security weakness. The warning data can also be used for reactive power resource installation planning for voltage security.
- Better understanding on how transactions impact the stability margin
- The monitoring tools will provide a foundation for potential transaction curtailment tools to enhance voltage stability during transactions

Budget: Two PhD students support and 1-month salary support of the PI. Some support for travel between College Station and ERCOT is included. Estimated cost is $93,000.