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Solutions for Smart Transmission Panel

Future of Power System Protection

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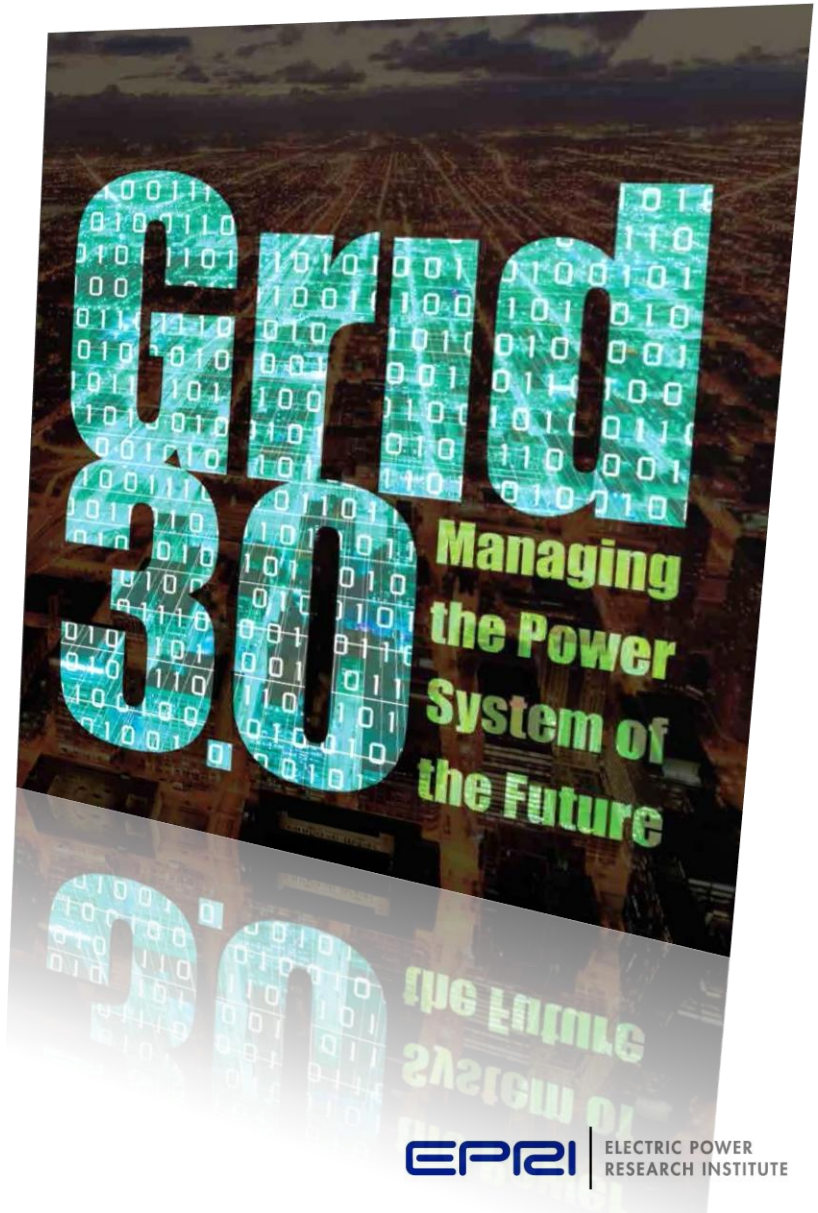

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Background and Motivation

- Protection Settings Has Become a Very Complex Process
  - Human Error
  - Unable to coordinate due to conflicting factors
- Resources with Power Electronic Interfaces Exhibit Fault Currents Comparable to Load Currents (Fault Current Disparity).

Background and Motivation

- Detection and Locating of Faults is Problematic in a Few Cases (Protection Gaps).
  - Faults Near Neutrals of Generators/Transformers, Faults in SC Lines
  - High Impedance Faults / Down Conductors
  - Load Encroachment, etc.
- Faulty Sensors result in False Decisions (lack of systematic error correction and hidden failure detection)
- Model Errors Play a Major Role in many Control Failures as well as Blackouts

Long Term Objective / Vision

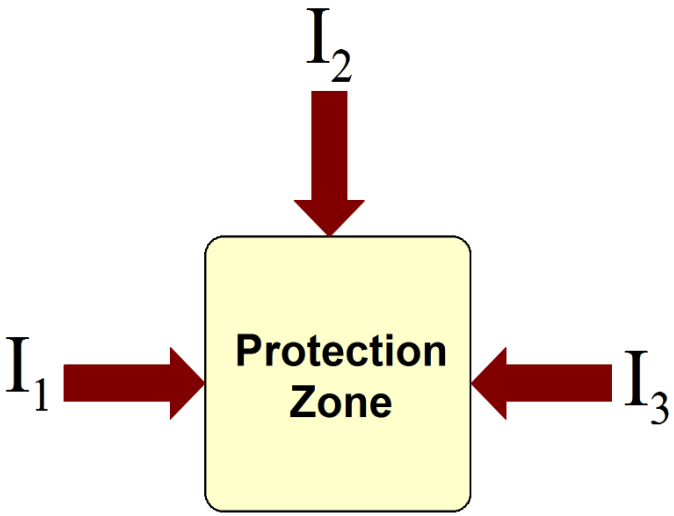
- Develop a New Approach and Method for Protection Based on Dynamic State Estimation
  - simplifies protection (setting-less protection)
  - validated and high fidelity dynamic model of protection zone
- Make the Setting-less Relay the “GateKeeper” of Device Dynamic Models. Relays are Ubiquitous → 100% Coverage of System Model

Long Term Objective / Vision

- Setting-less Protective Relay Transmits the Validated Model UpStream (substation, control center, enterprise, etc.): Models are available with minimum latencies: → Use Models for various Applications (as needed) in a Process that is Free of Human Error
- The Approach Presently Forms the Core Research Activities of EPRI's Grid Transformation Program.

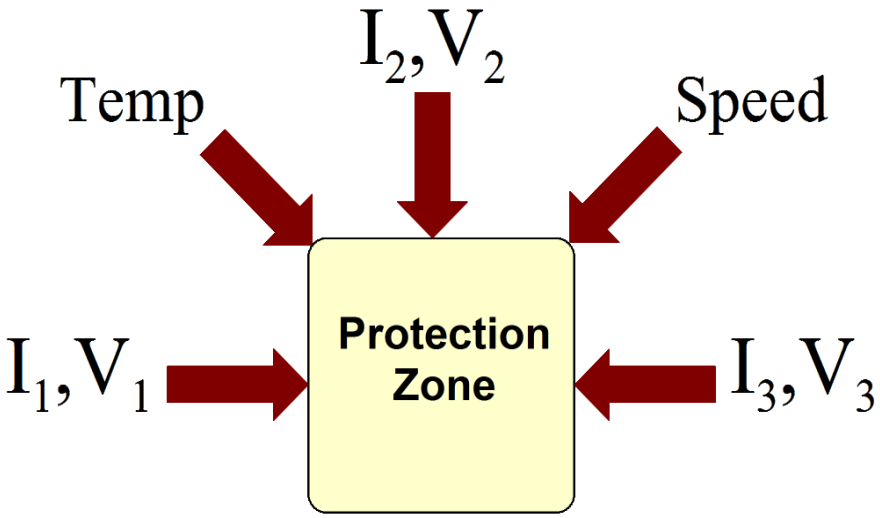
In Search of Secure Protection

Setting-less Protection can be viewed as Generalized Differential protection



Differential Protection

(Monitors KCL Only)



Setting-less Protection

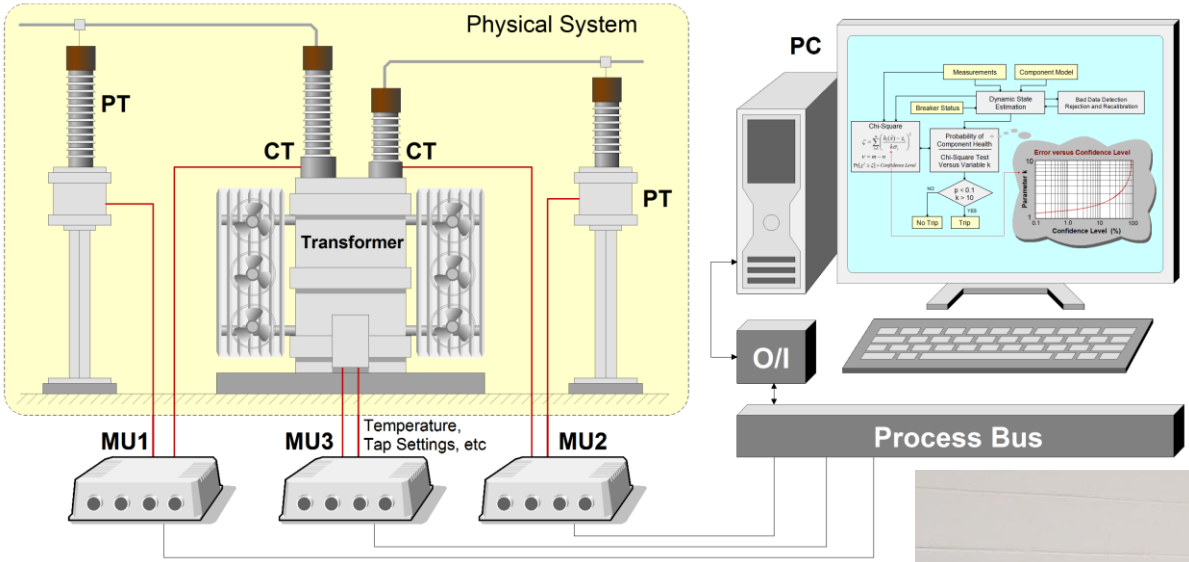
Monitors All Laws Applied to the Device
(KCL, KVL, Thermal Mechanical,
i.e. Complete Device Model)

Analytics: Dynamic State Estimation (systematic way to determine observance of physical laws)

The Zone Setting-less Protection Approach

- Measure/Monitor as Many Quantities as Possible and Use Dynamic State Estimation to Continuously Monitor the State (Condition, Health) of the Zone (Component) Under Protection. Identify bad data, model changes, etc.
- Act on the Basis of the Zone (Component) State (Condition, Component Health).
- Advantage: No need to know what is happening in the rest of the system – no coordination needed.

Laboratory Implementation



Experimental Setup

Block Diagram

Experimental Setup

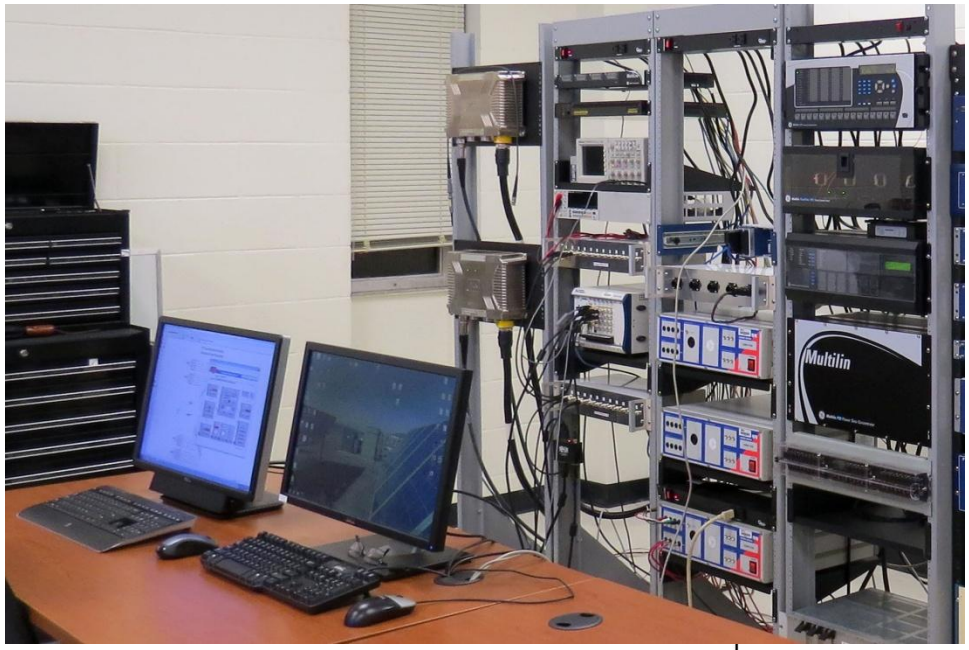
PC with D/A Hardware

Omicron Amplifiers (3)

GE Hardfiber (2)

PCIe Cards (2)

Protection PC (1)



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Recent Report

Program on Technology Innovation:

Setting-less Protection Methods for Grid Transformation

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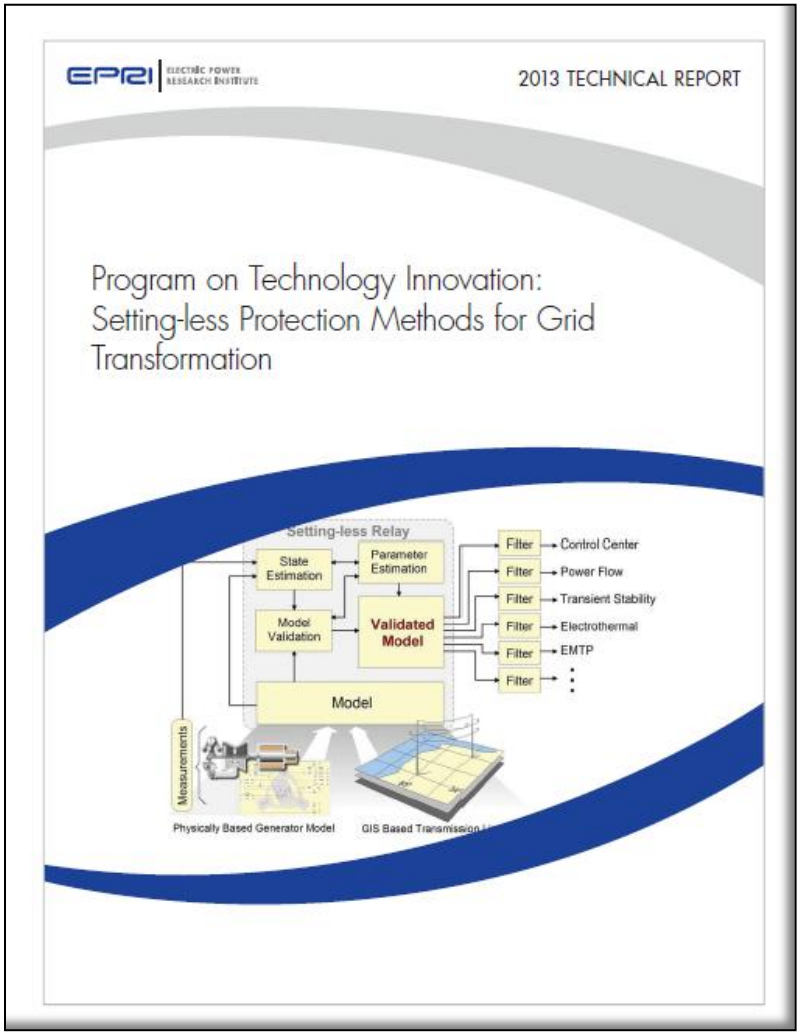

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