A New Subsynchronous Oscillation (SSO) Relay For Renewable Generation And Series Compensated Transmission Systems

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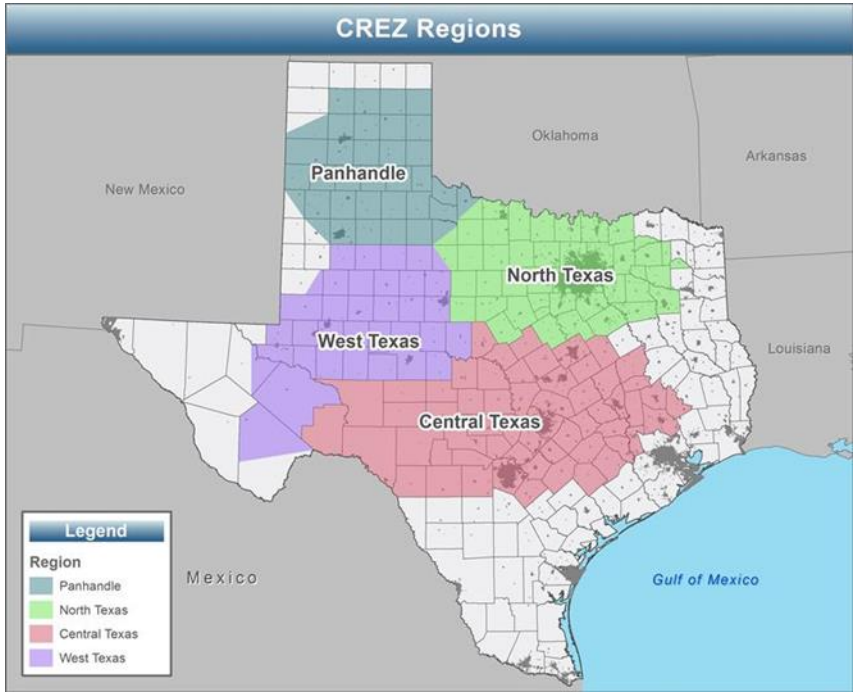
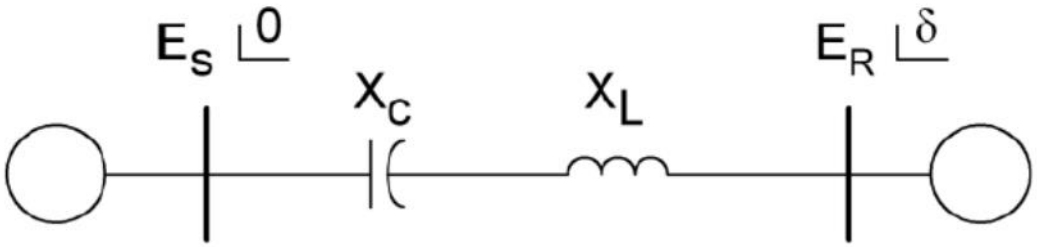
American Electric Power(AEP)

Texas Competitive Renewable Energy Zones (CREZ)

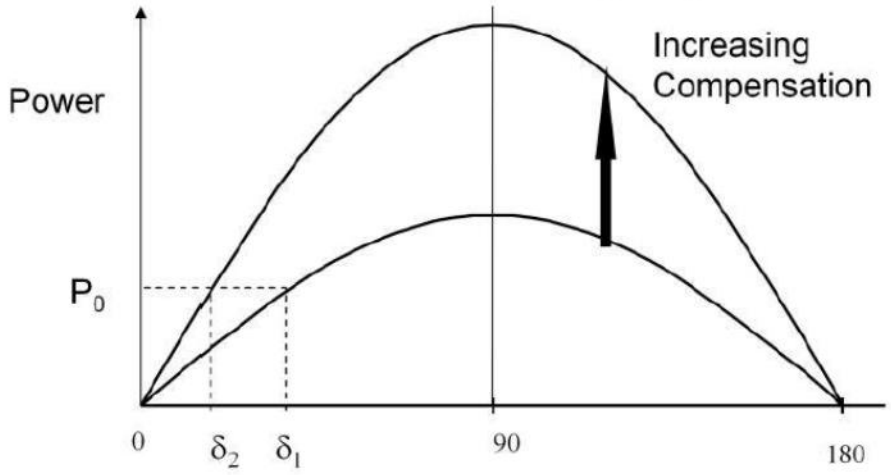
- **Public Utility Commission(PUC) of Texas issued order 33672 designating five CREZs for wind power generation**
- **Transmit 18,456 (MW) of wind power from West Texas and Panhandle**
- **With total capital investment over 9 billion $**



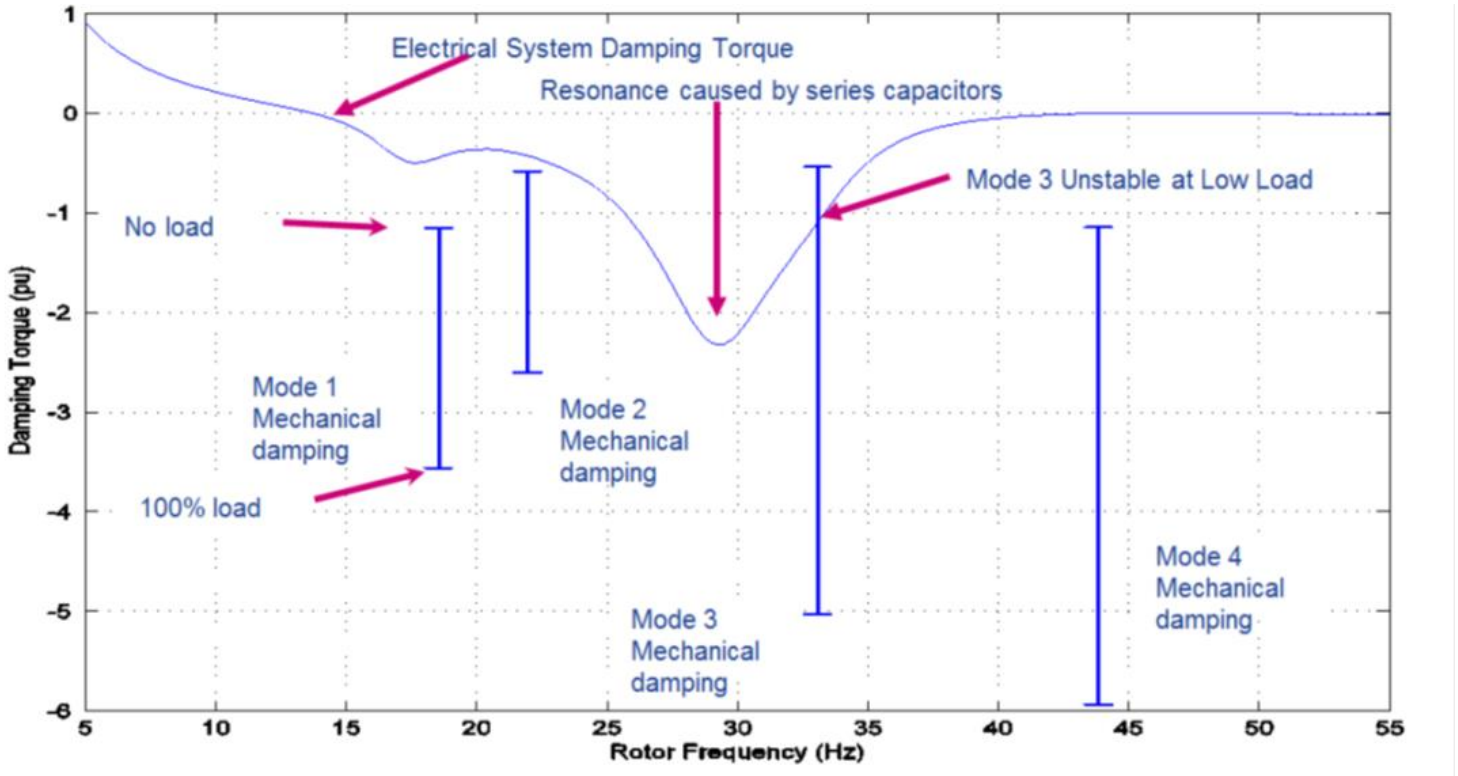
Series Compensated Transmission Line Increase Power Transfer



$$\text{Power Transfer} = \frac{E_S E_R}{X_L - X_C} \sin \delta$$

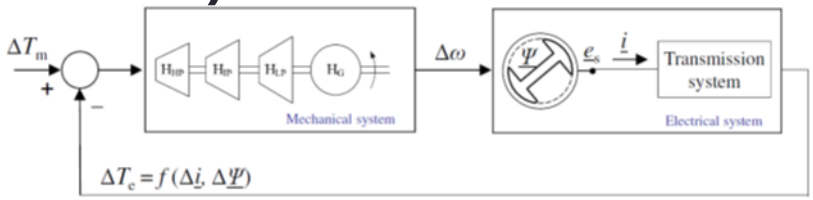


Power System Resonant Frequencies with Series Capacitor Banks



Sub-Synchronous Oscillation (SSO)

- **Sub-Synchronous Resonance (SSR)**
  - **Synchronous generator shaft torsional modes in the same frequency range as the sub-synchronous modes of the network (1970 Mohave generator station)**

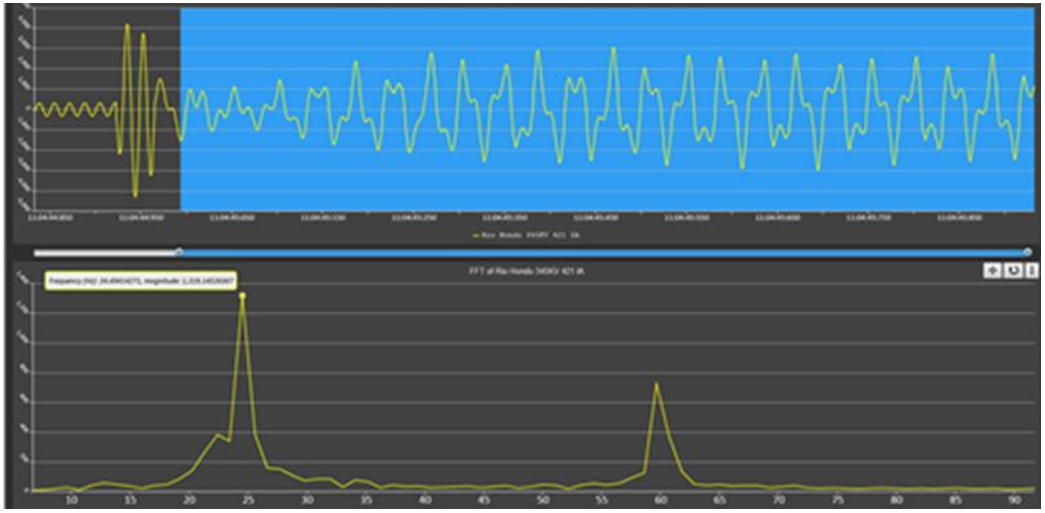


- **Sub-Synchronous Control Instability (SSCI)**
  - **Interaction of power electronics control systems (wind farm, SVC, FACTS, HVDC) with sub-synchronous modes of the network (2009 Texas)**

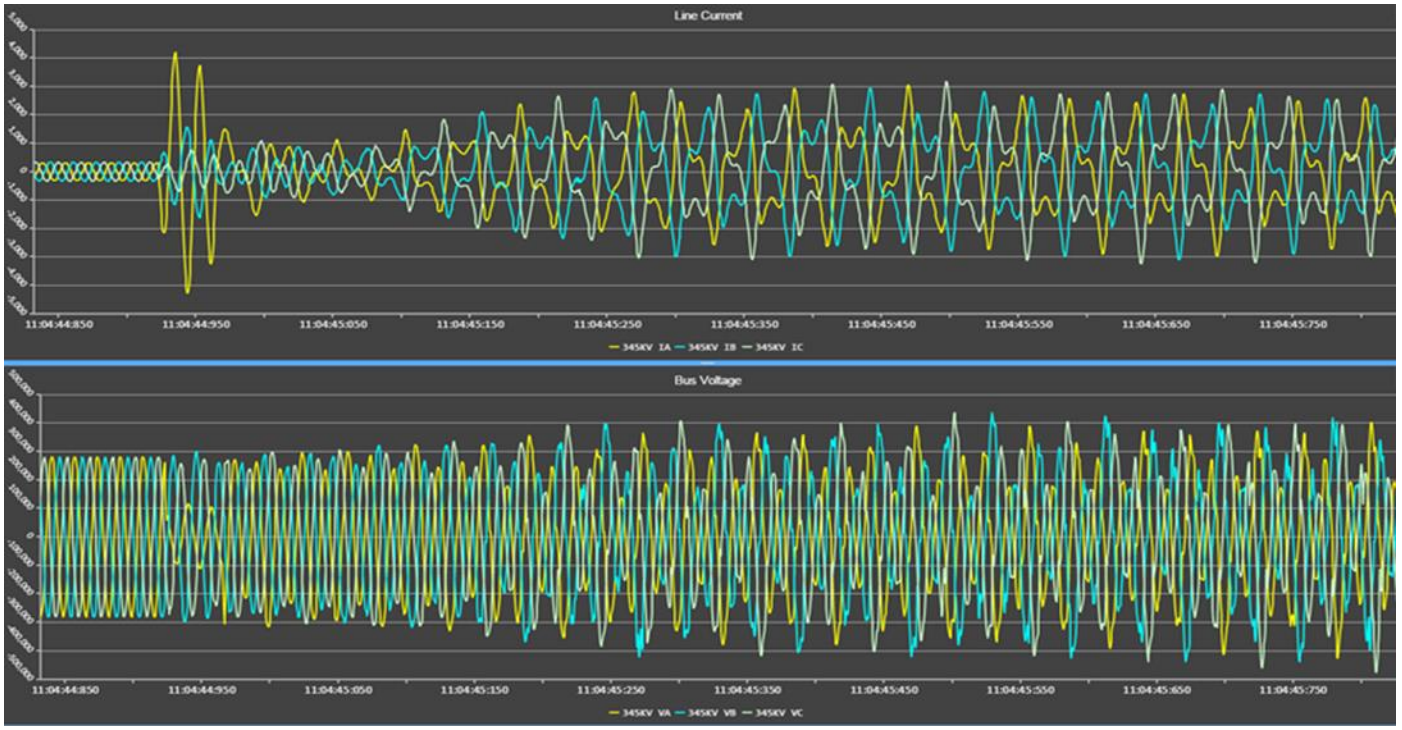
Wind Generation with Series Compensated Lines Prone to SSCI



Sub-Synchronous Control Interaction (SSCI)



Power System Currents and Voltages Under SSCI Conditions



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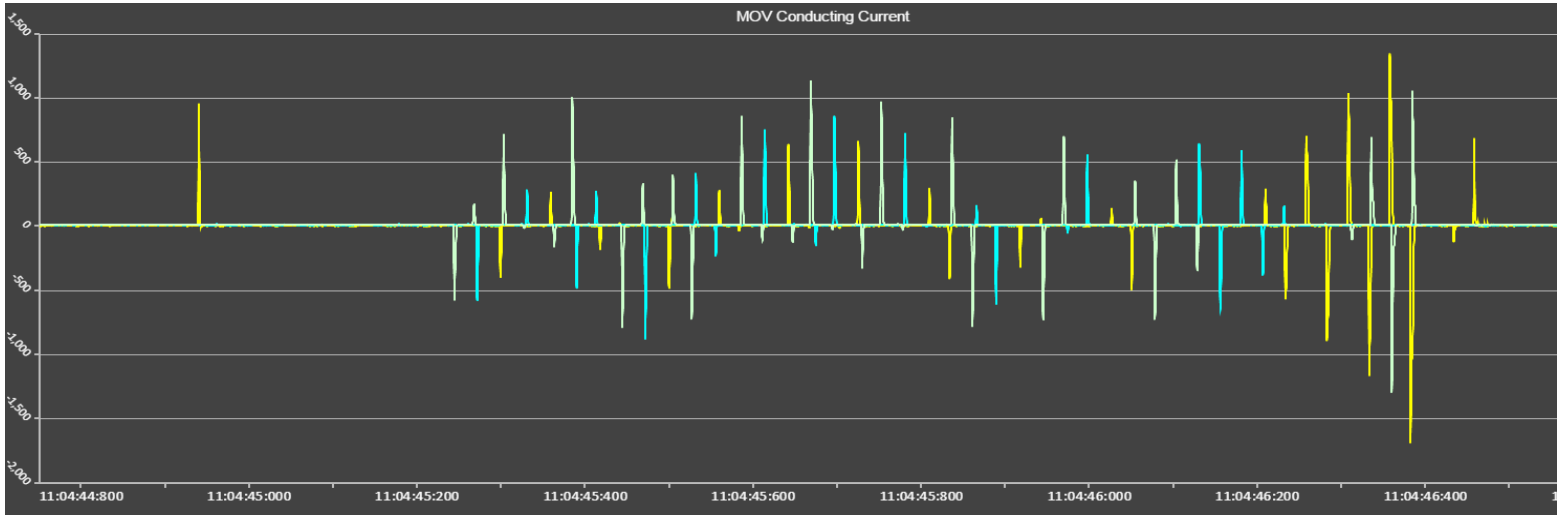
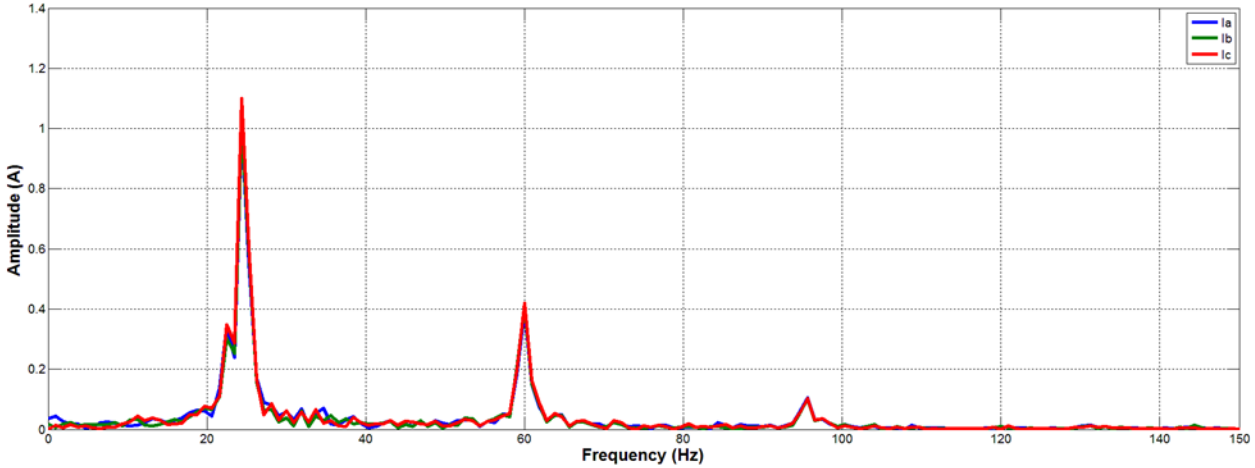
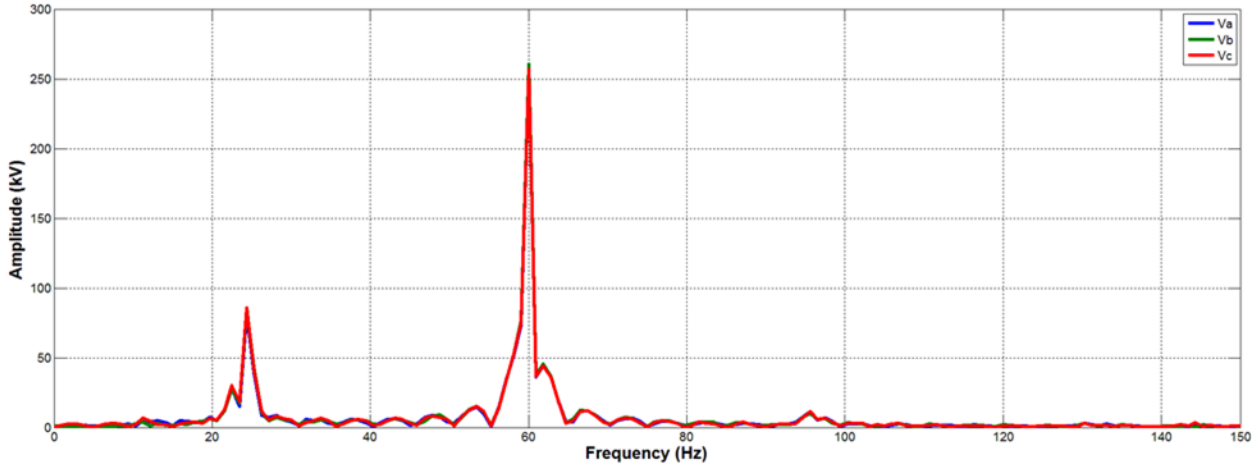
MOV Conducting Under SSCI Conditions



Spectrum Analysis of Currents and Voltages

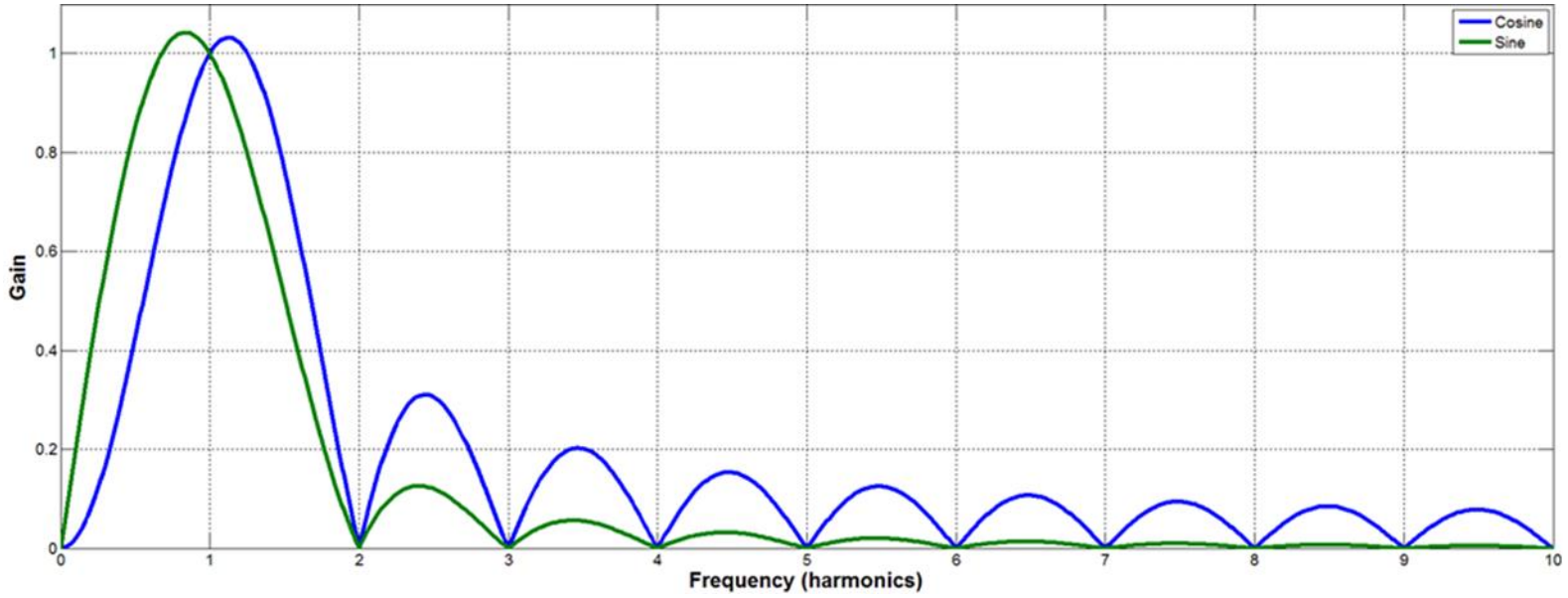


Currents

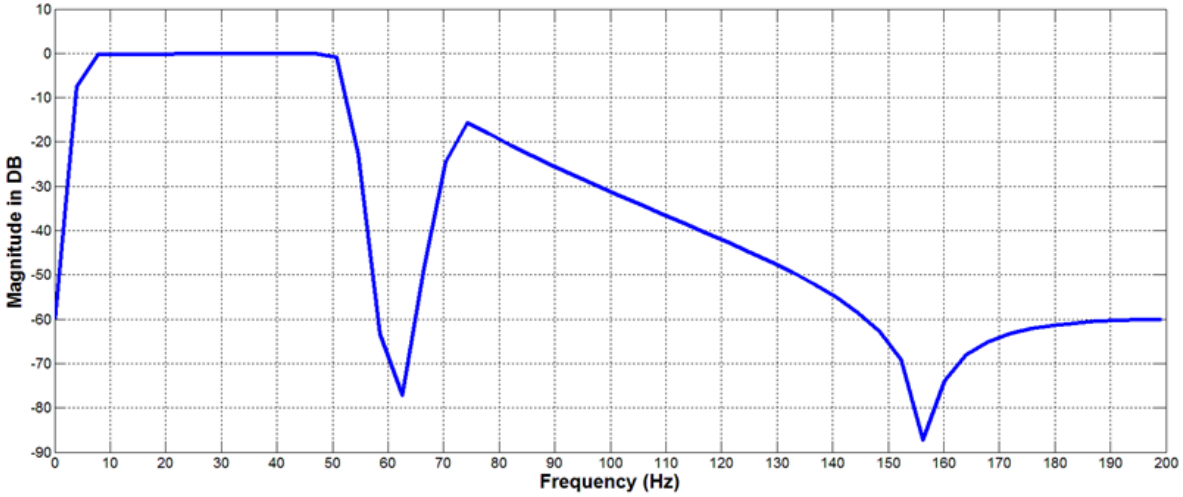


Voltages

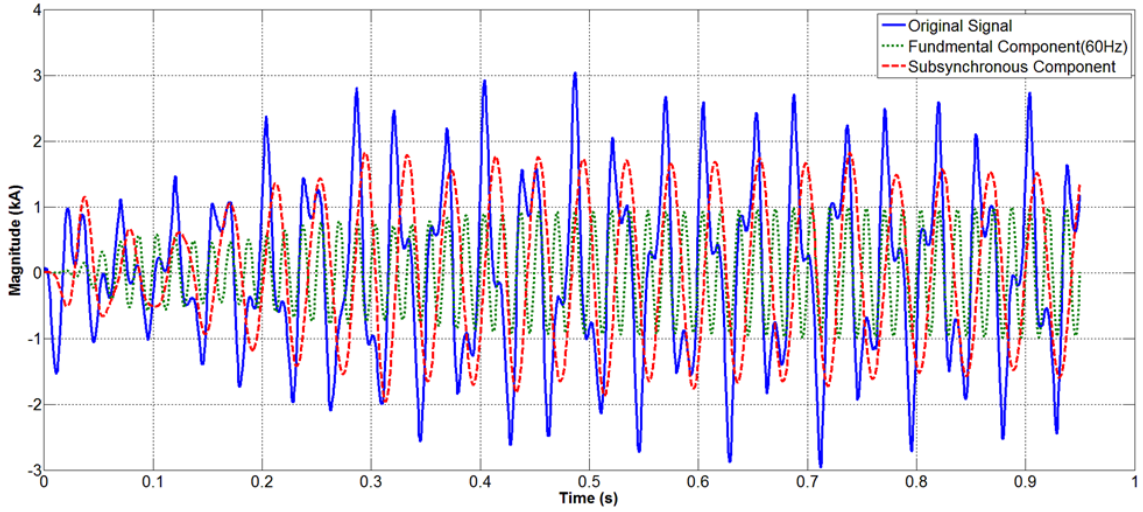
Traditional Protective Relay Signal Processing Targeting 60Hz Signal



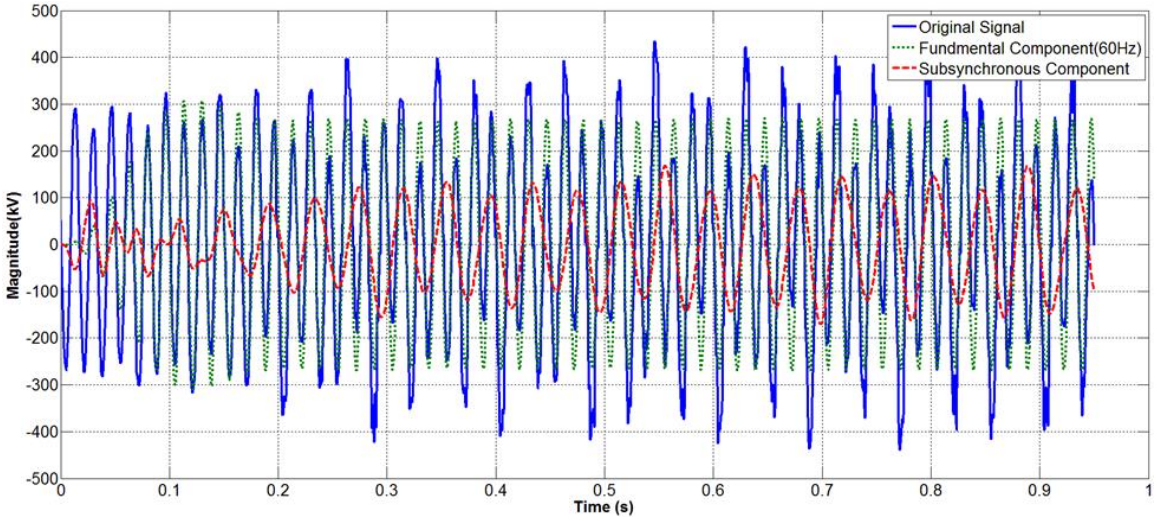
SSO Relay Signal Processing Targeting Subsynchronous Component



Special Filter Effectively Extract Subsynchronous Component

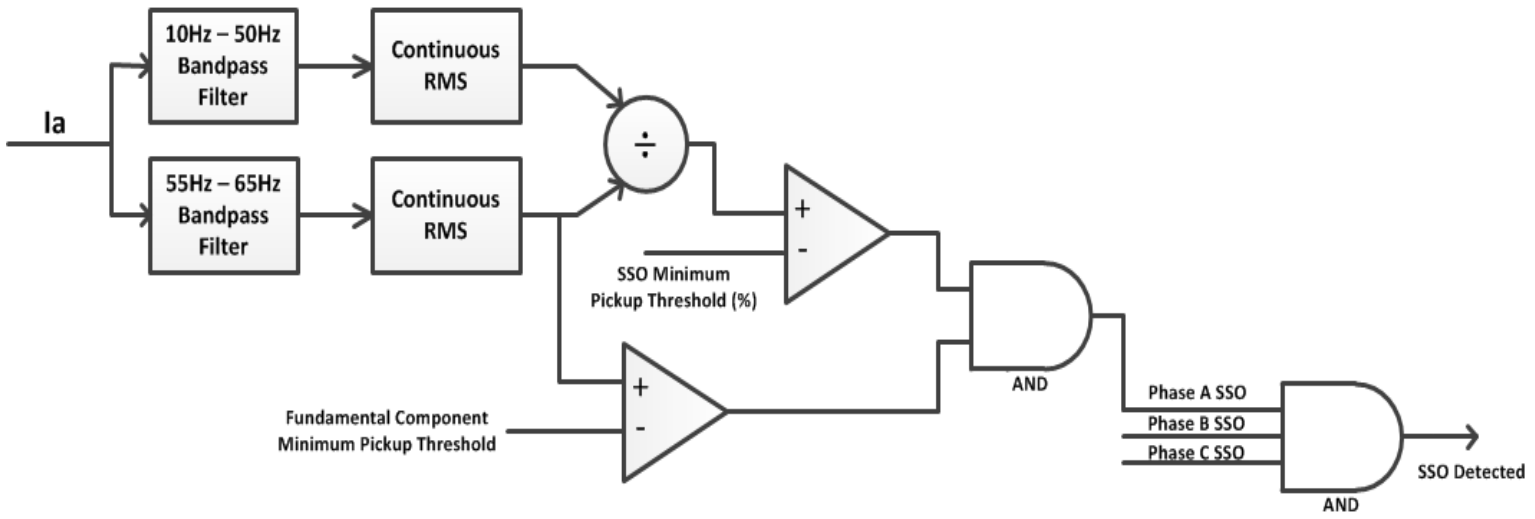


Currents

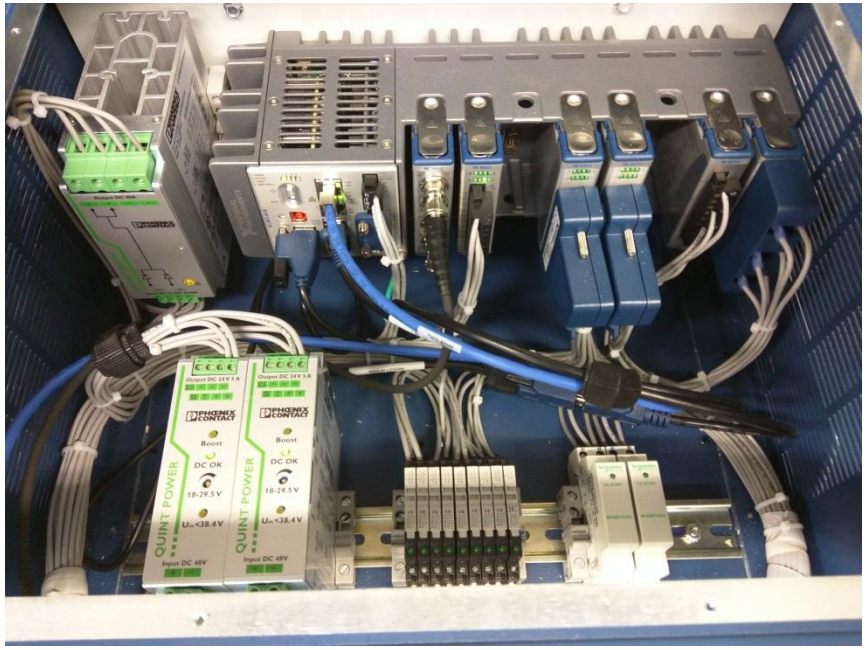


Voltages

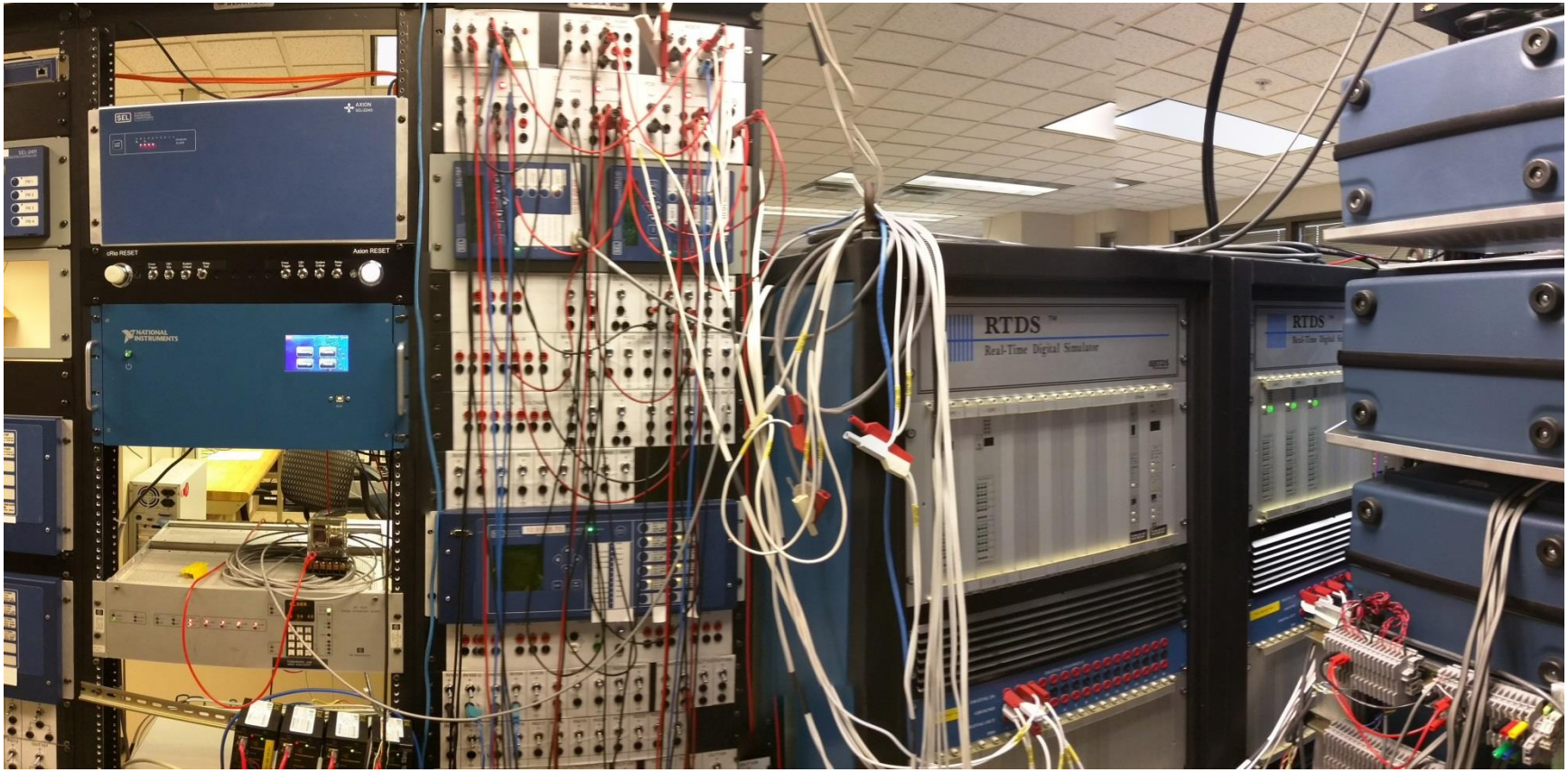
Protection Logic with Reliability and Security



SSO Relay Hardware Platform



Hardware-In-The-Loop Test of SSO Relay



SSO Deployment

- **First unit was commissioned at October 8th at Matador substation in Texas**

SSO Deployment Guidance

- **All generation point of interconnection (POI) if generator has an SSO issue for any contingency between N-1 and N-6**
- **All wind and solar facilities at the POI if there is a short circuit ratio issues. This will be based on the wind turbine or solar converter data from the manufacturer**
- **All HVDC, STATCOM, and SVC locations if the studies determined that there is an SSO issue**
- **Series capacitor banks if SSO issues have been found for any generator that is impacted by the series capacitor banks**

Thank You