



ERCOT SSR Workshop

March 13, 2015

ERCOT System Planning

Outline

- SSR Updates
- Definition and Scope: SSO/SSR
- Study Methodology and Criteria for SSR
 - SSR Screening
 - Frequency Scan
 - Proposal to Review Screening and Frequency Scan Results
- SSR Process
 - Existing Generation Resources
 - New Generation Projects
 - New Transmission Projects
 - Annual Review
- EMS SSR Alarm System
- Next Step

SSR Updates

- Revise the SSO/SSR definition and scope:
 - Focus on SSR between generation and series capacitors
 - Include torque amplification in the SSR scope
 - Revise SSR screening and frequency scan scope, criteria, and data needs
- Draft a plan to revise the SSR screening and frequency scan criteria
- Develop SSR processes for new generation, new transmission, and annual review

Discussion: SSO/SSR Definition

- Subsynchronous Oscillation (SSO) [NPRR 562]
 - Coincident oscillation occurring between two or more Transmission Elements or Generation Resources at a natural harmonic frequency lower than the normal operating frequency of the ERCOT System (60 Hz).
- Subsynchronous Resonance (SSR) [to add in NPRR562]
 - Coincident oscillation occurring **between Generation Resources and a series capacitor compensated transmission system** at a natural harmonic frequency lower than the normal operating frequency of the ERCOT System (60 Hz).
 - NPRR 562 focuses on series capacitor related issues

SSR Scope

	Synchronous Generator	Wind/Solar
Subsynchronous Resonance (SSR)	Induction Generation Effect (IGE)	(IGE) / Subsynchronous Control Interaction (SSCI)
	Torsional Interaction (TI)	
	Torque Amplification (TA)	

Torsional Interaction (TI)

The torsional interaction between series capacitors and turbine-generators.

Induction Generator Effects (IGE)

The electrical interaction between Generation Resources and series capacitors.

Torque Amplification (TA)

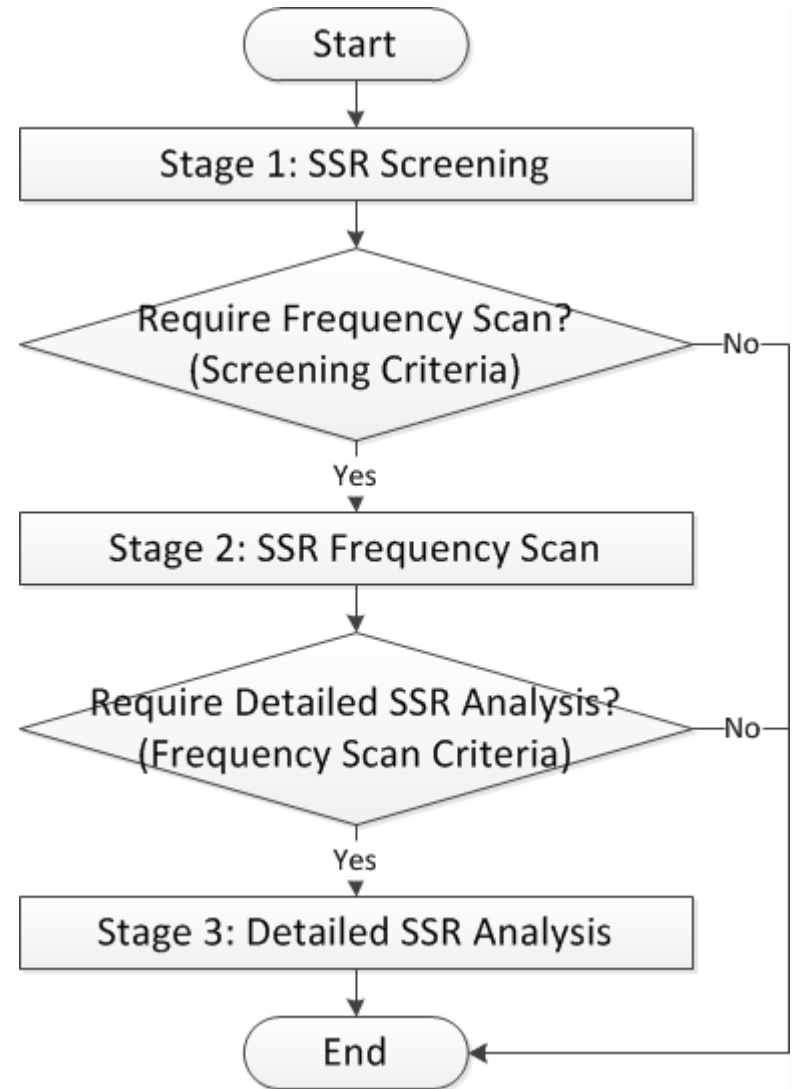
The interaction between Generation Resources and series capacitors can result in high torques during/post-fault.

Subsynchronous Control Interaction (SSCI)

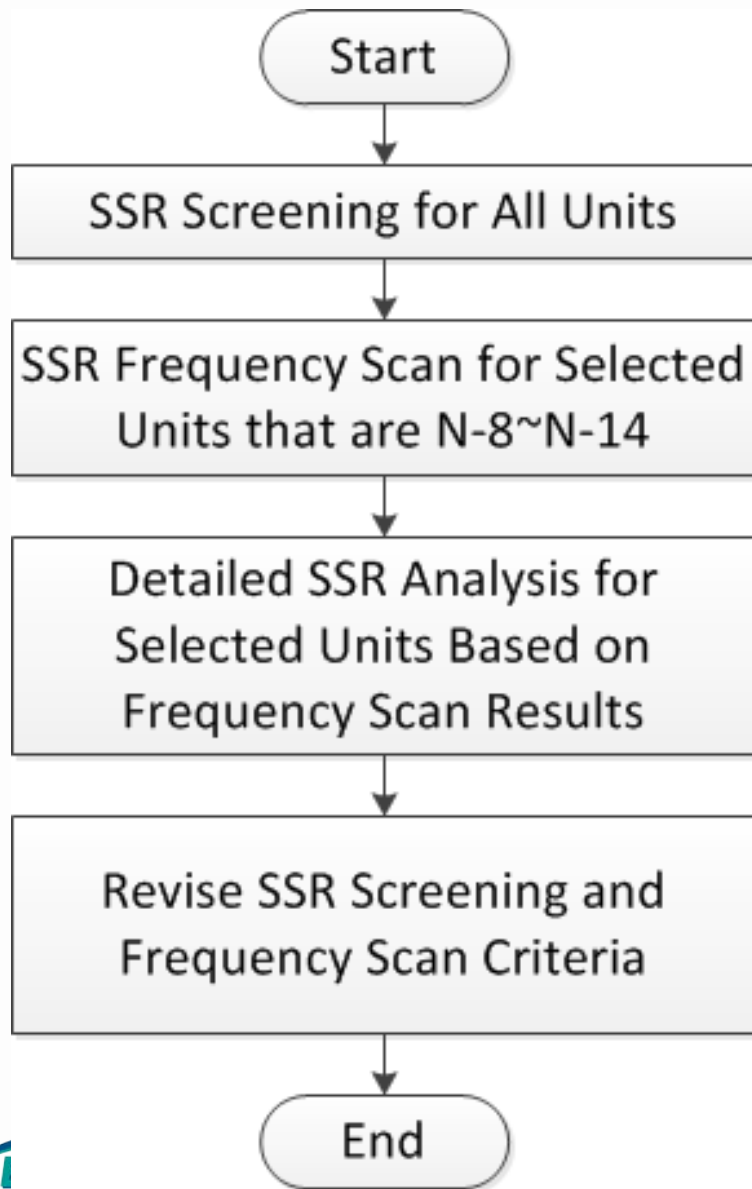
The interaction between series capacitors and generator's control devices.

SSR Study

- Screening
 - To exclude the units that have low or no risk of SSR
- Frequency Scan
 - To identify the units that may be vulnerable to SSR
- Detailed SSR Analysis
 - To identify the SSR risk and develop SSR measures (mitigation, protection, or outage coordination) if needed.



Review Screening and Frequency Scan Criteria



- Screening: 3/15/2015
- Frequency Scan: 5/31/2015
(if generator model and data are available, subject to be revised)
- Detailed Analysis: estimated 4th quarter of 2015

Stage 1: SSR Screening and Criteria

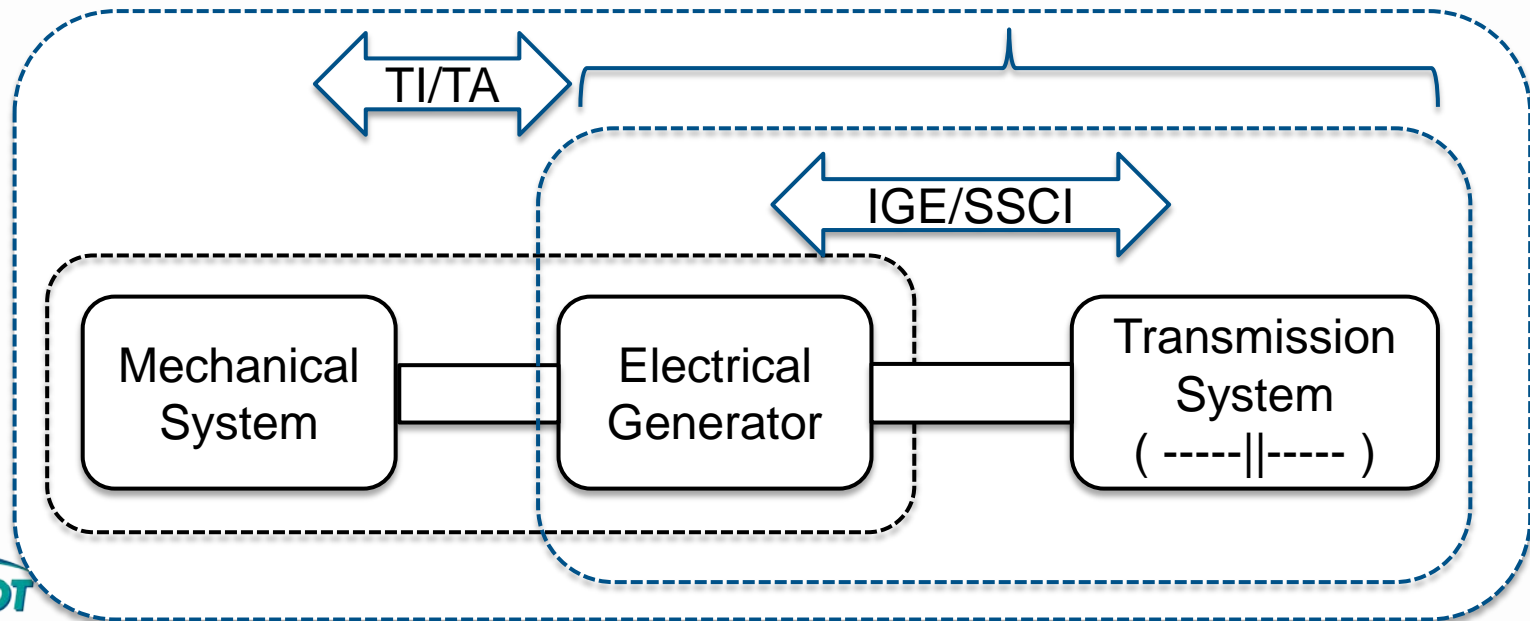
	# of circuit outages (N-x)*	
	$x > 8 \sim 14^{**}$	$x \leq 8 \sim 14$
Reliability Risk	Low	Vulnerable
Frequency Scan	No	Yes
Comment	Interconnecting Entity should evaluate mitigation/protection options if concerned.	Require further SSR analysis

* Number of outages to be radial connected to series capacitors.

**ERCOT in consultation with TSPs may revise the screening criterion.

Stage 2: Frequency Scan Scope

	Synchronous Generator	Wind/Solar
Subsynchronous Resonance (SSR)	Induction Generation Effect (IGE)	(IGE) /
	Torsional Interaction (TI)	Subsynchronous Control
	Torque Amplification (TA)	Interaction (SSCI)



Stage 2: Frequency Scan Criteria

Scope	Frequency Scan Criteria under N-6 or less*	Frequency Range
IGE/SSCI	Positive resistance at reactance crossover frequency (Generator + System)	10 ~ 50 Hz
TI	Positive Total Damping (Electrical + Mechanical)	10 ~ 50 Hz
TA	Less than 5% reactance dip within +/- 3Hz of the 60 Hz complement of a modal frequency. **	10 ~ 50 Hz

*ERCOT in consultation with TSPs may revise the SSR frequency scan criteria.

** M. El-Marsafawy, "Use of frequency-scan techniques for subsynchronous resonance analysis of a practical series capacitor compensated AC network", Proceedings of IEE Generation, Transmission and Distribution conference, vol. 130, no. 1, pp. 28-40, 1983.

Stage 2: Frequency Scan Data Requirement

- Transmission System:
 - System Topology
- Electrical Generator:
 - Synchronous Gen: dynamic model and data (used in the stability study)
 - Wind/Solar: frequency dependent impedance table (through PSCAD analysis or provided by developers/manufactures)
 - Number of turbines/converters, output dispatch, voltage control settings
- Mechanical Generator:
 - Synchronous Gen: mass, spring, damping constant of the mechanic system

Stage 2: Frequency Scan Assumption

- Power system topology: frequency dependent transmission elements in the system
 - Transmission Line, Series Capacitor, Transformer, Shunt
- Neighboring Generator:
 - Turning Off: in general, this provides a reasonable variation for SSR frequency results.
 - May include the nearby generators if
 - they are electrically close to the study gen under tested contingency
 - their frequency modes match the study generator

Proposed SSR Process

- Existing Generation Resources
- New Generation Project: GINR
- New Transmission Project: RPG
- Annual SSR Review

Existing Generation Resources

- Assess all existing Generation Resources after SSR Screening and Frequency Scan criteria are finalized
- Notification Process:
 - Screening Results
 - Frequency Scan Results
 - Detail Analysis Results

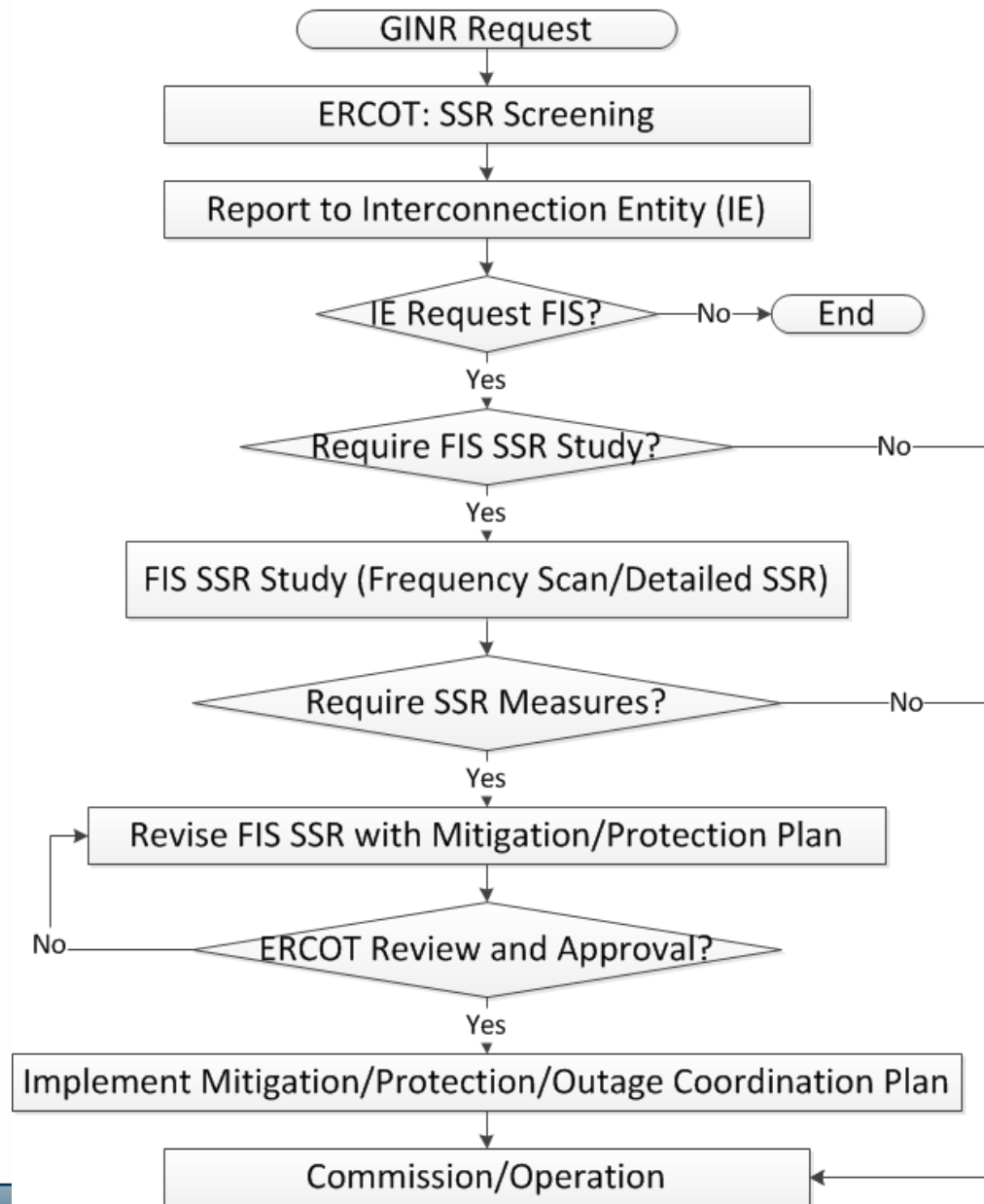
SSR Process: New Gen

- SSR Study Stages and Responsible Entity:

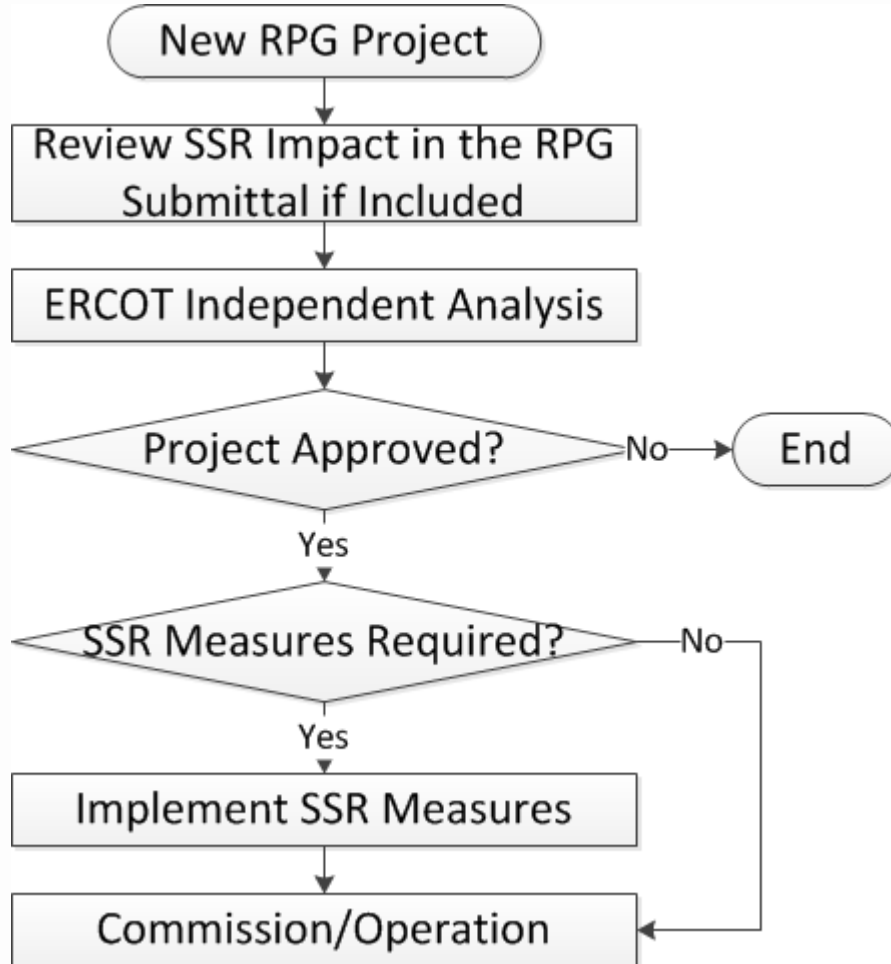
SSR Study Stages		Responsible Entity
1.	Screening	ERCOT
2.	Frequency Scan	TSP
3.	Detailed SSR Analysis	TSP

- Discussion:
 - SSR study, if required, shall be included in the FIS scope.
 - Generator's dynamic and mechanical data may not be available in the screening study stage.
 - Multiple TSPs may be involved in the SSR analysis.

SSR Process: New Generation

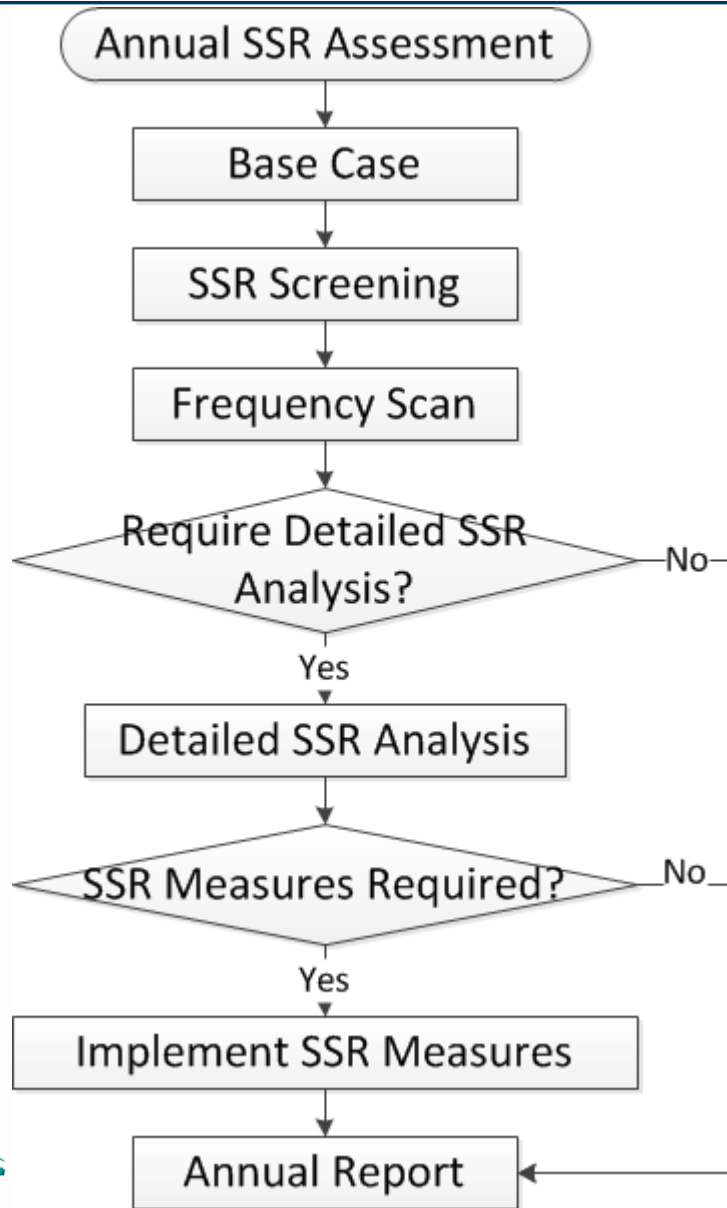


SSR Process: New Transmission



- SSR assessment may be included in the RPG submittal
- ERCOT will include SSR assessment in the independent analysis if needed

SSR Process: Annual Assessment



- Discussion:
 - Need to develop a process to request generator's dynamic and mechanical data
 - Through RARF
 - Usage and limitation of the generator's dynamic and mechanical data

Discussion – SSR Measures

	Potential Risk	Action
(a)	3 or fewer concurrent Transmission Outages	Protection and Structural Mitigation
(b)	4 or fewer concurrent Transmission Outages	Protection
(c)	5, 6 concurrent Transmission Outages	Procedural Mitigation

- Panhandle SSR Risk:
 - A significant amount of generation may be disconnected from the Panhandle under the condition of the loss of two double circuit lines. This could lead to widespread instability.
 - Consider to require Protection and Structural Mitigation for 4 or fewer concurrent Transmission outages.

ERCOT EMS SSR Alarm System

- Application:
 - Real Time (RT) Control Room
 - Day-Ahead Operation Support
 - Outage Coordination (OC)
- Purpose:
 - Monitors defined combinations of relevant contingencies and generator statuses and provides alarms
 - Combinations are defined and input to tool if a generator's SSR risk is within N-X transmission circuit outages
- Tool Development Status:
 - Tool is operational, awaiting inputs
 - May need revision based on the final protocol language

ERCOT EMS SSR Alarm System (Continue)

- Output and Action:
 - Normal: more than X circuit outages away from the SSR risk
 - No action.
 - Warning: Y (two?) circuit outages away from the SSR risk
 - OC: Do not allow additional, relevant planned outages
 - RT: Inform ERCOT Transmission Operators about the warning.
 - Evaluating options, including but not limited to bypassing series capacitors, re-energize outage circuit.
 - Alarm: Z (one?) circuit outage away from the SSR risk
 - Inform ERCOT Transmission Operators to bypass series capacitors or turn off the impacted generators
 - X, Y, Z to be defined through stakeholder process

Next Steps

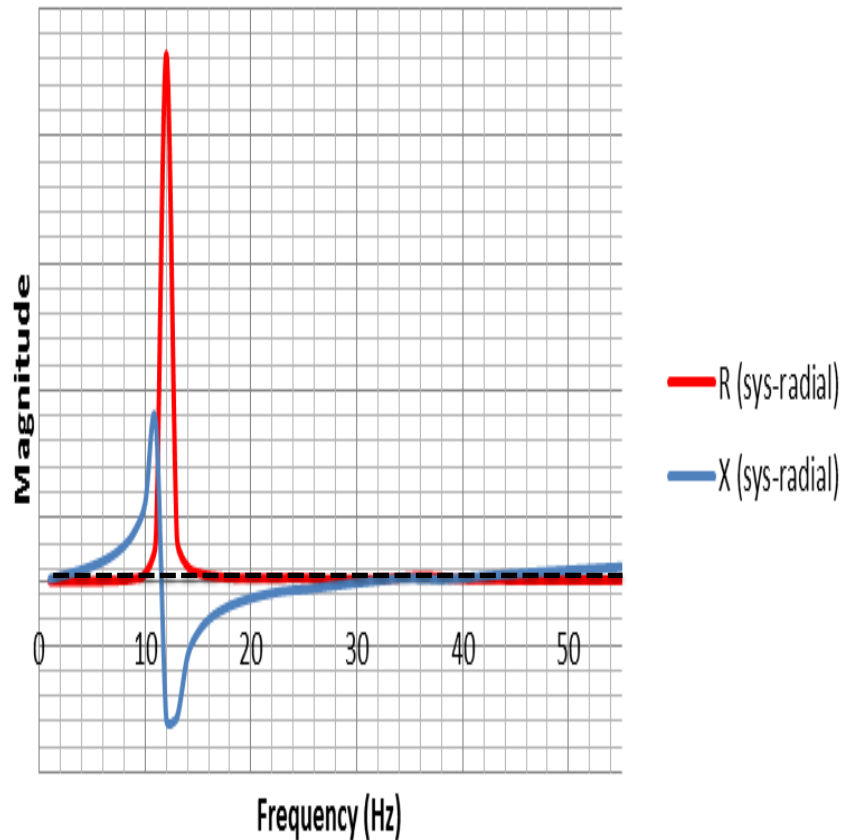
- Start messaging N-4 mitigation measure as part of the FIS process.
- Stakeholders submit comments as part of NPRR 562 by April 3rd, 2015.
- A follow up workshop in late April or early May if needed.
- ERCOT prepare comments for NPRR 562 in May/June 2015.
- Revise the screening and frequency scan criteria. (4th Quarter, 2015)

Appendix

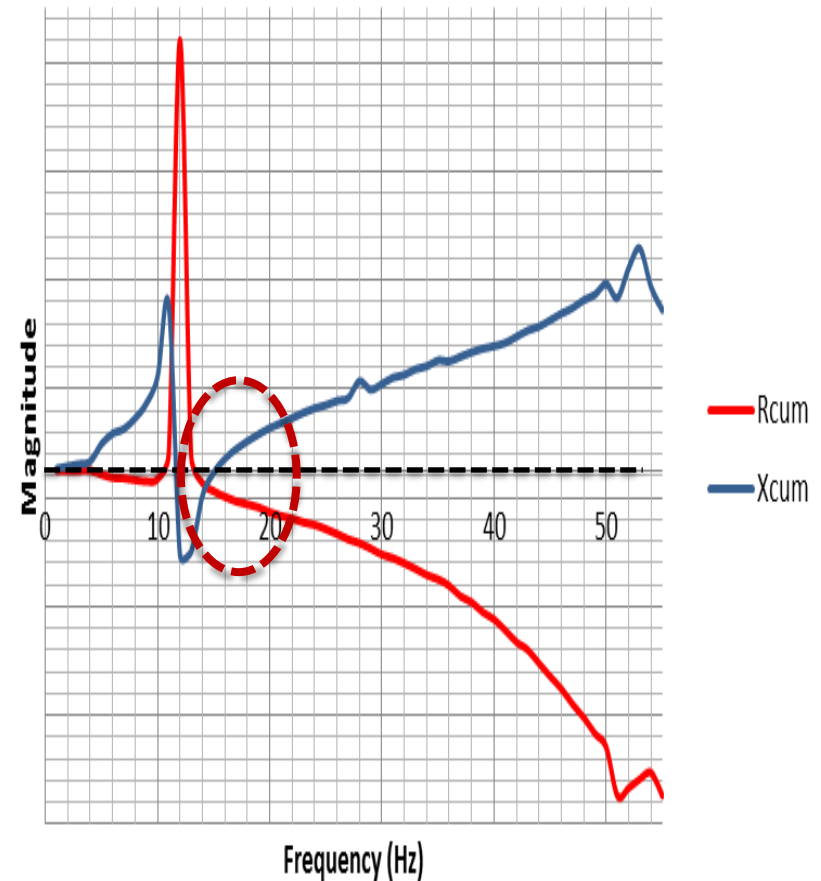
- R/X Plot Example
- Electrical Damping and Mechanical Damping
- Torque Amplification Frequency Scan Criterion

IGE/SSCI: R/X Plot

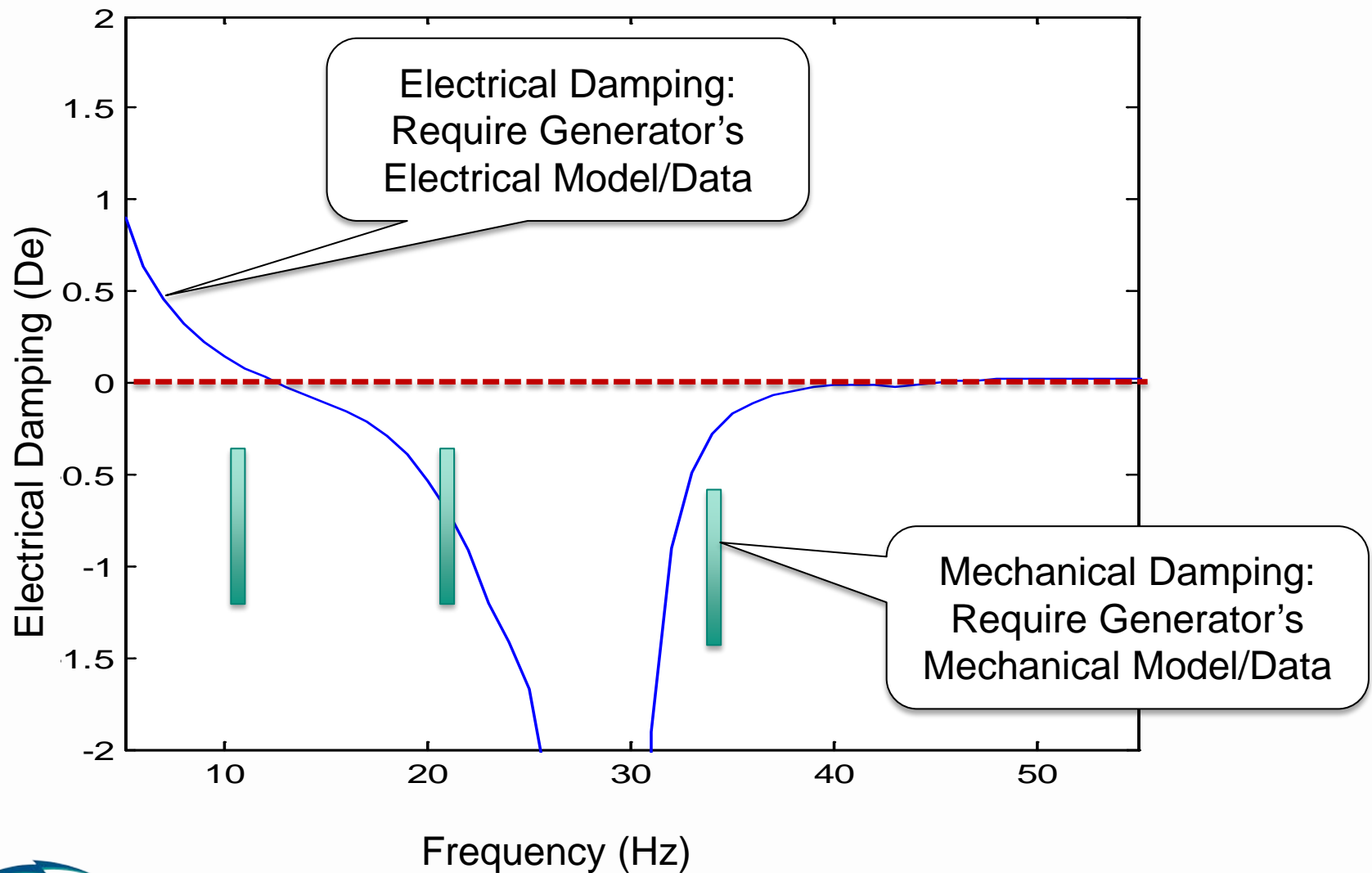
R and X (system side only)



R and X (system + turbine)



Torsional Interaction: Electrical and Mechanical Damping



Torque Amplification

