IMPERIAL
Department of Electrical and Electronic Engineering

Early Warning of IBR-Induced Sub-Synchronous Oscillations – A Tool for Future Control Rooms

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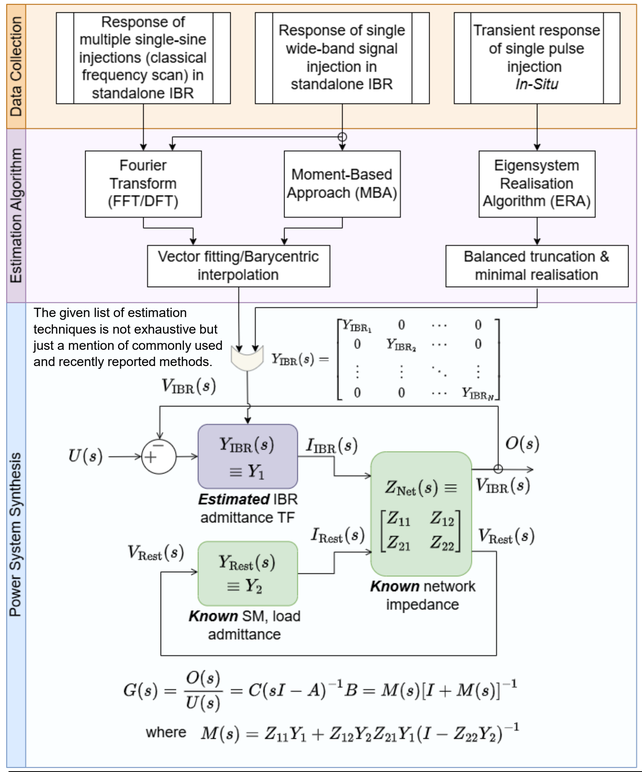
1. Introduction

In IBR-dominated grids, sub-synchronous oscillations (SSOs) can propagate system-wide, posing a serious threat to system security.
Using **estimated admittance transfer function (TF)** of each IBR, this poster presents a workflow for SSO early-warning tool that

- detects poorly-damped oscillatory modes,
- ranks IBR participation, and
- maps spatial spread via heatmaps.

2. SSO Early Warning Tool Workflow

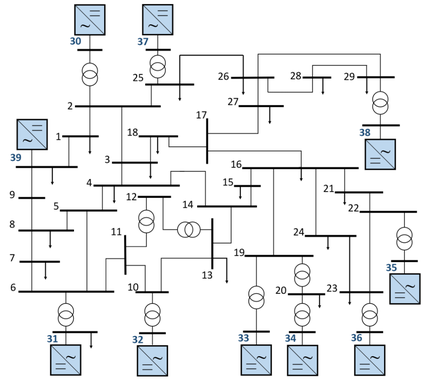
2a. Power System Modelling with Estimated IBR Admittance Transfer Functions



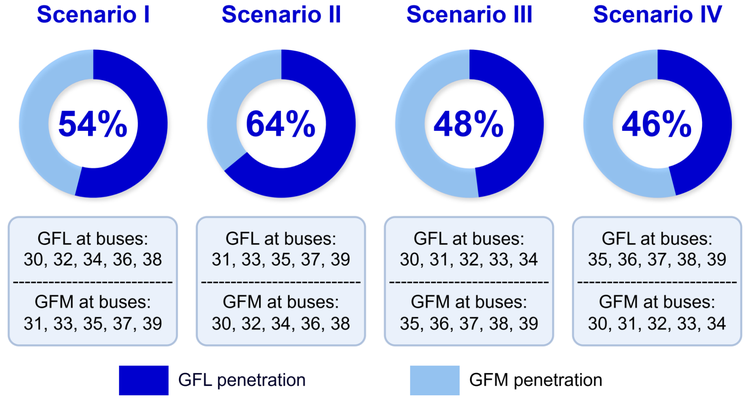
2b. Modal Analysis

- From A, we calculate eigenvalues Λ.
- For λ_i, corresponding right ϕ_i and left ψ_i eigenvectors are obtained.
- Observability of the poorly-damped mode is calculated, $\phi_i^{\mathrm{o}} = |C\phi_i|$
- Then we normalise it, $\tilde{\phi}_i^{\mathrm{o}} = \frac{\phi_i^{\mathrm{o}}}{\max \Phi_i}$
- Participation magnitude of IBRs' cumulative states in λ_i is:
$$\mathcal{P}_i^{\mathrm{IBR}} = |\phi_i^{\mathrm{IBR}} \odot \psi_i^{\mathrm{IBR}}|$$
- Normalising it gives $\tilde{\mathcal{P}}_i^{\mathrm{IBR}} = \frac{\mathcal{P}_i^{\mathrm{IBR}}}{\max P_i}$

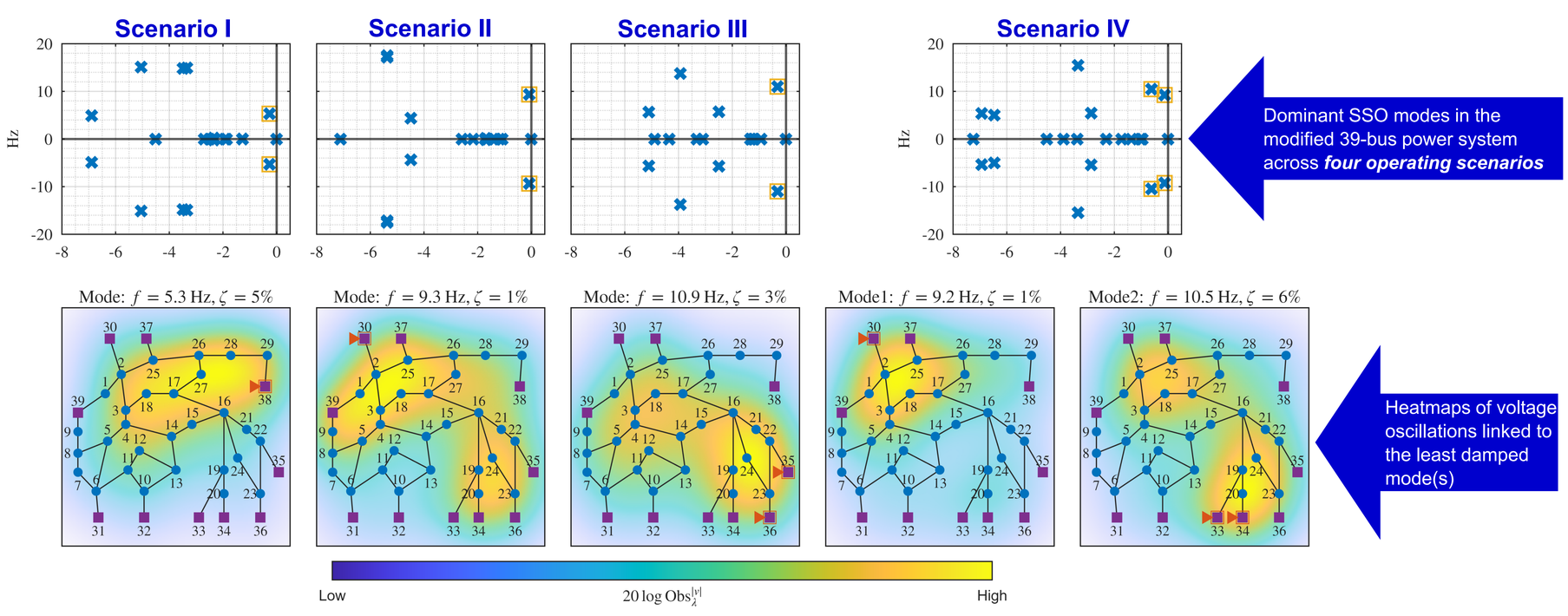
3. 39-Bus Test System



4. Four Operating Scenarios



5. Vulnerable Zones and Major Contributor(s) of SSO



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