ECE422/522 Course Project

• Choose one from two practical industry problems:
  – Contingency ranking by dynamic simulation software considering different load models
  – Estimation of the secure operating region
<table>
<thead>
<tr>
<th>Group</th>
<th>Project</th>
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<tbody>
<tr>
<td>1</td>
<td><strong>Osipov, Denis</strong>&lt;br&gt;Dave, Rohan P.&lt;br&gt;Zhou, Dao</td>
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<td>2</td>
<td><strong>Estep, Stephen T.</strong>&lt;br&gt;Biddings, Aaron&lt;br&gt;Raoufat, Mohammad E.</td>
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<td>3</td>
<td><strong>Patterson, Russell W.</strong>&lt;br&gt;Jones, Terry R.&lt;br&gt;Till, Micah J.</td>
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<td>4</td>
<td><strong>Wang, Siqi</strong>&lt;br&gt;Kelley, Brandon R.&lt;br&gt;Zhang, Yichen</td>
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<tr>
<td>5</td>
<td><strong>Smith, Mitchell T.</strong>&lt;br&gt;Duan, Nan&lt;br&gt;Zhu, Yongli</td>
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Schedule

• 3/13 (Thu): two project topics provided
• 3/18-3/20: spring break
• 3/25 (Tue): each group decide the topic and get data
• 4/24 (Thu): each group present project results
• 5/1 (Thu): submit the project report
**Introduction of Operating Boundaries**

NERC developed the concept of “boundary conditions” in order to derive the real-time operating region/limits for system operators’ situational awareness:

- Where we are?
- How far we can go?
- What we should do?

**Operating region** - the set of operating states at which the system is secure and will be secure under anticipated contingencies.
Determination of the Operating Boundary

- Boundary mainly relies on
  - Network topology
  - Contingencies

- Approximated by a set of hyper-planes
  - Limits on power injections, e.g. generation limits and line thermal limits
  - Stability limits depending on contingencies, e.g. for transient, voltage and damping
Case Study on a Real System

- The system has stability concerns in the North Zone
  - Monitor two interfaces to the east and central (axes for visualizing the operating boundary)
  - Consider 1000+ operating points (normal or stressed)
  - Simulate 100+ N-1&N-2 contingencies for each operating point
  - Check security criteria:
    - Generation limits
    - Line thermal limits
    - Post-contingency transient stability

Simulation Results (3D Display)

View Point 1

View Point 2
Simulation Results (2D Display)

- North→Central Interface Flow (MW)
- North→East Interface Flow (MW)
- Load of the North Zone (MW)
- Thermal Limit
- Generation Limit
- Transient Stability Limit
Operating Boundaries at Different Load Levels

Load of the North Zone (MW)

- Thermal Limit
- Generation Limit
- Transient Stability Limit

North->Central Interface (MW)

Fitting errors<10MW (1~5%)

North->East Interface (MW)

North->Central Interface (MW)
Operating Boundary for a Specific Load Level

Load of the North Zone = 2400MW

Early Warning to Operator
Comprehensive Operating Boundaries

1. Stress the operating condition in reasonable directions
2. Perform online security assessment for stressed operating conditions to identify the operating limits in terms of different criteria
3. For each type of criteria, visualize the operating region about monitored variables, e.g.
   - Interface flows
   - Generation/load of a zone
4. Determine the common part of those regions

Simulations on stressed operating conditions based on the current system state
Operating boundaries for both pre- and post-contingency conditions

- Small-signal (cont. 1)
- Generation limit
- Thermal limit
- Angle stability (cont. 1)
- Transient voltage (cont. 1)

Security Region about Cont. 1

- Angle stability (cont. 3)
- Angle stability (cont. 1)
- Angle stability (cont. 2)

Security Region about angle stability
Examples of Operating Boundaries

Figure 5.7
Steady-State Operating Boundaries for Hours 17, 18 and 19 Generated by VSAT

Figure 5.10
Steady-State and Dynamic Operating Boundaries for Hour 18
Examples: Existing Tools

Region Of Stability Existence (ROSE) by V&R Energy

- Defines the range of phasor measurements or other system parameters for which system securely operate based on N-k criteria
- Voltage stability (PV), voltage constraint, thermal overloads may be monitored, enforces and visualized on the boundary

Source: ROSE Presentation at NASPI Feb 2011 by M Vaiman
Examples: Existing Tools

VSAT by Powertech Labs

- The secure region is computed in radial directions, each starting from the base-case point (3500, 2800 in the figure) until the secure boundary is reached where one or more contingencies cause the violation of one or more voltage security criteria.

Source: VSAT User Manual
Software

• Powertech DSA Tools are installed at server rd0.eecs.utk.edu

• Please send ithelp@eecs.utk.edu a request for remote access of that server.
Create a Project in Powertech’s TSAT

1. Create a new project
2. Specify the powerflow file in PSS/E (*.raw) or PSAT (*.pfb) format
3. Specify the dynamic data file in PSS/E format (*.dyr)
Monitor Data

1. Create a monitor data file
   - The reference generator may be the swing bus
2. Add generators, buses or branches for monitoring
Contingency Data

Automatically create a list of N-1 contingencies (all 3 phase faults on 500KV lines)
Contingency Data

Create a customized contingency (}

Contingency Creation

Please Select One Of The Following Options To Create Contingencies:

- Create Customized Contingency Using The Contingency Editor
- Create A Nofault Contingency
- Create Contingencies Associated With A Bus Using A Wizard
  This Allows You To Create A Group Of Contingencies
  With Different Faults Located Around A Bus. Faults
  Can Be Cleared By Various Clearance Options.
- Create Contingencies Associated With A Subsystem
  This Allows You To Create A Group Of Contingencies
  With The Same Fault And Clearance Option In A
  Specified Subsystem.

Contingency Editing Window

- Description: Contingency 1
- Simulation Length: 11 Seconds
- Switching Commands:
  - At Time 1 Seconds
  - Three Phase Fault On Line ;6 ;7 ;1 0
  - After 5 Cycles
  - Clear Three Phase Fault On Line At Near End
  - Clear Three Phase Fault On Line At Far End

- Application Of The Contingency:
  - Basecase Analysis: Yes
  - Transaction Analysis: Yes
Load Modeling

TSAT Scenario Edit Window - Parameters

- Scenario Data
  - Description
  - Parameters
  - Powerflow Data
  - Dynamic Data
  - Monitor Data
  - Criteria Data
  - Contingency Data
  - Dynamic Representation Data
  - Transaction Data
  - Sequence Network Data

Parameters

<table>
<thead>
<tr>
<th>Security Criteria</th>
<th>Simulation Control</th>
<th>Model</th>
<th>Transaction</th>
<th>Early Termination</th>
<th>Sequence Network</th>
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</thead>
<tbody>
<tr>
<td>Default Load Model For P</td>
<td>MVA</td>
<td>%</td>
<td>CUR</td>
<td>100 %</td>
<td>IMP</td>
</tr>
<tr>
<td>Default Load Model For Q</td>
<td>MVA</td>
<td>%</td>
<td>CUR</td>
<td>0 %</td>
<td>IMP</td>
</tr>
</tbody>
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- Include Induction Motor In Load Shedding: No
- Threshold Value Of Zero Impedance Line: 0.000100 PU
- Solution Option For Generator Swing Equation: Power
- Automatic Dynamic Data Correction: Yes
- Common MVA Base: 100.00 MVA
- Common Frequency Base: 60.00 Hz
Load Modeling
Automatic CCT Calculation
Automatic Stability Margin Calculation
Conduct Basecase Analysis
Define the Transfer File

- Search the security limit in one dimension
Conduct Transaction Analysis