Collaborative Research on Power Systems between Shandong University and Overseas Universities

Prof. Hongtao Wang
28 July. 2014
School of Electrical Engineering
Shandong University
Outline

• Introduction of Shandong University

• Introduction of School of Electrical Engineering (Research Labs and Facilities in School of Electrical Engineering)

• Research Areas and Selected Research Topics
  Power system Restoration in School of Electrical Engineering
History of Shandong University

• Shandong Imperial College, the former of Shandong University, established in 1901, was the 2nd national university in China.

• The new Shandong University was founded in 2000, by merging Shandong Industrial University, Shandong Medical University and Shandong University.
Scale of Shandong University

• Over 7,000 academic, technical and administrative staffs, 60,000 full-time students;
• 42 Schools, 3 affiliated hospitals;
• Covering an area of over 533 hectares, with 8 campuses (6 campuses in Jinan, 1 campus in Weihai, 1 campus in Qingdao).
The main campuses locate in Jinan, Shandong, China. Jinan is the capital of Shandong Province. Jinan locates in the east of China, 1 hour 40 mins to Beijing and 3.5 hours to Shanghai by fast train. Jinan is famous for various springs inside the city.
School of Electrical Engineering

• Locates at the Qianfoshan Campus, Jinan
• Close to city center and Qianfoshan Mountain.
• 135 staffs including 31 professors, 46 associate professors and 23 lecturers.
• 1200 undergraduate and 500 graduate students.
Research Areas in School of EE

- Power System
- Power Electronics
- Machine and Drives
- High Voltage Technologies
- Electromagnetics
Research Labs and Facilities

- Key Laboratory of Power System Intelligent Dispatch and Control (Shandong University), Ministry of Education
- 7 Research Institutions
- 4 Provincial Engineering Technology Centers
- Power system dynamic model and simulation platform, RTDS, integrated substation automation system, advanced digital power system simulator.
Power system restoration and power grid self-healing

- Power system black start field test in Shandong provincial power grid.
- Developing power system restoration aided decision/dispatching/control system
- Book on power system restoration 《Power system restoration theory and technology》
<table>
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<tr>
<th>Grid</th>
<th>Voltage (kV)</th>
<th>Capacity of BSU (MW)</th>
<th>Maximum electric motor (MW)</th>
<th>Length of lines (km)</th>
<th>Date of filed test</th>
<th>Remarks</th>
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<tr>
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<td>Total black out</td>
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<tr>
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<tr>
<td>Shandong</td>
<td>500</td>
<td>250</td>
<td>6.6</td>
<td>140</td>
<td>2012.11</td>
<td>success</td>
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</tbody>
</table>
Shandong Power Grid 220kV 101 km transmission lines 330MVA Thermal Unit involved in black start

Shandong Power Grid 500kV 140 km transmission lines 660MVA Thermal Unit involved in black start
Developing Navigator type Power system restoration supporting systems

Main Features:

- The whole restoration process decision are supported involving generator black-start, power grid reconfiguration, load restoration.
- The whole restoration process could be validated such as self-excitation, transient overvoltage, harmonic analysis voltage drop of large induction motor starting, etc.
- The whole levels of dispatching could cooperate within one system and coincident real time data.
Main contents
- Black start
- Network reconfiguration
- Load restoration

Main Theories
- Leader-follower hierarchical
- Group intelligent
- Pareto-optimal
- Expert system technology

Special Practice
- Grid black start experiment
- AC/DC system restoration
- Restoration considering new energy power generation

Power system restoration theory and technology
Power system restoration and power grid self-healing

1. Project:
   – National Natural Science Foundation of China
   – National High-tech Research and Development Program of China (863 Program)

2. Collaboration:
   – Shandong provincial electrical dispatching & control center
   – Manchester University of UK
   – Jinan True Technology Co.

We are Looking forward to further collaborations with US universities or US company!
Thanks for your attention!

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Shandong University
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US/China international collaboration
Collaboration with University of Tennessee, Knoxville

Shandong University
Key Laboratory of Power System Intelligent Dispatch and Control of Ministry of Education

• Exchange scholars:
  Changgang Li: visiting scholar. 2012-2014
  Changqing Zhu: visiting scholar. 2012-2013
  Chunjuan Jia: visiting scholar. 2012-2013
  Wenjing Hu: visiting scholar. 2012-2013

• Participate in US Projects:
  “Synchrophasor-based power system dynamic modeling for stability estimation” (project No. P39.015) supported by Electric Power Research Institute (EPRI), and project “High-performance hybrid simulation/measurement-based tools for proactive operator decision-support” (project No. DE-FOA-0000729) supported by Department of Energy (DOE) and EPR.

Prof. Yilu Liu
Governor’s Chair at UTK and Oak Ridge National Laboratory (ORNL).
Collaboration with University of Texas at Arlington

Shandong University
Key Laboratory of
Power System
Intelligent Dispatch
and Control of
Ministry of Education

• Exchange scholars:
  Ming Yang: visiting scholar. 2011-2012
  Kejun Li: visiting scholar. 2010-2011
  Huibin Sui: visiting scholar. 2009-2010

• Collaboration research area:
  Power system operation, control and stability

• Published Paper Jointly:
  1. Probabilistic Short-Term Wind Power Forecast Using Componential Sparse Bayesian Learning.
  2. Design and Implementation of SOPC-Based Frequency Variable Inverter.

Prof. Wei-Jen Lee

• IEEE Fellow
• Fellow of IEEE
• Vice Chair-Technical of the IEEE/IAS, ICPSD
Collaboration with University of GeorgiaTech

- Shandong University
  Key Laboratory of Power System Intelligent Dispatch and Control of Ministry of Education

- Exchange scholars:
  Zhihao Yun: visiting scholar. 2010-2011

- Collaboration research area:
  Power system reactive power/voltage optimization

- Chair of the Electrical Energy Technical Interest Group.
- PES President

Prof. Miroslav Begovic
Collaboration with University of Wisconsin-Madison

- Shandong University
  Key Laboratory of Power System Intelligent Dispatch and Control of Ministry of Education

- Exchange scholars:

- Collaboration research area: Wind power integration to power system and reactive power optimization.


- IEEE Fellow
- Fellow of Engineers Australia
- Chartered Professional Engineer in Australia.
- Professor at the University of Wisconsin-Madison. (2002-2008)
Collaboration with University of Connecticut

Shandong University
Key Laboratory of Power System Intelligent Dispatch and Control of Ministry of Education

- Exchange scholars:
  Hua Ye: visiting scholar. 2014-2015
- Collaboration research area:
  Renewable energy integration planning and operation risk assessment

Dr. Peng Zhang

- Assistant Professor, Department of Electrical and Computer Engineering, University of Connecticut
Thanks for your attention!

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Intelligent Restoration Decision-Theoretical Method

- The problem of restoration control and decision: multi-layer, multi-objective, nonlinear and time-varying.
- The proposed theoretical system of control and decision during power system restoration:
  - Distributed decision: leader-follower hierarchical decision theory
  - Multi-attribute: group multi-attribute decision theory
  - Multi-objective: Pareto-optimal decision theory

- Intelligent decision support system for restoration is developed to assist making restoration plan for power grid and plants.
Intelligent Restoration Decision - Process Simulation

- Power system restoration process involves many extreme operation modes. Currently, there is no comprehensive simulation tool available.
- The whole restoration process are studied and proposed, involving generator black-start, self-excitation, transient overvoltage, harmonic analysis voltage drop of large induction motor starting, etc.
- Integrated into Dispatcher Training System and Intelligent Restoration Decision Support System. Have been used to verify and guide the black start plan in real grid for many times.