Adaptive Damping Control for Three Major Utilities: Hardware-In-the-Loop Test

Yi Zhao¹, Lin Zhu¹, Chengwen Zhang¹, Ibrahim Altarjami¹, Xianda Deng¹, Yilu Liu¹,², Evangelos Farantatos³, Hossein Hooshyar³, Mahendra Patel³, Atena Darvishi⁴, George Stefopoulos⁴, Cosimo Pisanì⁵, Roberto Zaottini⁵, Ali H. Al-Mubarak⁶, Salem. O. Bashraheel⁶

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Background and motivation:
• Oscillation damping controllers tuned offline usually have limited adaptive capability to varying operating conditions.
• An adaptive measurement-driven controller has been developed and validated by simulations in three realistic large power grid models.
• Aiming at field demonstration, the controller is further tested in a hardware-in-the-loop (HIL) setup under realistic operating conditions including measurements noise, signal latency, and data loss, using realistic power grid models.

Technical approach:
• The controller was implemented on a generic hardware platform - CompactRIO
• Built a HIL test setup based on RTDS or OPAL-RT real-time digital simulator
• The realistic grid models were emulated on RTDS or OPAL-RT
• Included communication network impairment simulator to introduce time delay and data loss

Results:
RTDS/OPAL-RT based HIL test setup
• The controller was tested in three realistic power grid models using actual oscillation events: Continental Europe power grid, New York State power grid, and Saudi Arabia power grid.
• The controller can provide sufficient damping control under random time delay, occasional or consecutive data loss.
• The controller can enhance both small-signal stability and transient stability.

Conclusion:
• The controller was tested in three realistic power grid models using actual oscillation events: Continental Europe power grid, New York State power grid, and Saudi Arabia power grid.
• The controller can provide sufficient damping control under random time delay, occasional or consecutive data loss.
• The controller can enhance both small-signal stability and transient stability.
• Next steps: Field test and field demonstration
Hardware-In-the-Loop Test Setup and Controller Implementation

- Real-time digital simulator: RTDS or OPAL-RT
- Voltage amplifiers
- PMU devices
- National Instruments (NI) CompactRIO
- Communication Network impairment simulator

**Basic function modules:**
- PMU data receiver
- Lead-lag structure
- D/A converter
- Visualization GUI

**Advanced function modules:**
- Delay compensation
- Missing data handling
- Supervisory control
- Oscillation detector
Hardware-In-the-Loop Test Results in Three Realistic Power Grid Models: Continental Europe, NY State, and Saudi

- The controller can provide sufficient damping under random time delay, occasional or consecutive data loss.
- The controller can enhance both small-signal stability and transient stability.

HIL test: Continental Europe power grid
150-950 ms random delay + 60% data loss

HIL test: New York State power grid
Chunk of data loss for 10 seconds

2.04 GW generation trip

HIL test: Saudi Arabia power grid

System Separates

WADC prevents system separation
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