Laboratory Scale Demonstration of Power System Stabilization Using Energy Storage (Task 4)

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Objective

Study and demonstrate the development, sizing and application of short term, high power storage technology in stabilizing and damping power system response to disturbances

Laboratory Scale Demonstration of Power System Stabilization Using Energy Storage

Background:

Project will investigate how Energy Storage Systems can provide support to control power system dynamics during disturbances

In many disturbances a relatively small amount of storage with high power capability may be adequate

NMSU's El Paso Electric Power Laboratory has the capability to create a 4-6 node power system

Laboratory will be used as a scale-model test bed to investigate energy storage applications to power system dynamics/control

Laboratory Scale Demonstration of Power System Stabilization Using Energy Storage

FY'06 Goals and Deliverables

4a: Scale Model Test Bed Development/Demonstration

- Extend existing test bed capabilities by adding generator controls
- Integrate power converter with energy storage (ESMA super capacitor)
- Demonstrate power system response

>>Report describing test bed and demonstrations(1/15/06)

Laboratory Scale Demonstration of Power System Stabilization Using Energy Storage

FY'06 Goals and Deliverables

4b: Simulation Models and Validation

- Develop simulation model of test bed and validate responses
  - EMTDC
  - PSS/E
  - EDSA
- Develop scenarios of interest in demonstrating storage applications

>>Report comparing simulations and measurement(1/15/06)

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FY'06 Goals and Deliverables

4c: Preliminary Research on Storage Sizing and Control

- Literature Review
- Implementation of simple/existing control algorithms
  - Advanced algorithm development in future
- Investigation of Sizing Considerations
  - Possibly analytical

>>Report (1/15/06)

Test Bed Components

LabVolt Test Benches with Prime Mover/Generator/Load are networked through a set of transmission lines to create a power system

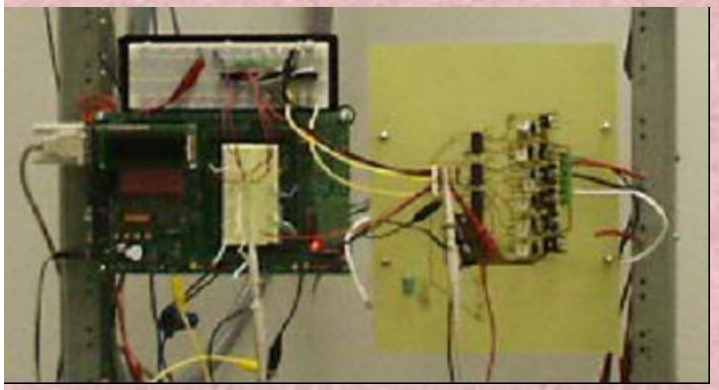
Test Bed Components

Typical Ratings

Benches(6)	60 Hz, 120/208 V, 8A
Generators	1800rpm, 60 Hz, 120/208 V, 1 A, 300VA
Loads	R,L,C, Motors 100-300V
Network	6 Buses and Lines Breakers in Ring Bus Short circuit capacity ~ 15 A

Test Bed Components

PV System 48 Vdc, 7 A dc



Inverter 48 V dc – 120/208V

Up to 15 A ac

60 Hz Standalone

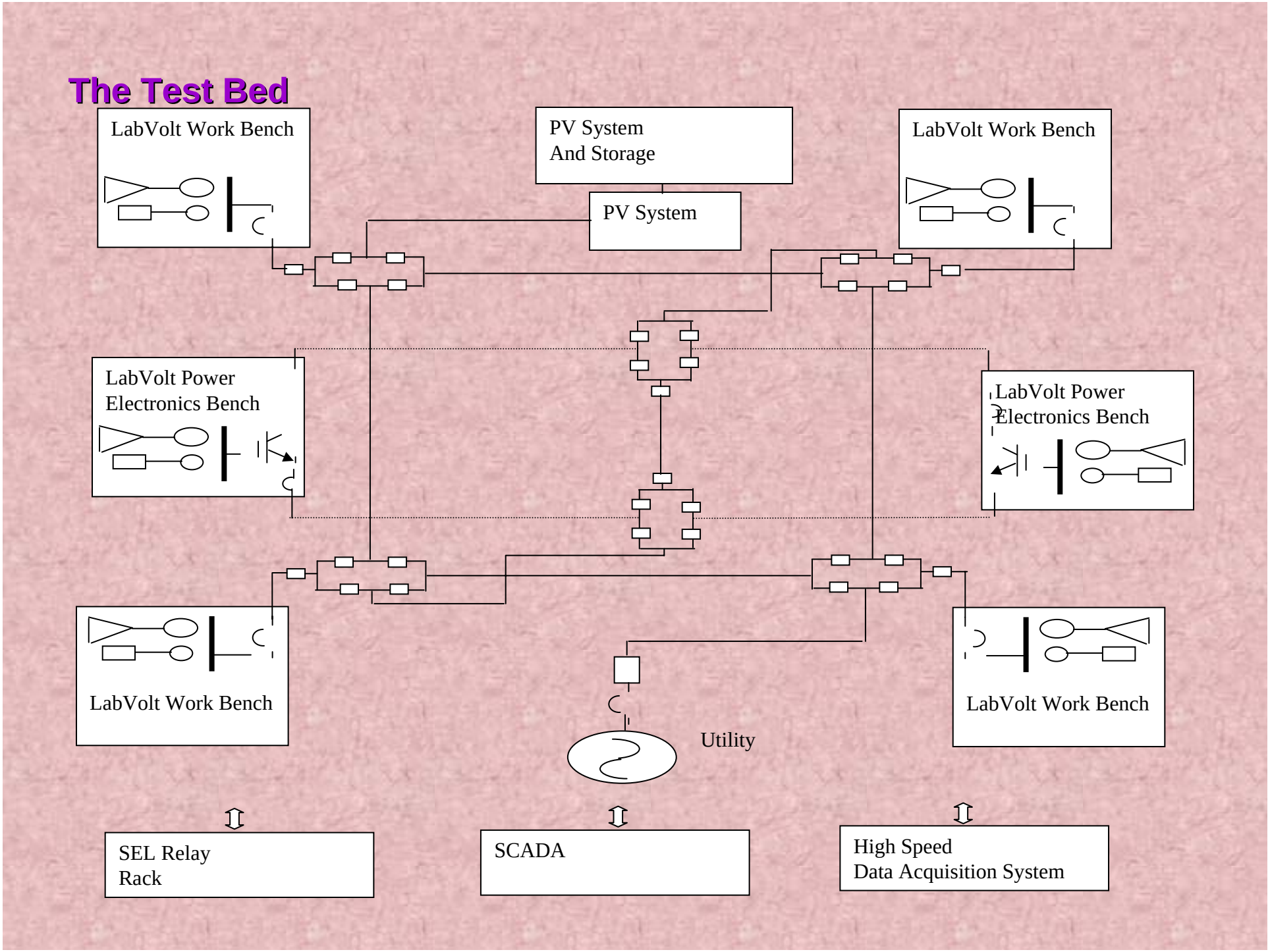
Ultracapacitor

ESMA 48V

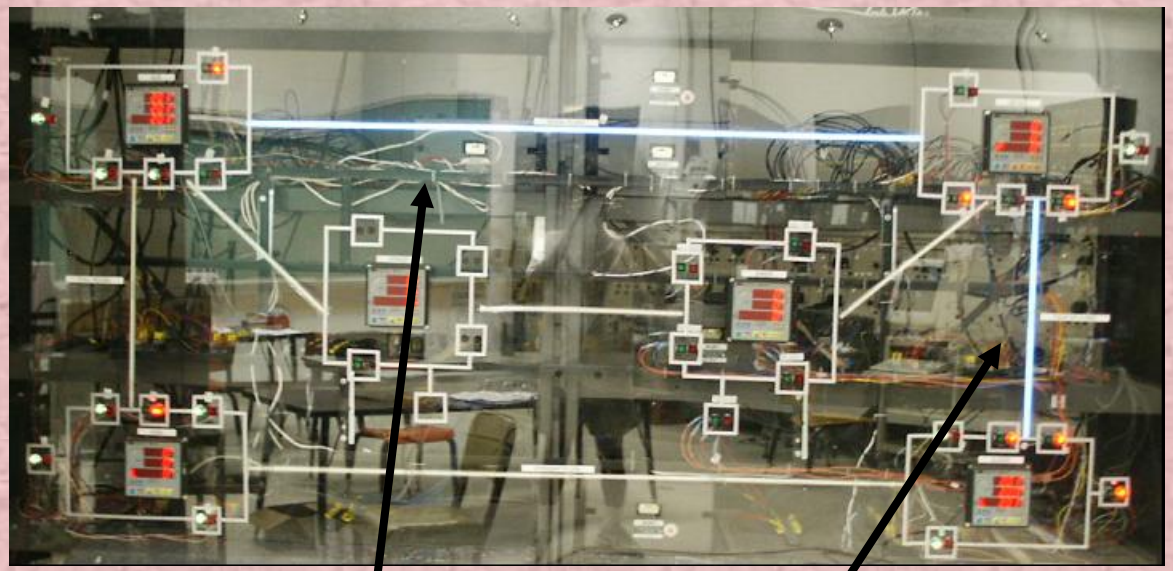
Maxwell

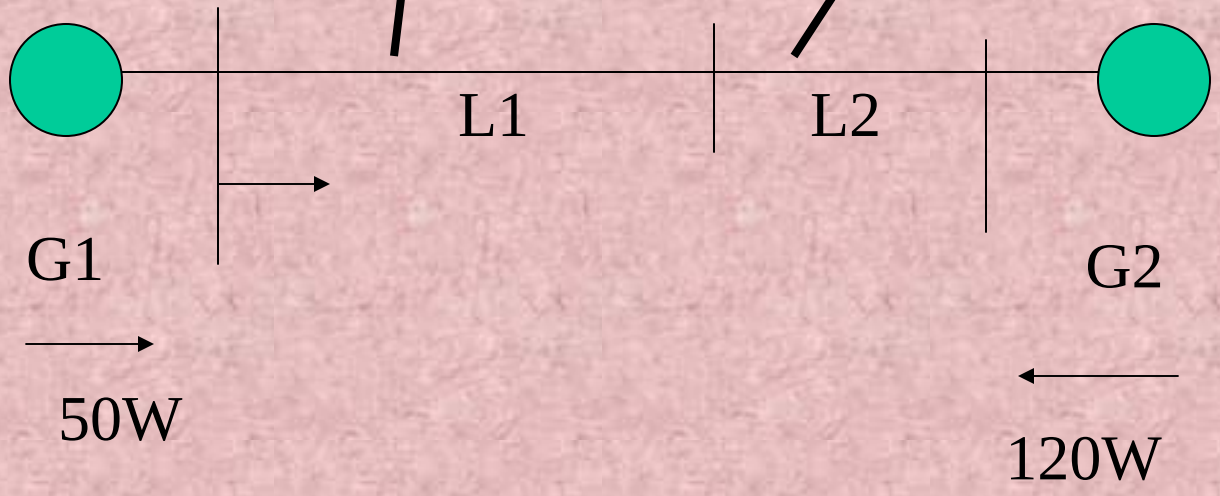
Evans

The Test Bed


LabVolt Work Bench
PV System
And Storage
PV System
LabVolt Work Bench
LabVolt Power
Electronics Bench
LabVolt Power
Electronics Bench
LabVolt Work Bench
LabVolt Work Bench
Utility
SEL Relay
Rack
SCADA
High Speed
Data Acquisition System

Example use of test bed





Two generator system

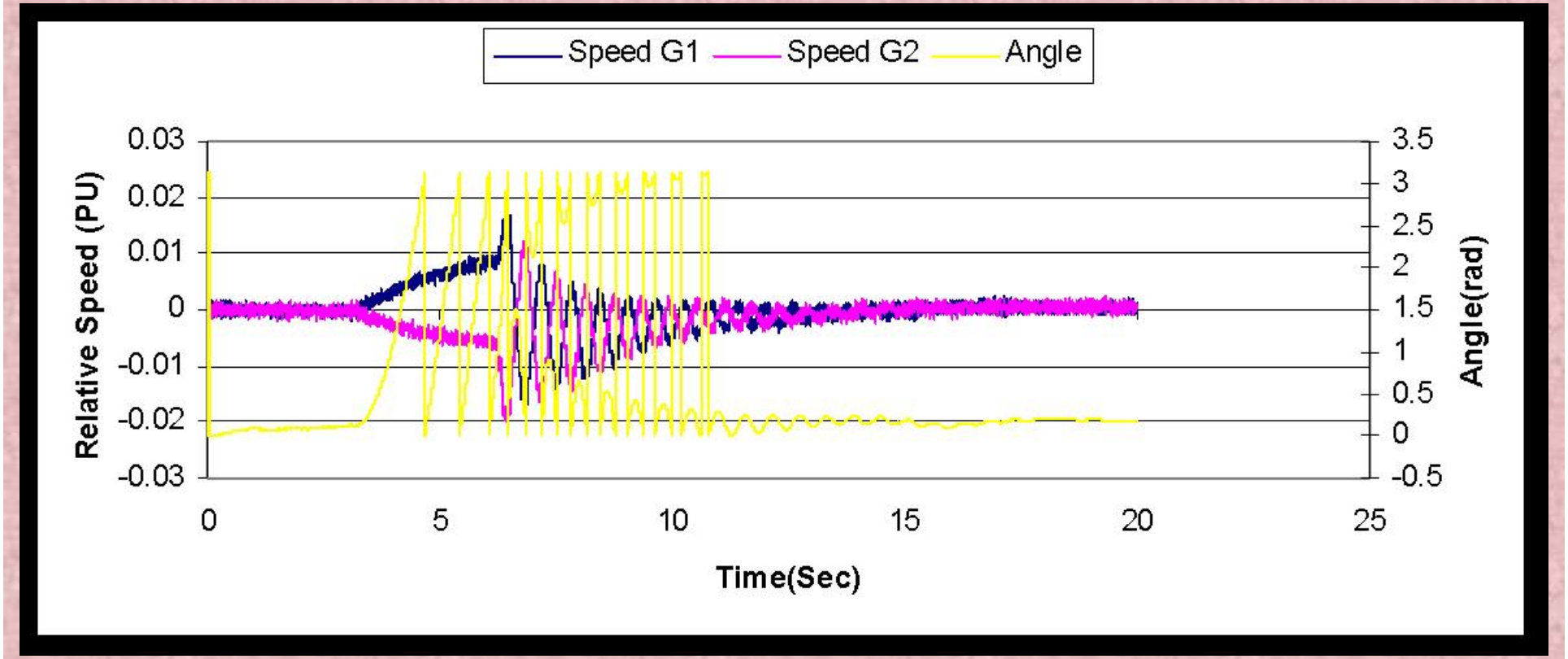
Example 1 (Stable)

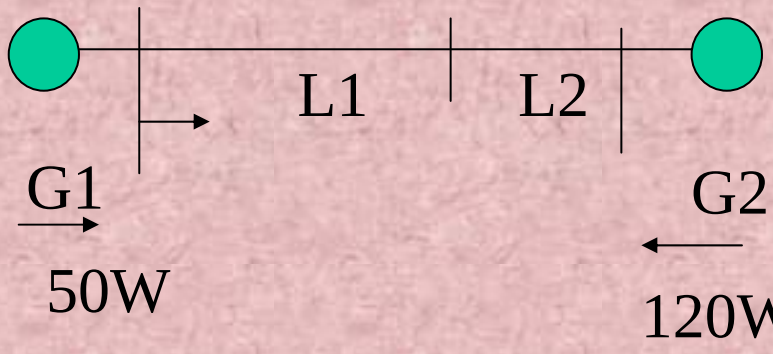
Open and Close L1

Example 2 (Unstable)

Sudden change in load

Example use of test bed

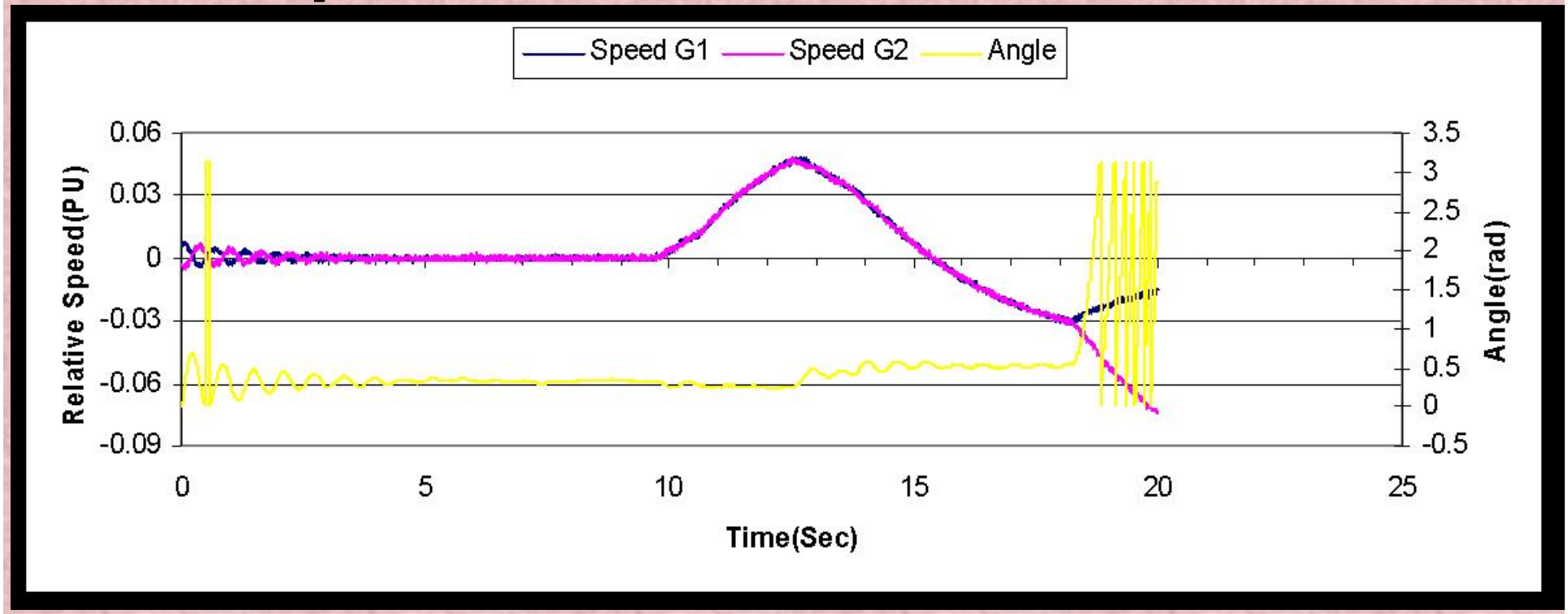


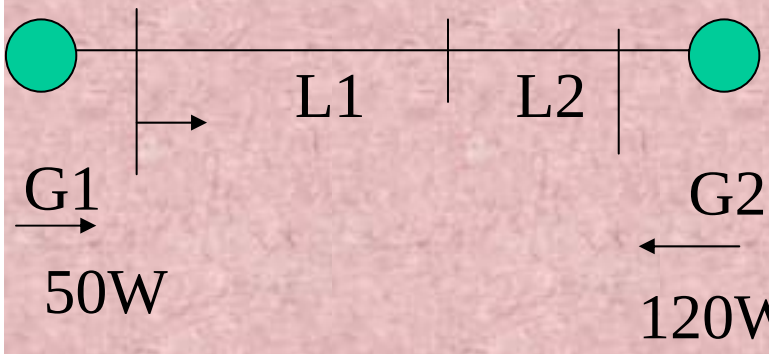


Example 1 (Stable)-- Open and Close L1
Speeds diverge then converge in an oscillatory fashion

Storage can be used to add damping?

Example use of test bed





Example 2 (Unstable)– Switch 200 W Load off/on

Speeds track but eventually instability sets i

Can Storage be used for a short time at the onset of instability to stabilize?

Task Summary

4a Test Bed Development

- Add governors/ voltage regulators
- Design/Fabricate bi-directional inverter
- Procure commercial Inverter to which control algorithms can be added
- Integrate
- Develop standard test scenarios
  - Faults/Clearing
  - Line Open
  - Load change

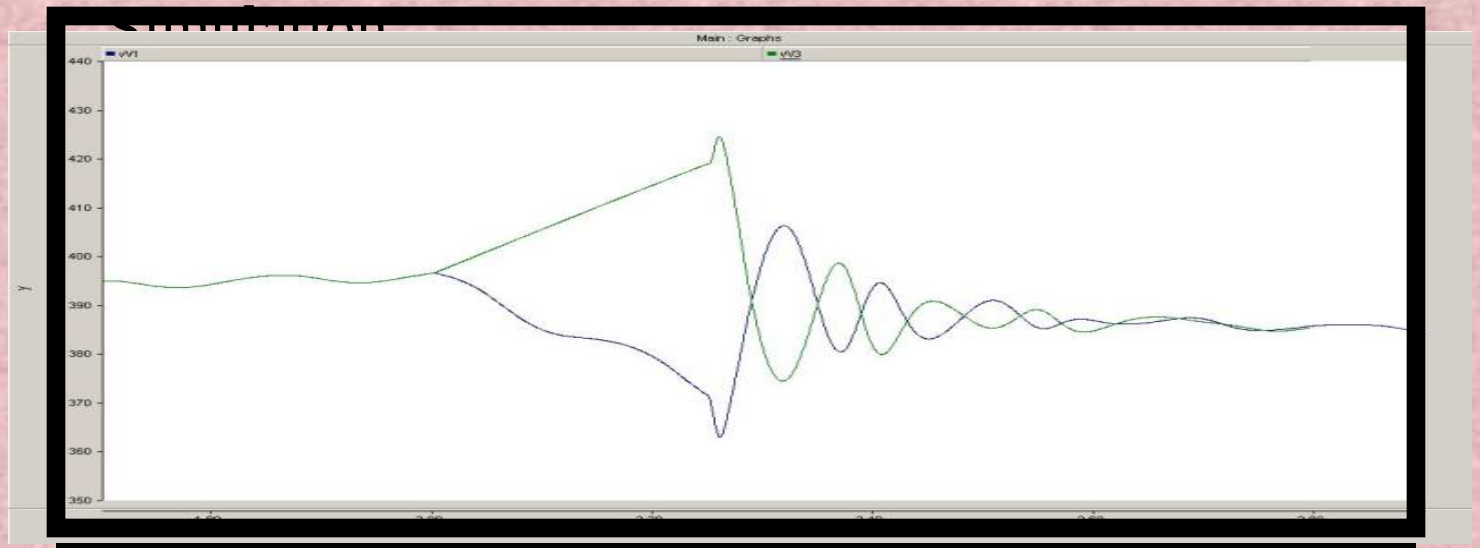
Task Summary

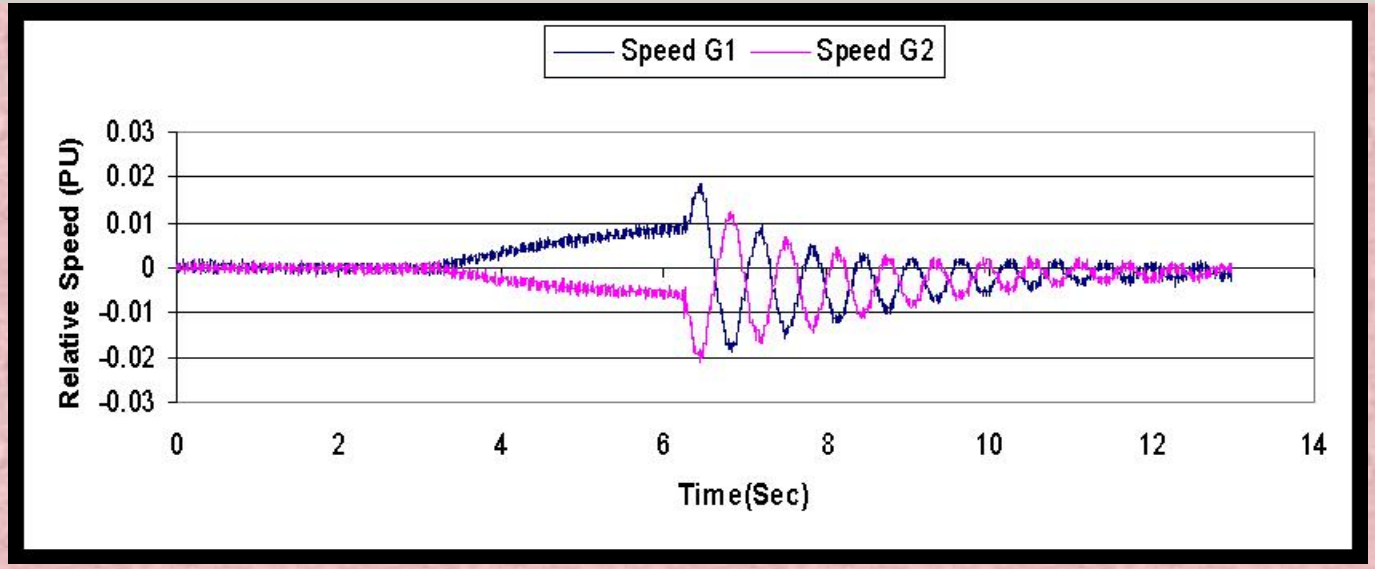
4b Simulation

- Develop simulation in EMTDC/ PSS/E and EDSA
- Validate using standard test scenarios

Task Summary

4b





Task Summary

4c Preliminary Research on Storage Sizing and Control

- Literature Review
  - Significant work exists in system stabilization/damping/coordination
  - FACTS devices extensively studied
  - Much recent literature deals with voltage, rather than angle stability

- Implementation of simple/existing control algorithms
  - Modern research target WAMS(PMU)
  - Some research on Intelligent Systems based on Energy analysis

Task Summary

4c Preliminary Research on Storage Sizing and Control

- Investigation of Sizing Considerations
  - Usually based on simulation

- This project will provide a thorough review
- Focus on using small to moderate-sized systems assist damping
- Demonstrate that dynamics can be *affected*
- Initially implement existing algorithms for control
- Investigate potential for algorithms based on Energy analysis and WAMS

Expected Contributions

Demonstration on scale model system

- •Not an alternative but a complement to simulation
- •Can provide additional insight, by capturing effects such as transducer and data limitations, and physical device behavior

Extends understanding of role of storage in system control

- •It is hoped that for certain class of problems it is not necessary to implement large storage systems

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