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Electrical & Computer ENGINEERING

Chapter 17: DynamicStabilityof Electric Power Systems in theAzores Archipelago

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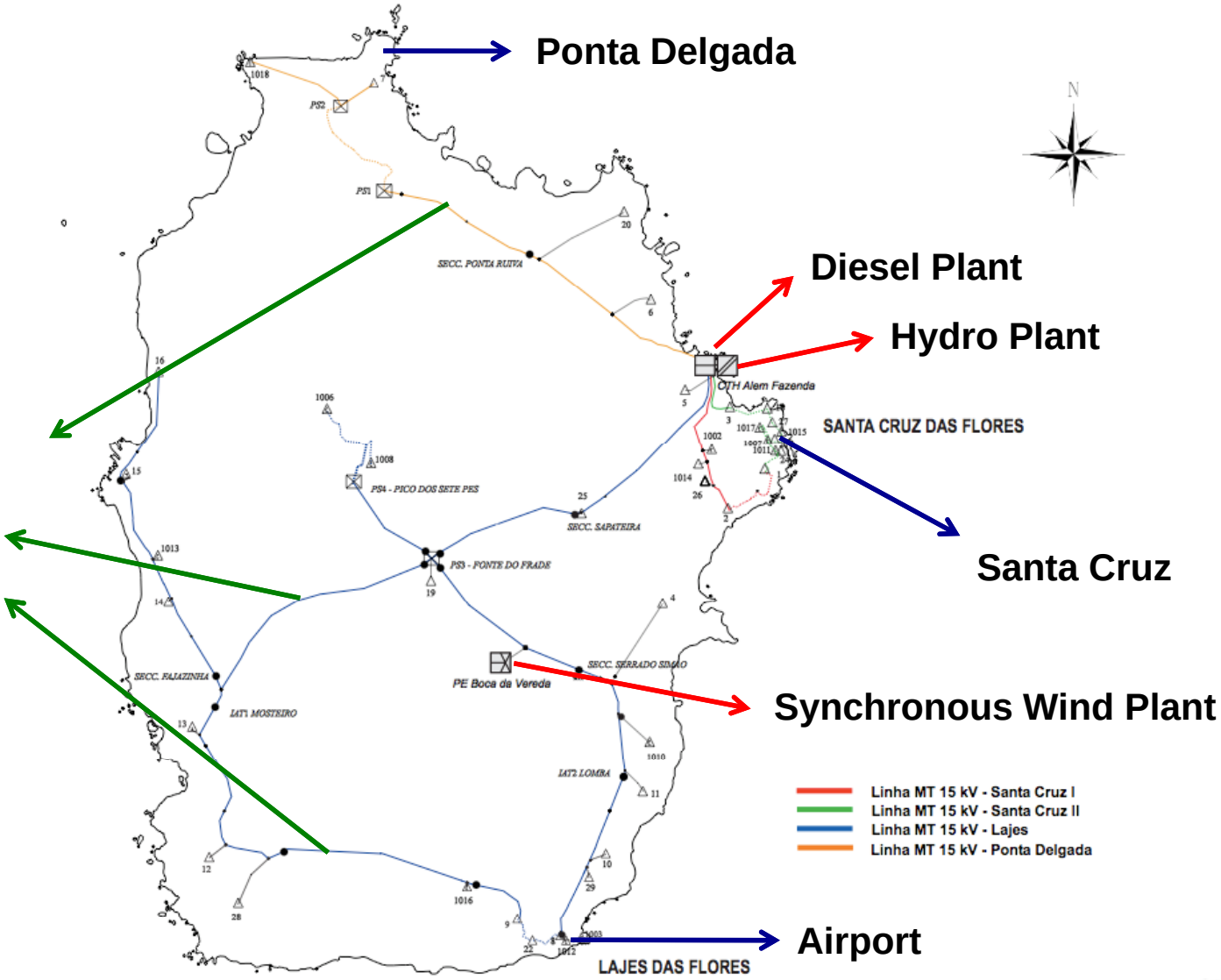
Talk outline

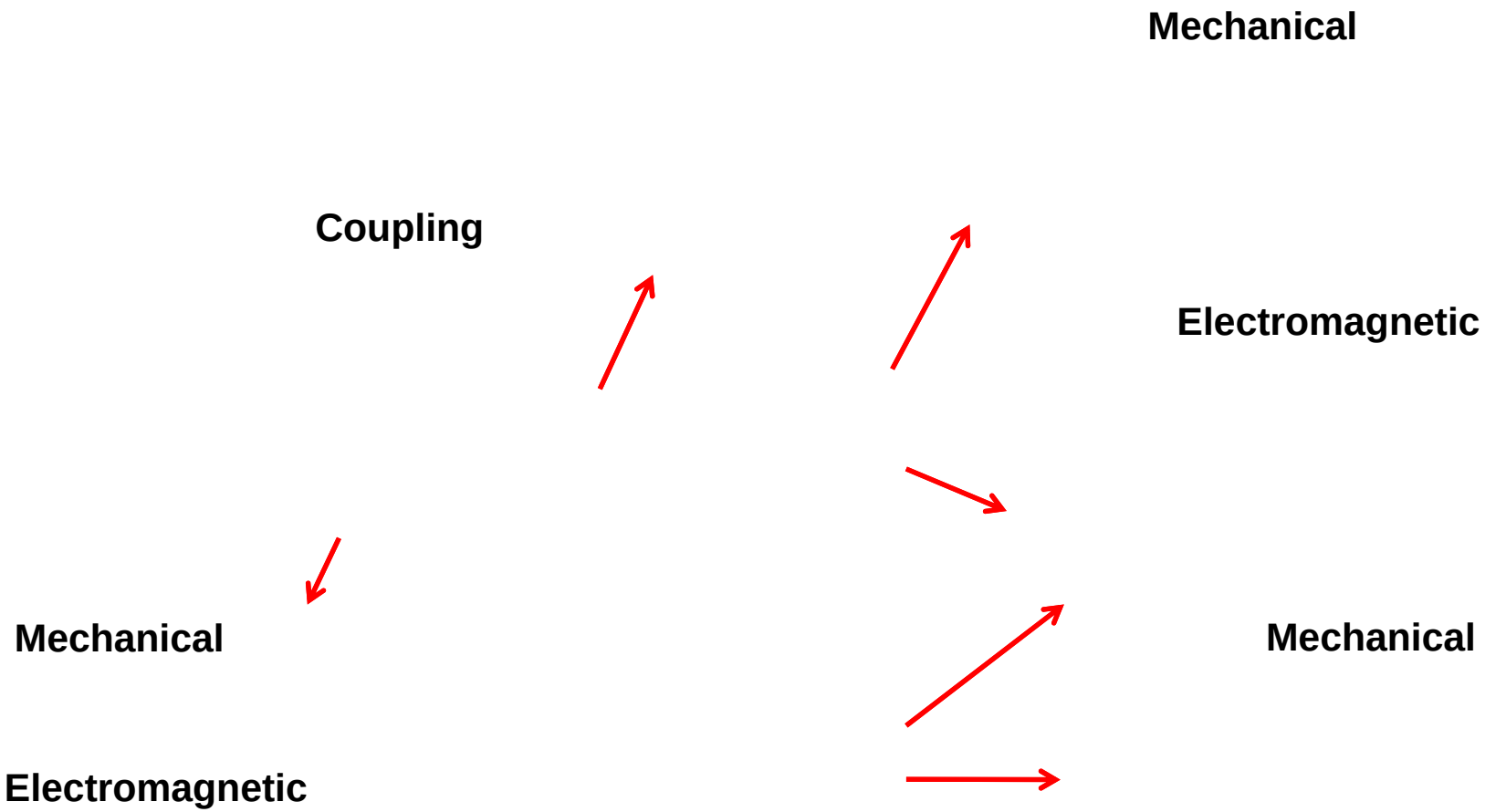
- Dynamic model of systems studied
- Small signal stability analysis
  - Flores Island
  - Sao Miguel Island
- Major finding: The need to design governor control using coupled real power-voltage dynamic model
- Conclusions and future outlook

DYNAMIC MODEL OF FLORES ISLAND

46-node Radial Distribution System



DYNAMIC MODEL OF FLORES ISLAND

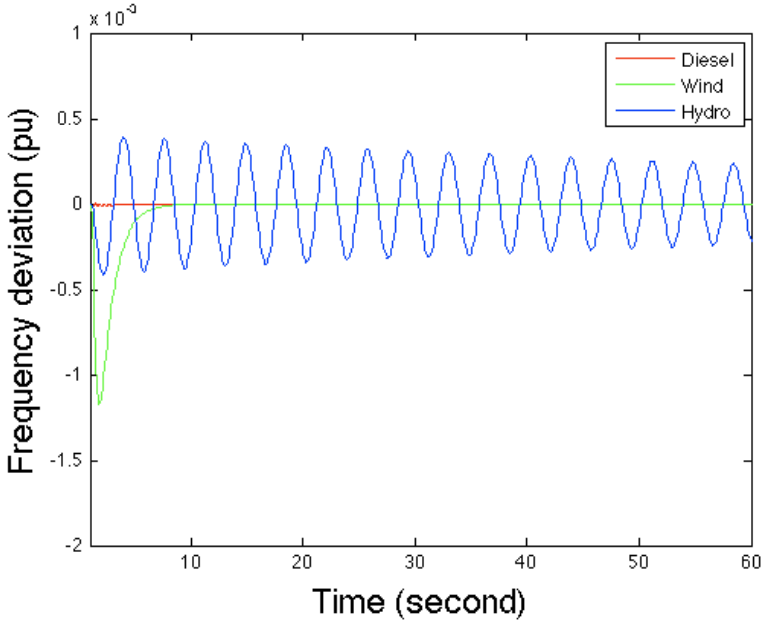


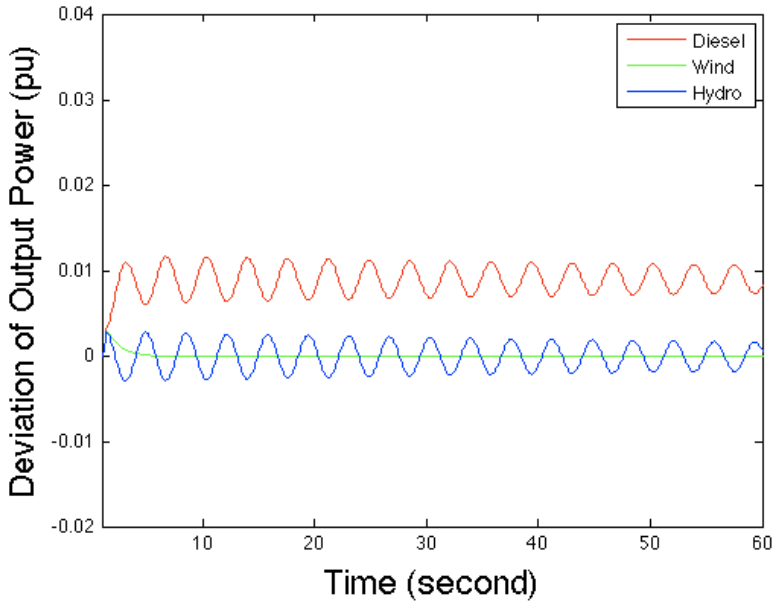
One-line diagram of the equivalence power system of Flores Island

[1] M. Ilić and **M. Honarvar Nazari**, "Loss Minimization and Voltage Profile in Azores Archipelago", Chapter 13, Engineering IT-Enabled Electricity Services, Springer 2012.

FREQUENCY RESPONSE WITH THE GOVERNOR DESIGN USING DECOUPLED MODEL

- Stable oscillatory response (small stability margin)





[1] M. Honarvar Nazari and M. Ilić, "Dynamic Stability of Azores Archipelago", Chapter 14, Engineering IT-Enabled Electricity Services, Springer 2012.

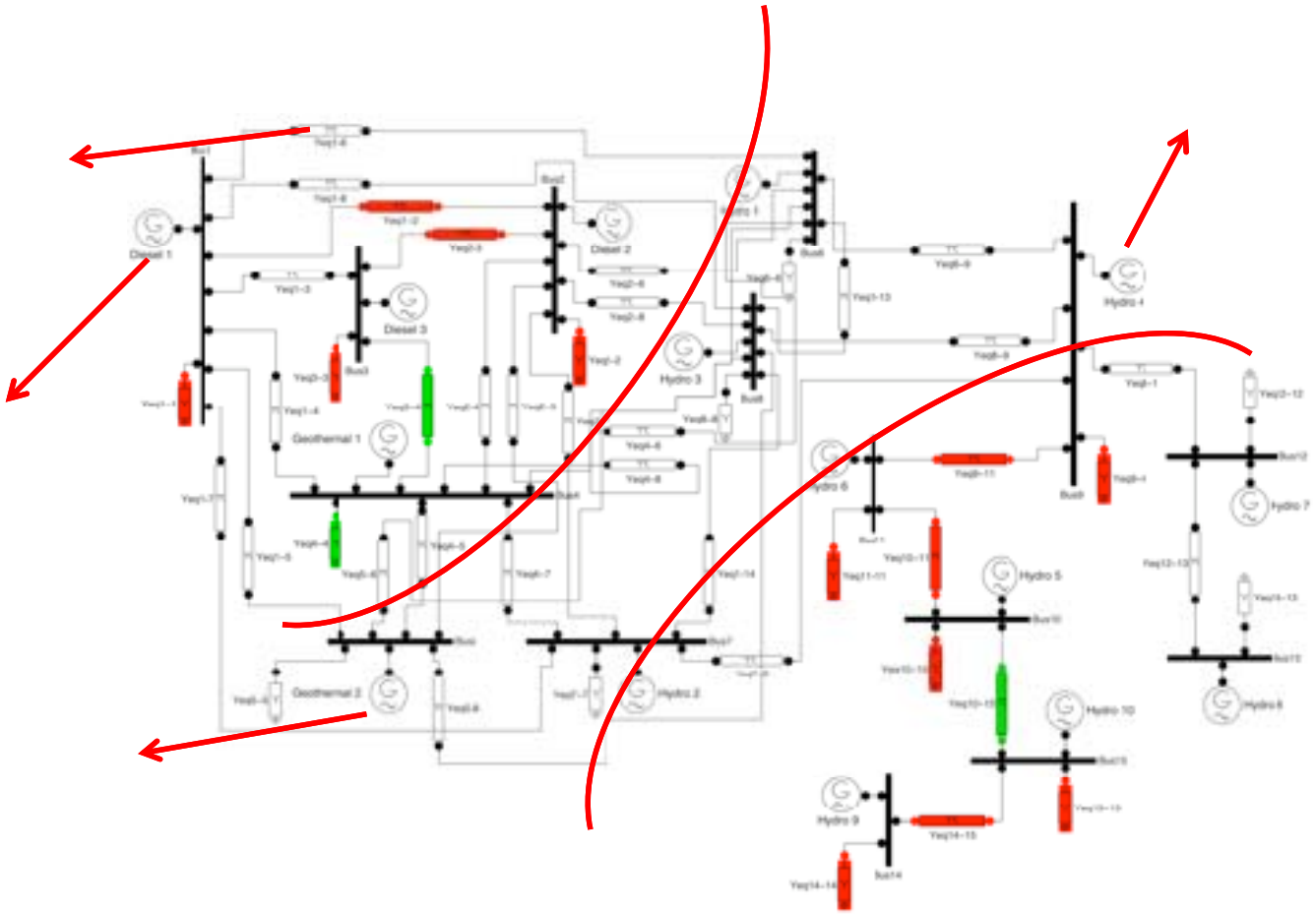
FREQUENCY RESPONSE OF THE COUPLED MODEL USING GOVERNOR DESIGN BASED ON DECOUPLED MODEL

- Interaction between the electromagnetic and mechanical parts of the generators exaggerates frequency oscillations.

- Tuning G-C of the plants without considering coupling between real-power and voltage dynamics can lead to system instability.

[1] M. Honarvar Nazari and M. Ilić, "Dynamic Stability of Azores Archipelago", Chapter 14, Engineering IT-Enabled Electricity Services, Springer 2012.

DYNAMIC MODEL OF SAO MIGUEL ISLAND



One-line diagram of the equivalence power system of Sao Miguel Island

Masoud Honarvar Nazari

[1] M. Ilić and **M. Honarvar Nazari**, "Loss Minimization and Voltage Profile in Azores Archipelago", Chapter 13, Engineering IT-Enabled Electricity Services, Springer 2012.

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PRESENCE OF LOW FREQUENCY OSCILLATIONS

- Decoupled Real Power Frequency Dynamic Model

  - Slow modes of oscillation exist in the system. This is attributed to the weak coupling between the thermal plants (diesel and geothermal) and hydro plants there.

[1] M. Honarvar Nazari and M. Ilić, “Dynamic Stability of Azores Archipelago”, Chapter 14, Engineering IT-Enabled Electricity Services, Springer 2012.

Issues of Using Diesel Generator for Primary Control

- Diesel generator is the only source to compensate fluctuations of intermittent resources
  - This could cause wear-and-tear of governor control
  - Increasing emission of diesel generator
  - Increasing operating and maintenance costs
- CMU work shows using gas turbine for compensating fluctuations of wind increases ~20% CO_2 and 50-70% No_x emission, compared to full power steady state operation.

Potential Solutions to Dynamic Stability Problem

- Designing faster control (e.g. bang-bang or high gain) for the hydro plant (applicable in Flores)
- Designing advanced power electronics control for diesel (PSS) and/or for wind plants
- Implementing flywheels with fast dynamic response

CONCLUSIONS

- Strong interactions between the electromagnetic and electromechanical parts of the generators could result in system instability

- Governor control of diesel generation should not be used for compensating fluctuations of wind

CONCLUSIONS AND FUTURE WORK

- Designing advanced control systems or implementing fast flywheel storage can ensure stability

- Future work is to design optimal control to ensure both efficiency and dynamic stability of the islands