Power System Engineering and Software

DIgSILENT Pacific

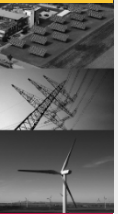
POWERFACTORY SOFTWARE | COMPLIANCE TESTING | CONSULTING SERVICES

- Transmission and distribution planning studies
- Co-generator compliance studies
- Wind and solar power integration studies
- Industrial system design and protection coordination
- Large system eigenvalue/small signal stability studies
- Harmonic and voltage flicker studies
- Excitation system modelling and design
- Generator compliance and R2 testing
- PowerFactory monitor
- PowerFactory training and support

DIgSILENT Worldwide

DIgSILENT Head Office (Gomaringen, Germany)

The DIgSILENT Group
>80 experts in 7 countries



A brief history of DIgSILENT Software

DIgSILENT PowerFactory & StationWare

1985: First commercial power system analysis software (Unix, M.Schmieg)
1995: Final release DIgSILENT 10.31
1998: DIgSILENT *PowerFactory* 11.0
2000: DIgSILENT *PowerFactory* 12.0
2001: DIgSILENT opens new offices in Gomaringen, Germany
2003: DIgSILENT *PowerFactory* 13.0
2005: DIgSILENT introduces *StationWare*
2008: DIgSILENT *PowerFactory* 14.0
2011: DIgSILENT *PowerFactory* 14.1

PowerFactory Installations in more than 100 countries; > 10,000 licenses

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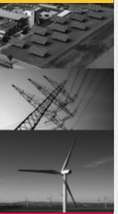
DIgSILENT Pacific

- Established in Australia in 2001
- Offices in Melbourne, Perth and Brisbane
- Total staff: 27
- Professional engineers: 22
- Our backgrounds
  - Transmission & distribution grid & controls planning
  - Generation control systems design
  - Renewable energy
  - Primary and secondary engineering



DIgSILENT Pacific

- Activities
  - PowerFactory support and training
  - Power system studies
  - Generation control systems design
  - Large emphasis on renewable energy
  - Generator, AVR and governor compliance testing services

Island Dynamic Modelling

- PowerFactory in Australasia
  - More than 100 PowerFactory user organisations in Australasia
  - More than 1,000 PowerFactory licenses sold locally
  - Many islanded networks applications – Example: mine sites in remote regions of Australia
  - Case 1: New Zealand: PowerFactory a standard in New Zealand for Transmission, Distribution, Generation and Regulatory authorities.

Island Dynamic Modelling

- Definitions:
  - Island network
    - Vary in size
    - Vary in generation mix (diesel turbines/reciprocating engines; hydro; steam)
    - Different networks may have different issues
  - Renewables
    - Typically refer to wind generation
    - Normally includes PV solar
    - Biomass; hydro

Island Dynamic Modelling

- The power system control issue

Controlled parameter	Short term	Medium term	Long term
	(~ 1sec)	(~ 5 sec – 1 min)	(~ 15 min – 1 hr)
Voltage (Reactive power)	AVR	Taps	Switching
Frequency (Active power)	Inertia	Governor & UFLS	Dispatch

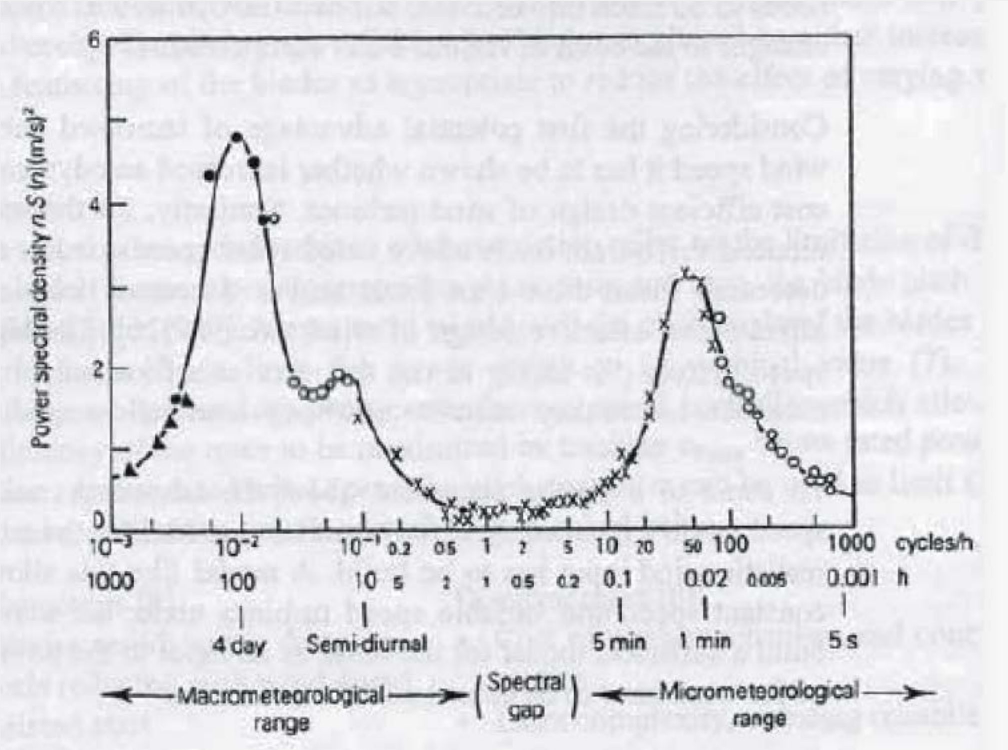
Island Dynamic Modelling

- What is unique about island systems?
  - Often diesel generators with relatively low inertia are used
  - Diesel generators must operate at rated capacity to avoid glazing of pistons
  - Wind and solar replacing conventional generators would further reduce inertia
  - Wind generation can introduce power oscillations that may lead to instability and damage to plant in extreme cases

  - Note: Other normal power system issues that apply for all grids are not explicitly discussed, but also applies

Island Dynamic Modelling

- Wind (and Solar) Generation
  - Power oscillations not present in conventional generation
  - Wind gusts/turbulence
  - Cloud movement across solar farm
  - Conventional power controllers are slow



Source: T Burton, D Sharpe, N Jenkins & E Bossanyi. Wind Energy Handbook

Island Dynamic Modelling

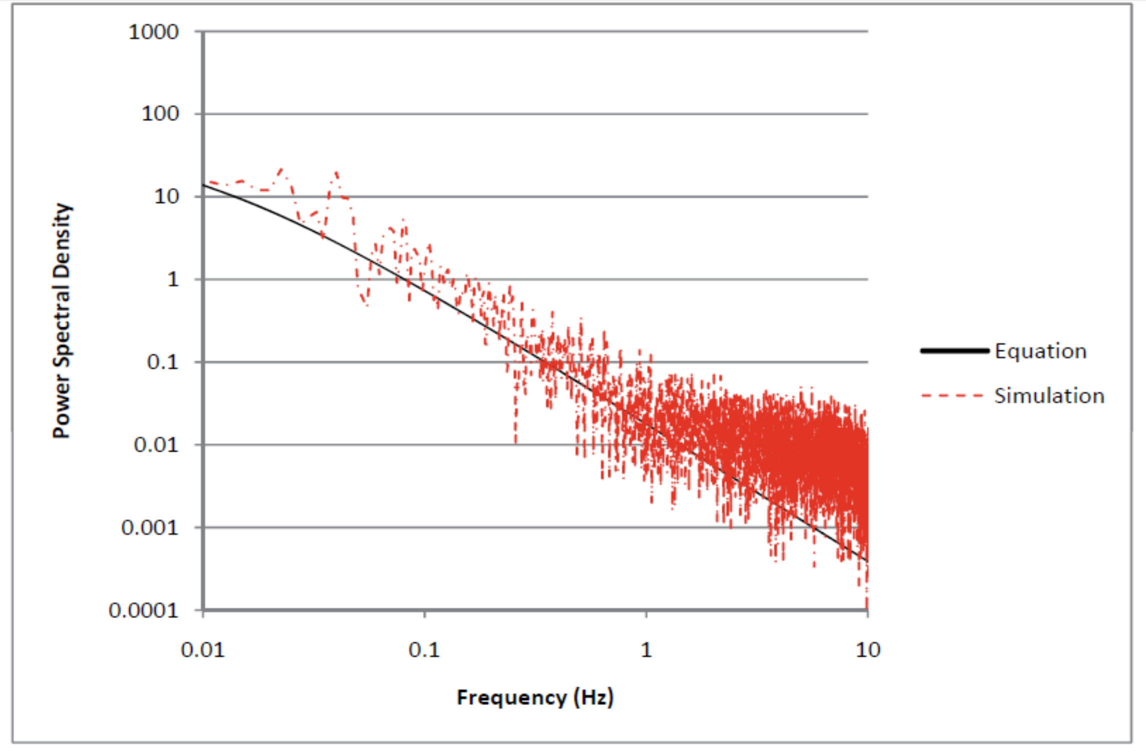
- To consider power oscillations on a power system:
  - Dynamic models of generation and load must be accurately modelled
  - Wind turbulence is stochastic described in terms of power spectral density (PSD)
  - Kaimal spectrum is commonly used

$$S_t(f) = \frac{\sigma^2 L}{2v_{w0}(1 + \frac{3Lf}{2v_{w0}})^{\frac{5}{3}}}$$

  - Where: L = turbulence length-scale
  - Often use (conservative) 9 m/s mean wind speed and 12 % turbulence intensity

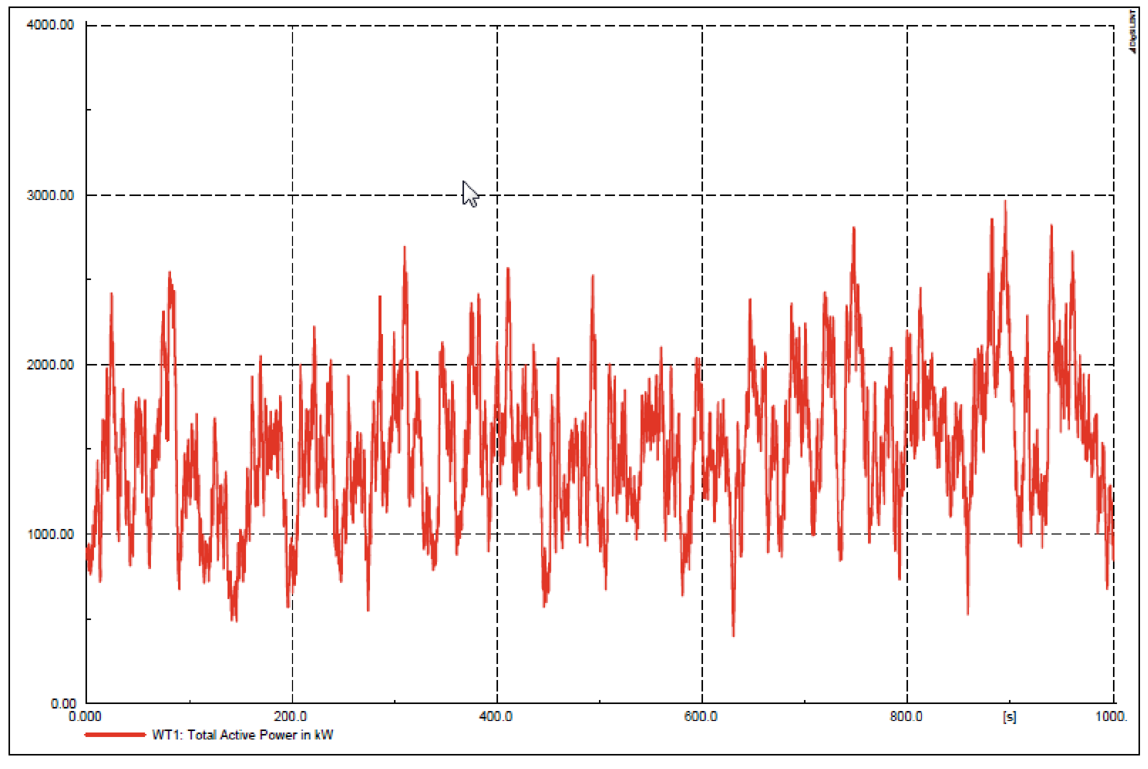
Island Dynamic Modelling - Example

- Figure compares simulation *vs* theoretical wind model
- Models to consider:
  - Blade aero dynamics
  - Turbine gearbox and shaft
  - Tower shadow effect
  - Turbine control system



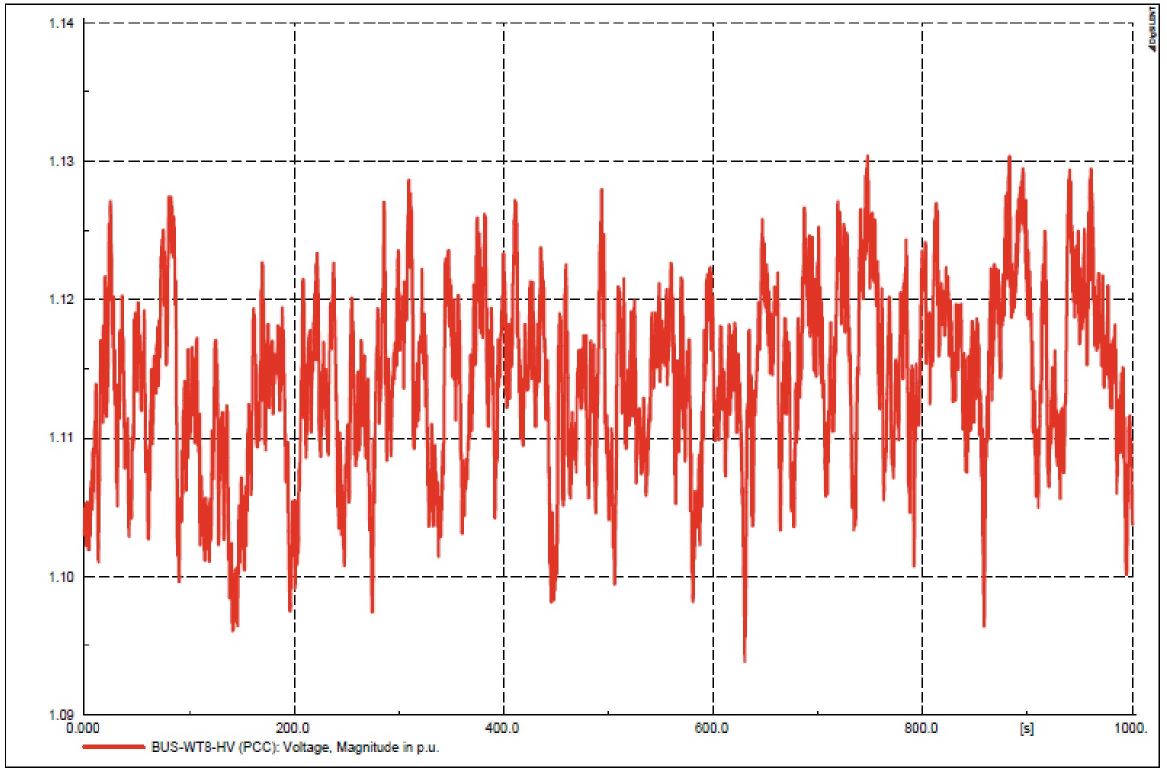
Island Dynamic Modelling - Example

- Simulated wind turbine power output due to wind turbulence
- Full scale: 1,000 seconds
- Power output: 600 kW – 3,000 kW
- Result: frequency variation – depending on system inertia



Island Dynamic Modelling - Example

- Simulated voltage at PCC
- Full scale: 1,000 seconds
- Voltage range: 1.05 – 1.13 (depends on power system fault level)



Island Dynamic Modelling

- PowerFactory functionality used:
  - Ease of dynamic modelling; not reliant on default models
  - Proven accuracy of results
  - Lots of world-wide studies in the area of wind – many examples
  - Powerful instrumentation including FFT for frequency domain representation
  - Much R & D in renewables conducted in Europe commonly uses PowerFactory software
  - Very strong support locally
  - De facto standard for power system modelling in New Zealand.

Island Dynamic Modelling

- Conclusion
  - Very easy to develop custom user defined models
  - Strong regional user base
  - Highly accurate models: Results match actual measurement
  - Leads to increased investment confidence