Microgrid & Supporting Technologies

Afshin Izadian, PhD
School of Engineering and Technology, IUPUI
May 6, 2014
Outline

• Microgrid Layers
• Enabling Technologies at ESPEL
  • Power Electronic Converters
  • A New Inverter Topology
  • A New Wind Power Transfer System
  • Hybrid Wind-Solar and Storage Microgrids
• Outcomes
Microgrid Enabling

What is a microgrid

ESPEL is involved:

- Power Electronics
  - Circuit and Controls
- Distributed Generation
  - Wind
  - Solar
  - Hybrid
- Control and Supervisory Layer
  - Component and System
- Energy Storage
  - Electrical
  - Mechanical

Power Electronics
-DC Choppers
Power Electronics
- AC-DC Rectifiers

Thyristor Based

Transistor Based
Power Electronics
- Inverter
Enabling Technologies
- New Inverter Design
Inverter

High Frequency  2-20 kHz

Low Frequency  60 Hz

Infinite-Level Voltage
Simulation Results

1-Phase Pure Sinusoidal Voltage Tracking Performance, 110V, 60 Hz

Output Voltage Reference Voltage

3-Phase Pure Sinusoidal Voltage Tracking Performance, 110V, 60 Hz

Phase a Phase b Phase c
Simulation of Robustness

Input Voltage Change at t=0.05 sec, from 75 to 100V

Arbitrary Voltage Tracking Profile, Single Switch Inverter
Load Change

Inductive Load Voltage and Current

Output Ref.  Load Volt  Load Current

Load Change

Output Ref.  Load Volt  Load Current

Load (Ω)  
3+j1.88  6+j1.88  6+j3.77  6+j7.54  10+j3.77  20+j3.77

THD  
0.09  0.10  0.09  0.10  0.15  0.23

Z_L = 6+j7.54  Z_L = 3+j3.77
Bipolar DC and HVDC

Robot Speed and Moving Direction Control

Output Voltage

Reference

HVDC-Power Inversion, 400kV DC to 400kV AC 60Hz
Variable Frequency

Variable Frequency (0-200Hz)

Amplitude (V) and (A)

Output Ref. Load Volt Load Current

$Z_L = 3 + j1.88$
New Inverter Experiment
Enabling Technologies
- Distributed Generation Wind Power
Hydraulic Wind Power
Energy Storage

High Wind

- Excess Fluid
- Charging Mode
- Energy Storage
- Valve
- Main
- G
- Aux.
- High Wind Power

Low Wind

- No Wind Power
- No hydraulic fluid from tower
- Discharging Mode
- Valve
- Main
- G
- Aux.
- Energy Storage

Nonlinear Model

Energy Systems and Power Electronics Laboratory
Purdue School of Engineering and Technology-Indianapolis
Nonlinear Modeling
- System Response

Energy Systems and Power Electronics Laboratory
Purdue School of Engineering and Technology-Indianapolis
Nonlinear Modeling
- State Space Simulation Results

- Primary Motor Flow
- Primary Motor Angular Velocity
- Pump/Motor Gauge Pressure
- Auxiliary Motor Angular Velocity
Piecewise Affine Models
- Modeling and Control Approach

Energy Systems and Power Electronics Laboratory
Purdue School of Engineering and Technology-Indianapolis
Piecewise Affine Models
-Experimental Validation
Control and Supervisory Layer

• Control of Power Converters
  • Explore the functionality and control of
    • Rectifiers
    • Inverters
    • Choppers

• Control of Distributed Generation
  • MPPT
  • Power Tracking
Enabling Technologies
- Distributed Power Generation

• Hybrid Wind-Solar-Battery

Energy Systems and Power Electronics Laboratory
Purdue School of Engineering and Technology-Indianapolis
Control of Wind Unit

![Diagram showing the control system of a wind unit]
Control Performance

The characteristic curve of wind turbine

Torque-Rotor Speed Characteristics of Wind Turbine

Wind MPP Tracking Profile

Energy Systems and Power Electronics Laboratory
Purdue School of Engineering and Technology-Indianapolis
Control of Solar Unit

![Graphs showing I/V and P-V characteristics of solar units with different irradiances.](image)

![Graph showing MPPT P&O Tracking with sudden changes in irradiance.](image)
Control of Combined Wind-Solar System

MPPT Tracking Profile for Combined System

- Wind Power
- Solar Power
- Load Power
- Power Reference (5HP)

Wind MPPT Mode
Solar MPPT Mode

- v=6m/s
  - R=1000W/m²
- v=8m/s
  - R=800W/m²

Wind MPPT Mode
Solar Power Tracking Mode
Thank you.

Afshin Izadian
aizadian@iupui.edu