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Advanced Power Systems and Controls Laboratory

Switching Control of Integrated Wind Turbine and Rechargeable Battery System

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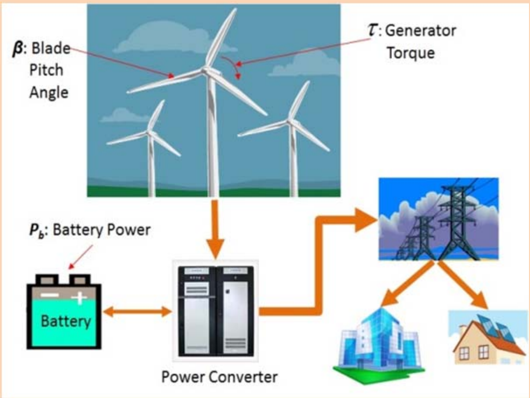
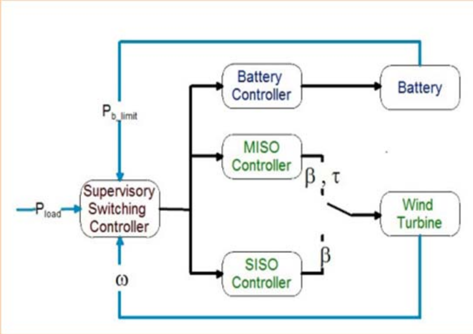


Motivation:
To mitigate wind power intermittency using rechargeable battery as reserve power source

Objectives:
- Design of supervisory switching controller for the integrated system
- Stability analysis of the controller

Methodology:
- Supervisory switching control based on power demand
- Two control modes for wind turbine: MISO & SISO
- Proportional Integral (PI) feedback control
- Switching conditions to establish global stability of the integrated system using Common Quadratic Lyapunov Function(CQLF)
- Simulation under varying wind speed conditions and varying power demand



System Modes	MISO	SISO
Inputs	Blade Pitch Angle, Generator Torque	Blade Pitch Angle
Output	Power	Power
Switching Condition	$P_{wind} < P_{load} + P_{charging}$	$P_{wind} > P_{load} + P_{charging}$

MISO control laws

$$\frac{d\beta}{dt} = K_{\beta M}(\beta_d - \beta)$$

$$\tau = K_\tau \omega^2$$

SISO control law

$$\beta = K_p(P - P_d) + K_i \int (P - P_d)dt$$

Open Loop System

MISO $$\dot{\omega} = -\frac{1}{J\omega_0^2}(P_{wind})\omega$$

SISO $$\dot{\omega} = -\frac{1}{J\omega_0^2}(P_{wind} - P_{load} - P_{charging})\omega$$

Contribution:
- Supervisory switching controller to mitigate wind power intermittency
- SISO control law
- Stabilizing switching conditions

Future Work:
- Stability of switched nonlinear system
- Control law robustness to modeling uncertainties and measurement noise

Closed Loop System with Feedback Control

MISO $$\begin{bmatrix}\dot{\beta}\\ \dot{\omega}\end{bmatrix} = \begin{bmatrix} -K_{\beta M} & 0 \\ \frac{a_1}{\omega} v_W^3 \frac{dC_P}{d\beta} & \frac{a_1}{\omega} v_W^3 \frac{dC_P}{d\omega} - \frac{a_1}{\omega^2} v_W^3 C_P - \frac{G_r}{J} 2K_\tau \omega \end{bmatrix} \begin{bmatrix}\beta - \beta_0 \\ \omega - \omega_0\end{bmatrix}$$

SISO $$\begin{bmatrix}\dot{\beta}\\ \dot{\omega}\end{bmatrix} = \begin{bmatrix} \frac{df}{d\beta} & \frac{\partial f}{\partial \omega} \\ \frac{a_1}{\omega} v_W^3 \frac{dC_P}{d\beta} & \frac{a_1}{\omega} v_W^3 \frac{dC_P}{d\omega} - \frac{a_1}{\omega^2} v_W^3 C_P + \frac{P_d}{J\omega^2} \end{bmatrix} \begin{bmatrix}\beta - \beta_0 \\ \omega - \omega_0\end{bmatrix}$$

Simulation Results