Maximum Power Point Tracking Strategy for Large-Scale Wind Generation Systems Considering Wind Turbine Dynamics

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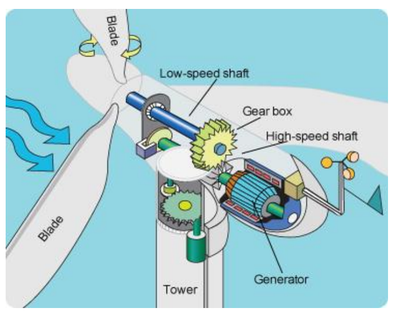
Objective: An improved maximum power point tracking (MPPT) method is proposed, such that short-term wind speed forecasting, wind turbine dynamics, and MPPT are collectively considered to improve system efficiency.

I. Introduction

➢ Challenges of Wind Power Utilization

- The uncertainties of wind speed
- The mechanical losses of the WECS
- The physical constraints of the WECS
- Multiple objectives of the control system

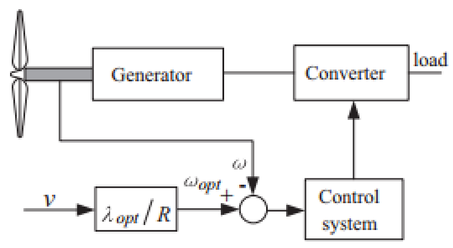


Wind power → Mechanical power → Electric power

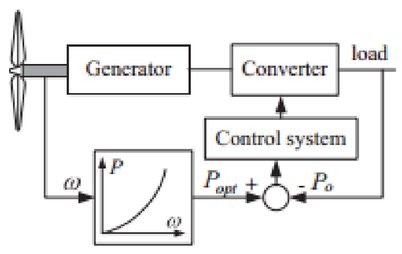
Wind Energy Conversion System (WECS)

➢ A Brief Review of Conventional MPPT Methods

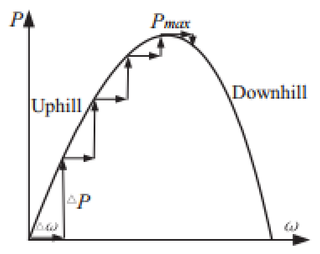
MPPT technique	Anemometer	Tracking reference	Prior-knowledge of system	Online updating	Complexity	Tracking speed
TSR	Required	$\omega^* = \lambda_{opt} v_m / R$	Required	No	Low	Fast
PSF	Not required	$P_g^* = k_{opt}\omega^3$	Required	No	Low	Fast
OT	Not required	$T_g^* = k_{opt}\omega^2$	Required	No	Low	Fast
WSE	Not required	$\omega^* = \lambda_{opt} v_e / R$	Required	Depending on training methods	High	Fast
HCS	Not required	N/A	Not required	Yes	High	low



Tip speed ratio (TSR)



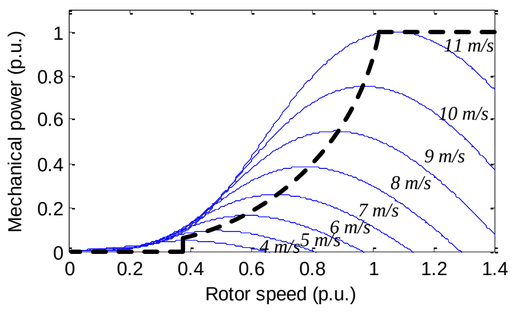
Power signal feedback (PSF)

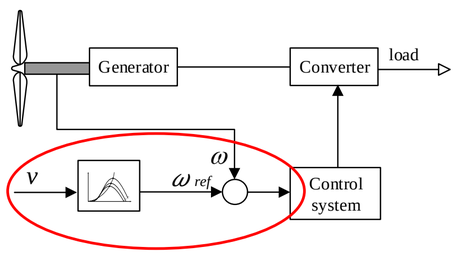


Hill-climb searching (HCS)

II. Problem Formulation and Solution Approaches

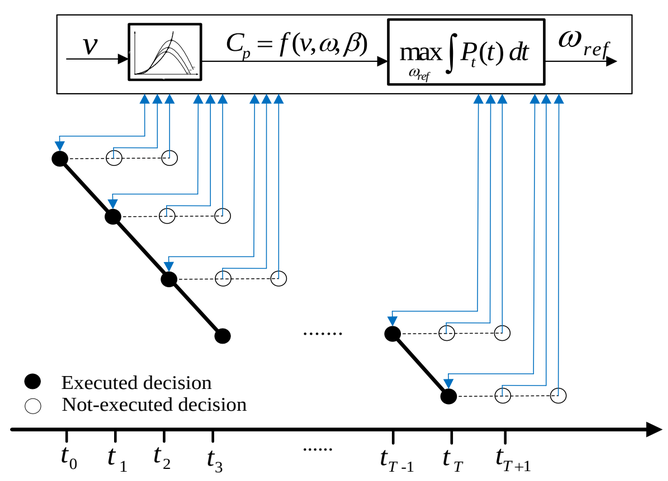
Conventional MPPT Method





$$\omega_{ref} = \frac{\lambda_{opt}}{R} v$$

Improved MPPT Method



$$\max_{\omega_{ref}} \left[\int_{t_0}^{t_1} \frac{\rho\pi R^2 v_1^3}{2} C_p(\lambda,\beta)\,dt + \int_{t_1}^{t_2} \frac{\rho\pi R^2 v_2^3}{2} C_p(\lambda,\beta)\,dt \right]$$

$$= \max_{\omega_{ref}} \left[\int_{0}^{t_1} \frac{\rho\pi R^2 v_1^3}{2} f(\omega)\,dt + \int_{t_1}^{t_2} \frac{\rho\pi R^2 v_2^3}{2} f(\omega)\,dt \right]$$

III. Simulation Results

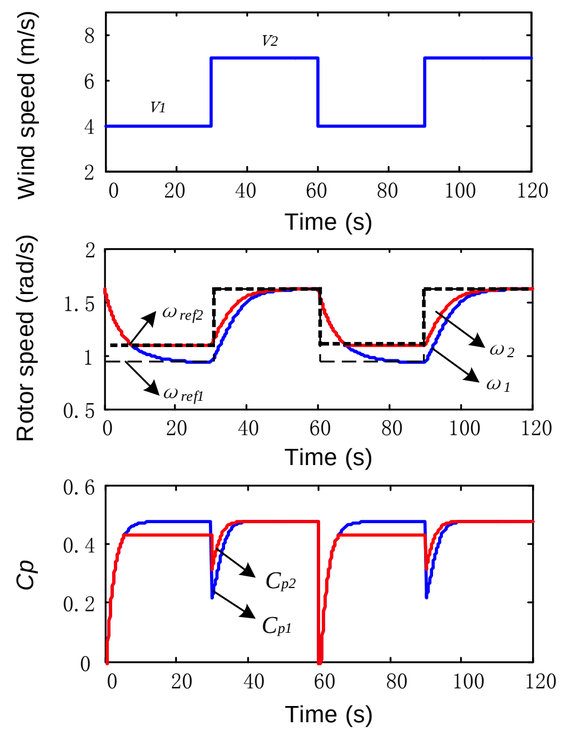


Figure. Simulation of two MPPT methods.

IV. Conclusions

- In this paper, a novel MPPT strategy is proposed for the variable-speed variable-pitch WECS operating in the partial load region. The control strategy aims to achieve a balance between power output maximization and operating costs minimization. It can improve the efficiency of MPPT and increase the life time of mechanical components.
- In the proposed approach, the wind speed error is modeled as Norm-Bounded without a known distribution. This likely represents a more realistic model in practice and avoids the assumption of the noise distribution.
- Furthermore, dynamic performances of large-scale wind generation systems are considered and an improved MPPT method is proposed to increase the system efficiency.

Reference

Can Huang, Fangxing Li, and Zhiqiang Jin, "Maximum power point tracking strategy for large-scale wind generation systems considering wind turbine dynamics," IEEE Transactions on Industrial Electronics, vol. 62, no. 4, pp. 2530-2539, April 2015