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Power strategies for maximum control structure of a wind energy conversion system with a synchronous machine

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Abstract

The control of a wind energy conversion system can be decomposed into two parts: a local control depending on the power structure and a global control (strategy) deduced from global considerations. The local part ensures an efficient energy management of each component of the system. The local control structure can be deduced from the Energetic Macroscopic Representation, which is a graphical description of the system according to action and reaction principle. Using inversion rules, the deduced control structure is composed of a maximum of control operations and measurements. The global control part is independent of the power structure. This strategy part leads to achieve power objectives (active and reactive power targets) and system constraints (machine efficiency and DC bus limitation). Several strategies can be defined for the same system. These control decompositions are applied to a wind generation system composed of a permanent magnet synchronous generator and two three-phase converters. Simulation results are provided for a 600 kW wind energy conversion system.
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Keywords: Wind energy; Wind systems; Wind turbine; Control

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Nomenclature

c (F)	various capacitor
C_T	torque coefficient of the wind turbine
e (V)	electromotive force
f (N ms)	coefficient of viscous friction
F (N)	various forces
i (A)	various currents
J (kg m^2)	moment of inertia
l (H)	various inductances
m	various modulation coefficients of power electronics converters
p	number of pole pair of the machine
P (W)	various active powers
Q (Var)	various reactive powers
r (Ω)	various resistances
R (m)	blade radius
s_{ij}	switching functions of power electronics converters
S (m^2)	swept area of the blades
T (N m)	various torques
u (V)	various voltages
v (m/s)	various speeds
x_{est}	estimated value of variable x
x_{mes}	measured value of variable x
x_{ref}	reference value of variable x
ϕ	flux of the machine
λ	tip speed ratio
Ω (rad/s)	various rotation speeds
Θ	rotor position of the machine
ρ (kg/m^3)	air density

1. Introduction

There has been a strong development in Wind Energy Conversion Systems (WECS) over the last 10 years. Indeed, they offer energy without important negative environmental impact. In line with reliability considerations, the design of the mechanical part is increasingly simplified [1].

But this imposes a more complex electromechanical conversion with a variable frequency operation [2,3]. Variable–speed variable–frequency systems improve the annual energy production [4], are more flexible under various wind conditions and reduce the stresses of the turbine [5]. Nowadays, several solutions can be achieved using the design evolutions of aerodynamics, power electronics and electrical machines. The squirrel cage induction machine with two voltage–source–converters is the most flexible conversion structure [6–8]. Doubly fed induction machines with a direct connection to

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