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Model Predictive Control of DFIG-Based Wind Turbine

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CERTIFICATE OF ORIGINAL AUTHORSHIP

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.
I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

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Date: *7 Ocotber 2014*

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Abbreviations

RET	Renewable Energy Target
VFC	Variable Frequency Converter
WT	Wind Turbine
WF	Wind Farm
DFIG	Doubly Fed Induction Generator
QP	Quadratic Programming
PI	Proportional Integral
LQG	Linear Quadratic Gaussian
MPC	Model Predictive Control
DMPC	Decentralised Model Predictive Control
CO_2	Carbon Dioxide
RSC	Rotor Side Converter
GSC	Grid Side Converter
SDR	Series Dynamic Resistor
NSW	New South Wales
HAWT	Horizontal Axis Wind Turbine
TSR	Tip Speed Ratio
PSF	Power Signal Feedback
MPPT	Maximum Power Point Tracking
SCIG	Squirrel Cage Induction Generator
WRIG	Wound Rotor Induction Generator
PMSG	Permanent Magnet Synchronous Generator
WRSG	Wound Rotor Synchronous Generator
WECS	Wind Energy Conversion System
WTGS	Wind Turbine Generator System
ORC	Optimal Regime Characteristic
MW	Mega Watt
MIMO	Multi-Input-Multi-Output
LVRT	Low Voltage Ride Through
HVRT	High Voltage Ride Through

Abbreviations

FRT	Fault Ride Through
STATCOM	Static synchronous Compensator
UK	United Kingdom
PCC	Point Common Coupling
IGBT	Insulated Gate Bipolar Transistors
GTO	Gate Turn-Off Thyristors
PWM	Pulse Width Modulation
APRC	Asymptotically Positive Realness Constraint

Abstract

Renewable energy as a green source of energy is clean, accessible and sustainable. Due to advanced control, lower cost and government incentives, wind energy has been the largest growth among other renewable sources.

With fast growing in the new generation of generators, Doubly Fed Induction Generators (DFIGs) became more popular because of handling a fraction (20-30%) of the total system power which leads to reduce the losses in the power electronic equipment and also their ability in decoupling the control of both active and reactive power. In addition, DFIGs have better behaviour in system stability. Therefore, in this study, the model of one-mass wind turbine with DFIG is represented by a third order model.

Model Predictive Control (MPC), as a powerful control method to handle multivariable systems and incorporate constraints, is applied in order to compensate inaccuracies and measurement noise. The optimization problem is recast as a Quadratic Programming (QP) which is highly robust and efficient. Multi-step optimization is introduced to bring the unhealthy voltages as close as possible to the normal operating points so that leads to minimize the changes of the control variables.

In order to regulate the power flow between the grid and the generator, it is essential to update reactive power with real power and actual terminal voltage besides reaching maximum reactive power. In this study, the updated control input applies feedback to MPC at each control step by solving a new optimization problem.