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Multiple target implementation for a doubly fed induction generator based on direct power control under unbalanced and distorted grid voltage

Key words: Direct power control, Doubly fed induction generator, Unbalanced and distorted grid voltage, Vector proportional and integral resonant regulator, Parameter deviation

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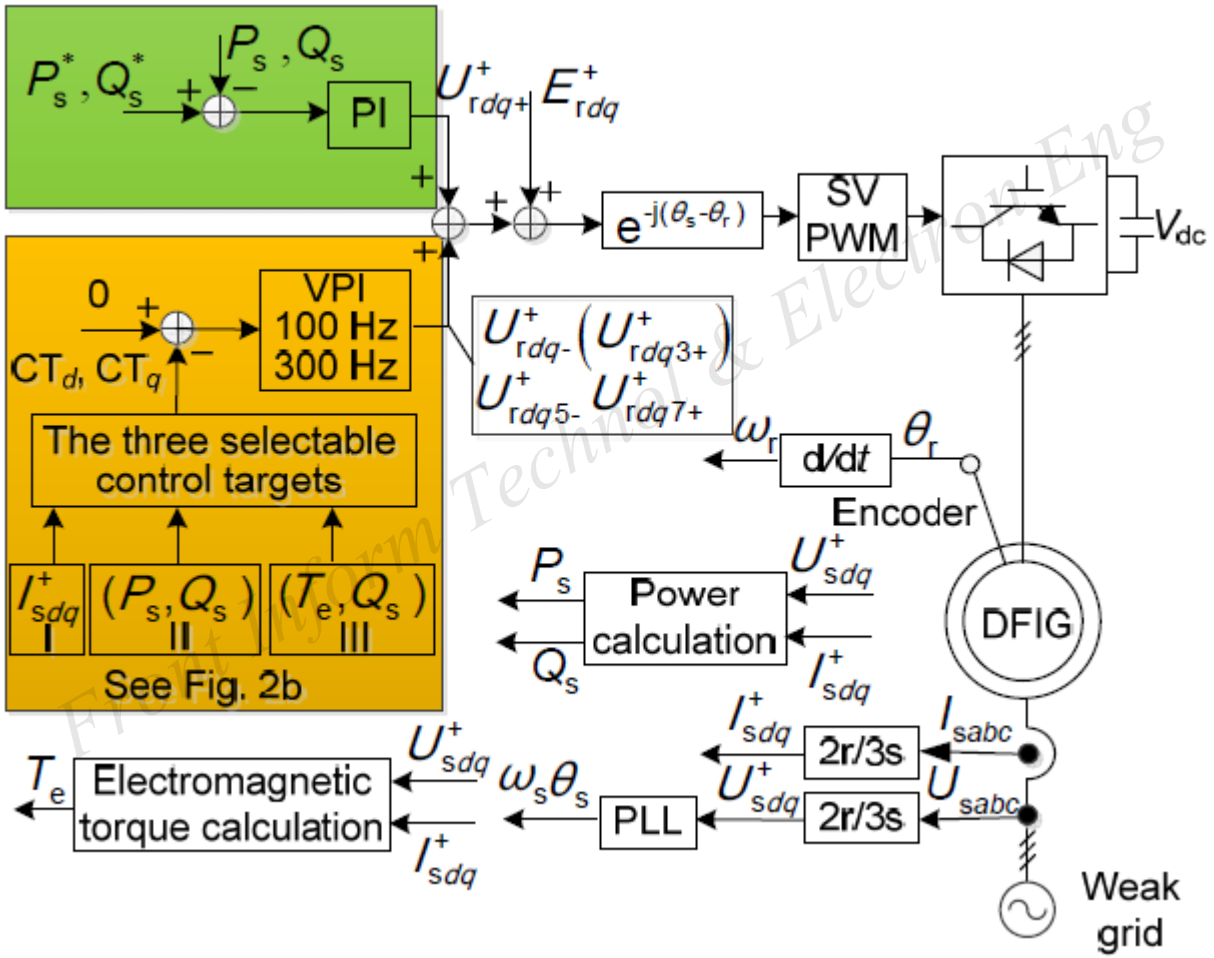
Introduction

• The operation performance of DFIG-based wind energy generation system can be deteriorated due to the existence of grid voltage unbalance and harmonic distortion.

• PI regulator is adopted to regulate the DFIG average active and reactive powers, while the VPI resonant regulator is used to achieve three alternative control targets: (1) balanced and sinusoidal stator current; (2) smooth instantaneous stator active and reactive powers; (3) smooth electromagnetic torque and instantaneous stator reactive power.

• The major advantage of the proposed control strategy over the conventional method is that neither negative and harmonic sequence decomposition of grid voltage nor complicated control reference calculation is required.

Control block diagram

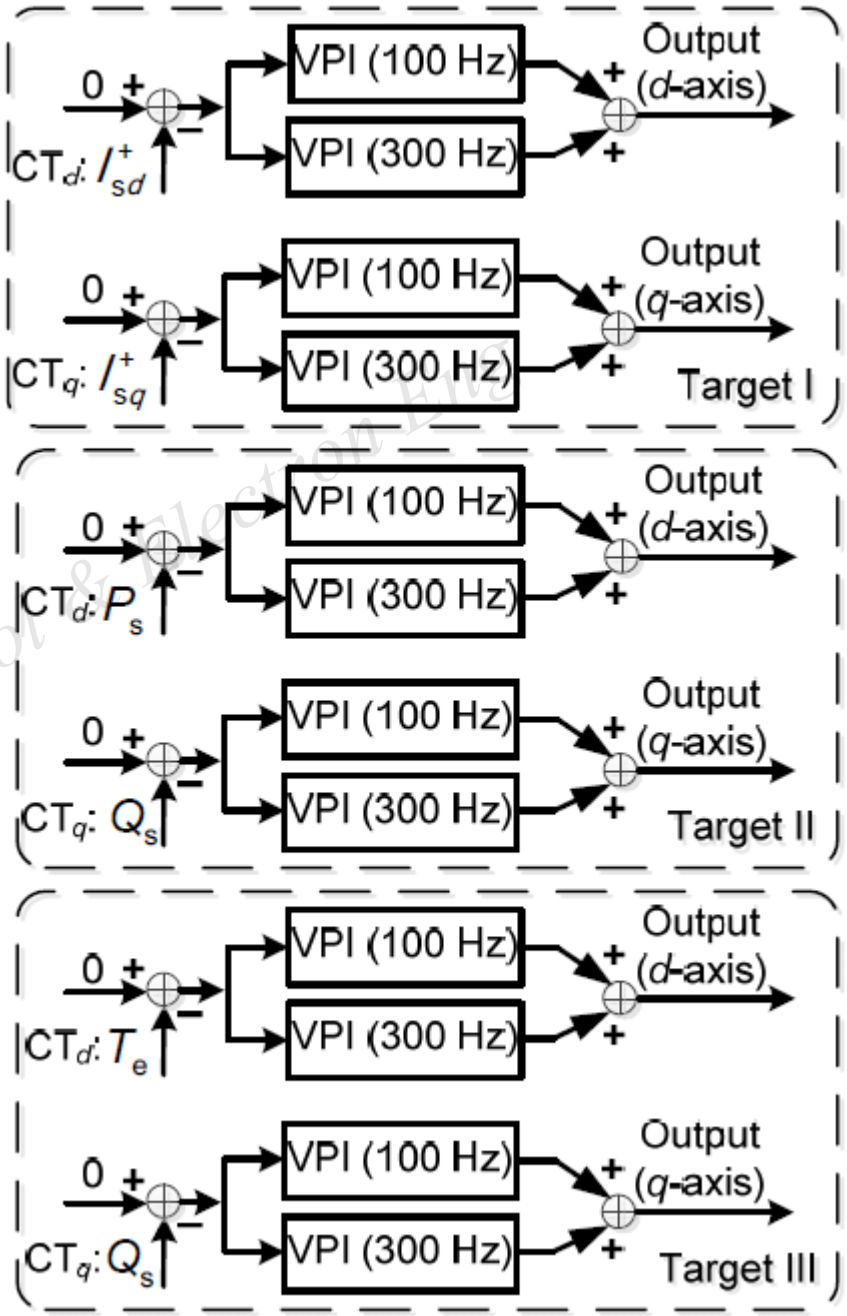


Detailed control target block diagram

Control target I:
balanced and sinusoidal stator current

Control target II:
smooth stator active and reactive powers

Control target III:
smooth electromagnetic torque and stator reactive power



Simulation results

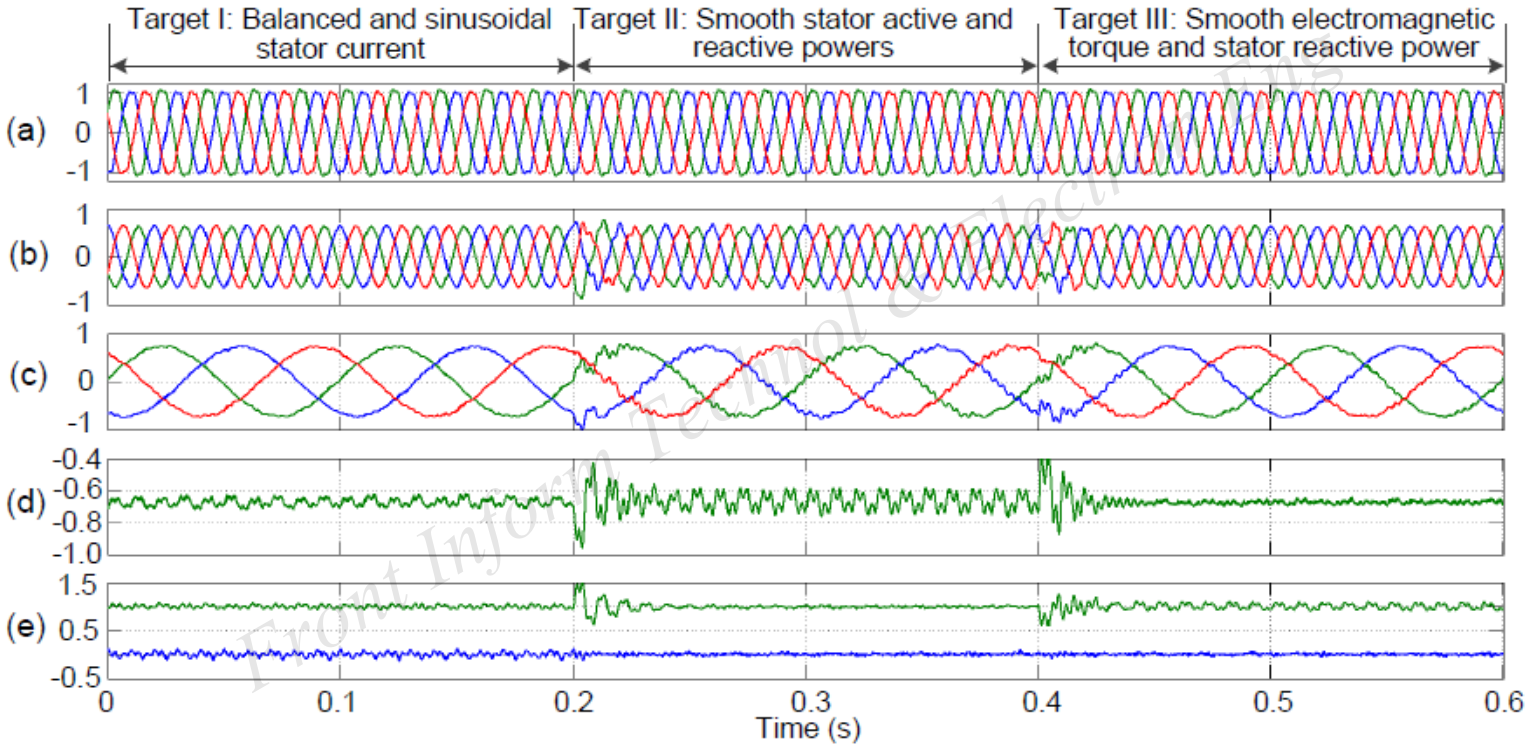


Fig. 4 Simulation results of steady state performance of DFIG when the three respective control targets are achieved

(a) Three-phase stator voltage (p.u.); (b) Three-phase stator current (p.u.); (c) Three-phase rotor current (p.u.); (d) DFIG electromagnetic torque (p.u.); (e) Stator active and reactive powers (p.u.)

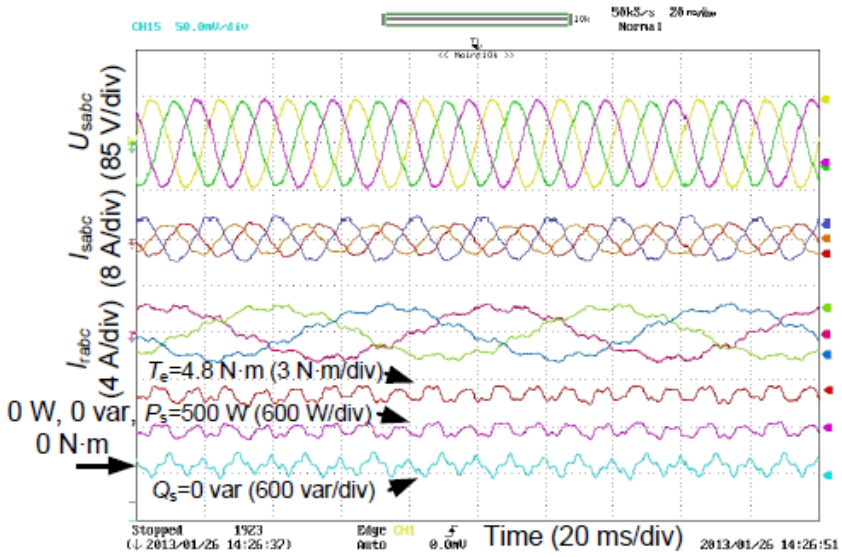
Simulation results (Con'd)

Table 2 Simulation analysis of the three control targets

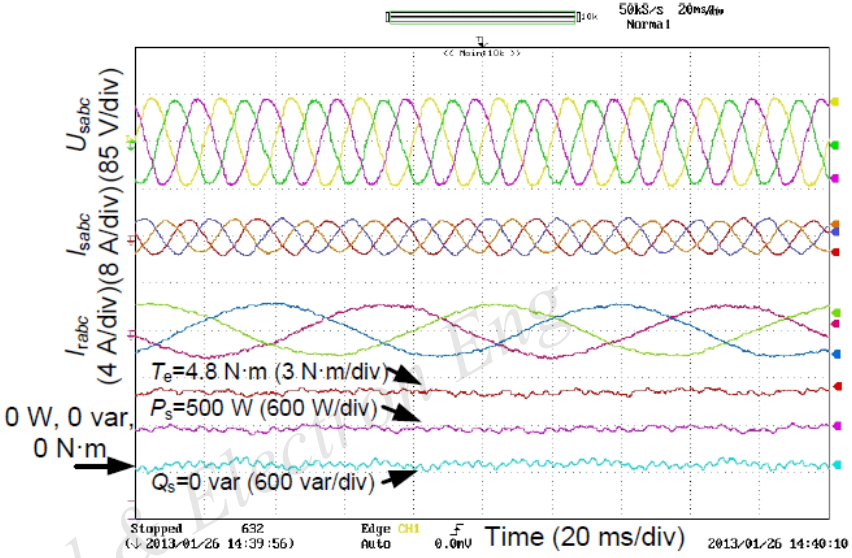
Parameter	Target I	Target II	Target III
I_s (5th)	**0.41%**	1.65%	1.04%
I_s (7th)	**0.46%**	1.79%	1.04%
I_s (negative)	**0.31%**	1.21%	0.33%
I_s (3rd)	0.37%	1.59%	0.25%
P_s (100 Hz)	2.66%	**1.54%**	4.44%
P_s (300 Hz)	3.87%	**1.95%**	4.25%
Q_s (100 Hz)	4.02%	**2.29%**	**2.23%**
Q_s (300 Hz)	4.24%	**2.04%**	**2.01%**
T_e (100 Hz)	4.01%	5.23%	**2.25%**
T_e (300 Hz)	1.41%	2.97%	**0.80%**

Bold values are the minimum ones in the corresponding target

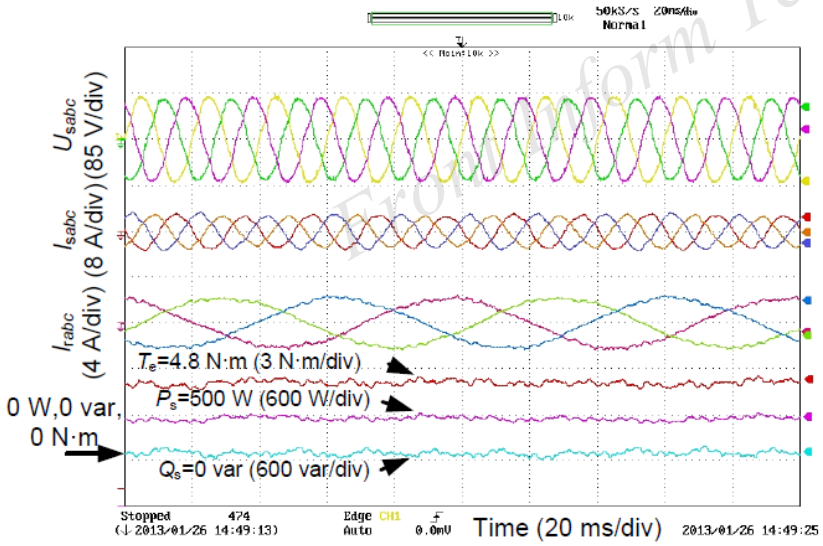
Experiment results



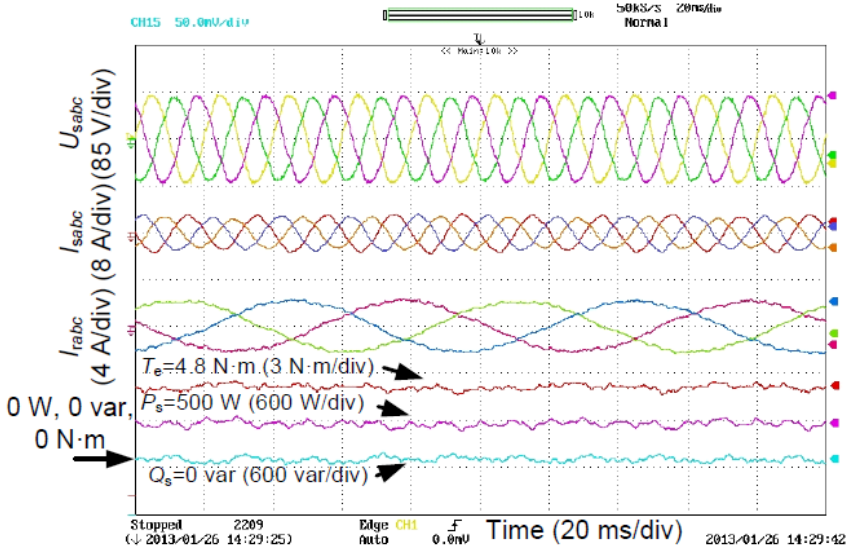
No control target



Control target I



Control target II



Control target III

Experimental analysis of the three control targets

Table 4 Experimental analysis of the three control targets

Parameter	No target	Target I	Target II	Target III
I_s (5th)	7.00%	**2.19%**	2.27%	2.58%
I_s (7th)	3.02%	**1.29%**	1.68%	1.62%
I_s (negative)	5.88%	**0.39%**	0.21%	0.81%
I_s (3rd)	0.30%	0.34%	2.90%	0.26%
P_s (100 Hz) (W)	±25	±6.1	**±4.5**	±12
P_s (300 Hz) (W)	±6.6	±2.4	**±1.9**	±2.1
Q_s (100 Hz) (var)	±25	±4.3	**±4.3**	**±4.5**
Q_s (300 Hz) (var)	±11	±8.1	**±4.1**	**±3.8**
T_e (100 Hz) (N·m)	±0.105	±0.019	±0.032	**±0.015**
T_e (300 Hz) (N·m)	±0.026	±0.009	±0.015	**±0.006**

Bold values are the minimum ones in the corresponding target

Conclusions

- This paper presents a multiple target implementation technique for DFIG under unbalanced and distorted grid based on DPC to achieve the three alternative control targets: balanced and sinusoidal stator current, smooth stator active and reactive powers, and smooth electromagnetic torque and stator reactive power.
- The major advantage of the proposed DPC strategy over conventional VOC and DPC strategies is that the need for a complicated and time-consuming grid voltage sequence decomposition and complicated reference calculation is eliminated, and thus faster dynamic response and more accurate steady state can be guaranteed.