A Review of Power Converter Topologies for Applications in Wind Energy

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Introduction

The potential converter and generator topologies for PMSG and DFIG are analyzed in this paper, along with some of the potential control approaches. This review provides a brief overview and contrast of the current state of the art for the topologies of power electronics and the transformation of wind energy methods.

Wind Energy Background

Each wind turbine's specific power consumption is determined and controlled by;

Pt = 1/2 ρACPv3wA, (1)

Where; Pt =turbine power,

ρ=air density,

A =swept turbine area,

CP =coefficient of performance and

v3w =wind speed

The tip-speed to wind speed ratio, or TSR, provided by a wind turbine affects the coefficient of performance of the device.

TSR=ωr/v_w (2)

Where; ω=rotational speed of turbine,

r =radius of turbine.

Permanent Magnet Synchronous Generator

The ability of using a notable cost benefit of using the PMSG is the absence of an outside excitation current, which necessitates a diode bridge rectifier at the generator sides.

A. Supply-Side Inverter For Thyristors
B. Supply-Side Inverter With Hard Switching
C. The Mid-Stage DC/DC Converter
D. PWM Back-To-Back Converters
E. Unconventional Schemes

Doubly Fed Induction Generators

The DFIG and induction generators work well for MW-scale high power applications. Significantly less converter power is rated, though. Although the stator receives the large amount of power, it is linked to the rotor.

A. SCR Converter And Static Kramer Drive Techniques
B. PWM Back-To-Back Converters
C. Matrix Converter

Wecs Summary

Generator (power range)

A. PMSG (kW)

1) Control Schemes
2) Converter Options
3) Device Count (Cost/Semiconductors)

B. DFIG (kW–MW)

1) Control Schemes
2) Device Count (Cost/Semiconductor)
3) Converter Options

Comparative Analysis-Pros And Cons

PMSG - Pros

• Lower expenditures and maintenance, Bearings survive longer.

• Speed of generator can be controlled even without gearboxes or gears.

• At low speeds, very huge torque can be acquired; removes the need for additional excitation or cooling.

• Flexibility of the design enables smaller as well as lighter layouts.

• Increased production level may be gained without needing to enhance size of generator.

DFIG - Pros

• Appropriate for high power usage, such as current developments in offshore system.

• Cheap converter price; typical converter rating is 25% of scheme power.

• Lowered deficits in the electronic power converter led to increased efficiency.

• Enables converter to produce or absorb reactive energy owing to the presence of DFIG.

• Due to the lower converter power rating, control may be applied more cheaply.

Comparative Analysis-Pros And Cons

PMSG - Cons

- Permanent magnet prices restrict the manufacturing of these kind of generators having turbine grid-connected designs on large scales due to their higher initial cost.
- Permanent magnets can become demagnetized by elevated temperatures, short circuiting and severe overloading.
- In the first stage of power conversion when a diode rectifier is used, the overall system's controllability is decreased.

DFIG - Cons

- A rise in control complexity brought on by the converter's increased switch count.
- Since the stator winding is connected to the grid directly, grid disturbances can affect it.
- Needs a maintenance-intensive gearbox because it is not direct drive.
- Has a higher initial cost and necessitates routine slip ring maintenance.
- Has higher sensitivity of slip ring and maintenance requirements in offshore installations.

New Developments In Converter Topologies

A systematic formula for deficit utilizing quadrature-direct axis current and speed is proposed, and a power-control method for WECS based on PMSG is recommended. Flux-weakening enables maximum torque at a given voltage and current, and SVM-based direct torque control (SVM-DTC) is used to manage switching non-linearity. Multiple-vector-direct-model-predictive power-control (MV-DMPPC) is introduced for GSC based on FPGA to address this problem.

Conclusion

The generation of wind energy has attracted a lot of research. Through this research, a succinct review of many WECS has been accomplished. In-depth descriptions have been provided of the converter topologies used in conjunction with PMSG and DFIG as well as various control schemes. To find a financially viable solution to the growing environmental problems, efforts are ongoing to improve converter and control schemes. With the advancement of power electronic technology, wind power generation has increased alarmingly the last ten years and thus will keep doing so.

Thank you

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