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Direct Driven Axial Flux Permanent Magnet Generator for Small-Scale Wind Power Applications

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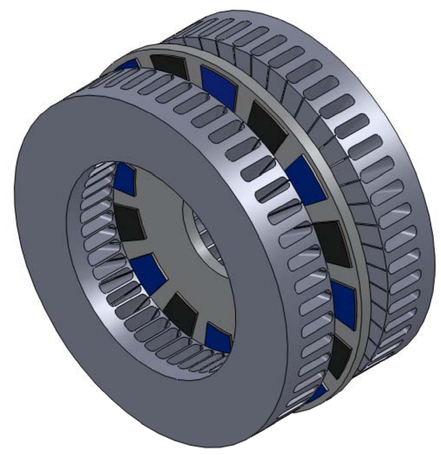
1 Summary

The use of direct driven generators in small-scale wind power conversion systems, instead of geared machines, reduces the number of drive components, which offers the opportunity to reduce costs and increases system reliability and efficiency. For such applications, characterized by low speed of rotation, the axial flux permanent magnet generator is particularly suited, since it can be designed with a large pole number and high torque density.

2 Proposed Structure

Double Sided Axial Flux Machine with Internal Rotor



Balanced axial forces

Slotted stators

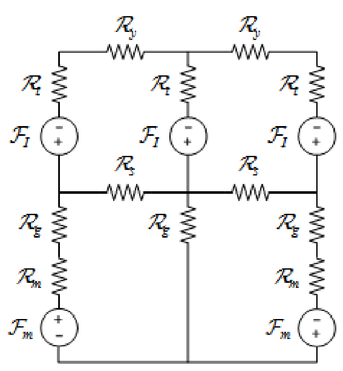
Three-phase distributed winding with one slot per pole and phase

Rare-earth PM axially magnetized

3 Design Procedure

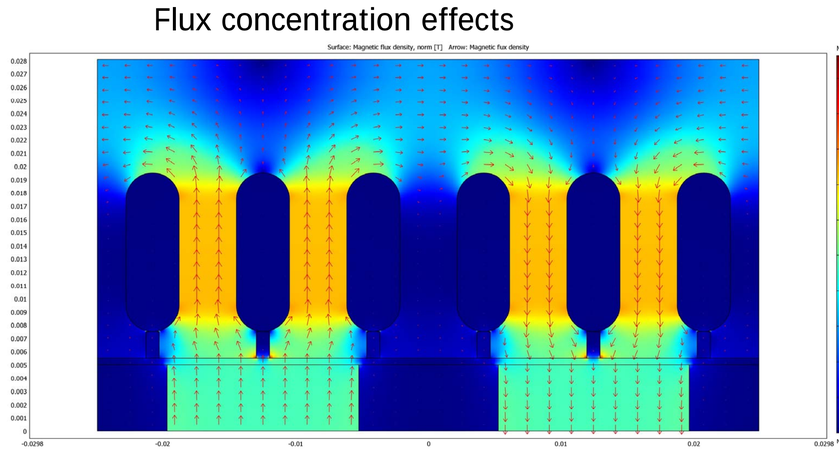
Analytical approach

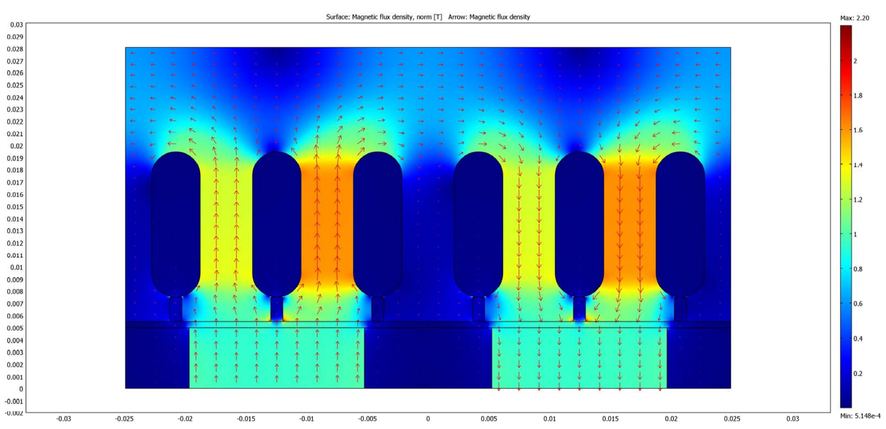
Magnetic loading
Non-linear reluctance network



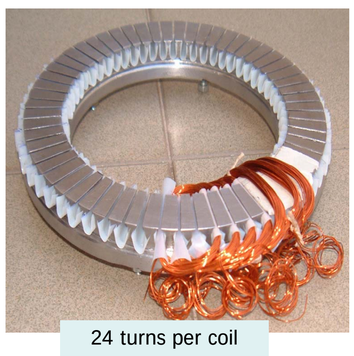
Numerical approach

2D FEA Magnetic flux density under no load and load conditions
Flux concentration effects

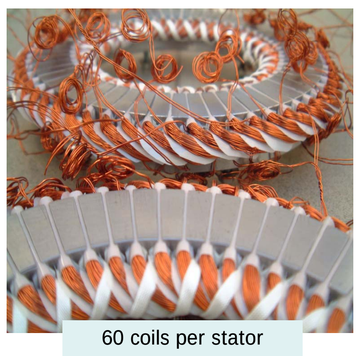




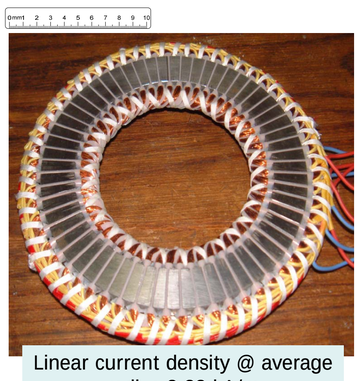
4 Experimental Generator



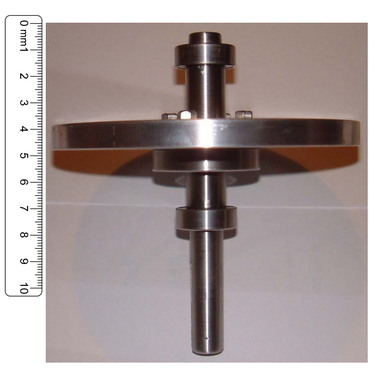
24 turns per coil

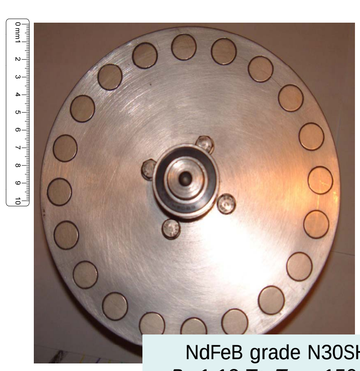


60 coils per stator

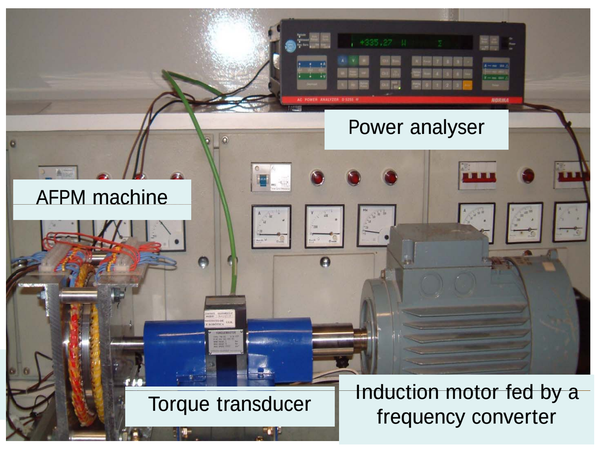


Linear current density @ average radius 8,28 kA/m



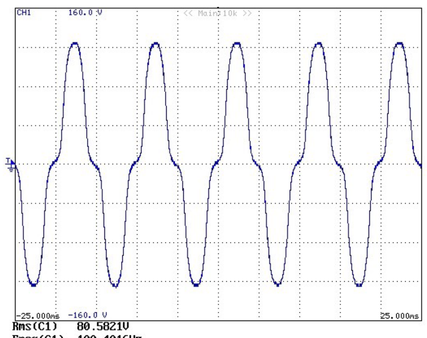


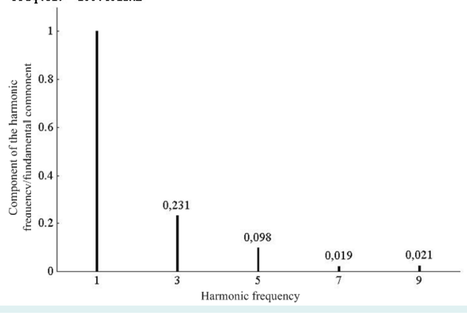
NdFeB grade N30SH
B_r=1,12 T; T_{max}=150 ºC



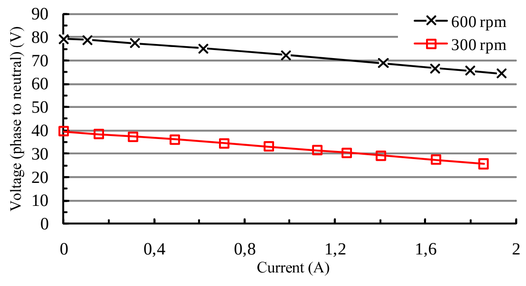
5 Test Results and conclusions

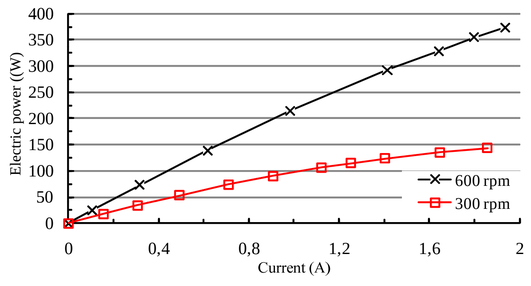
No load phase to neutral voltage@600 rpm

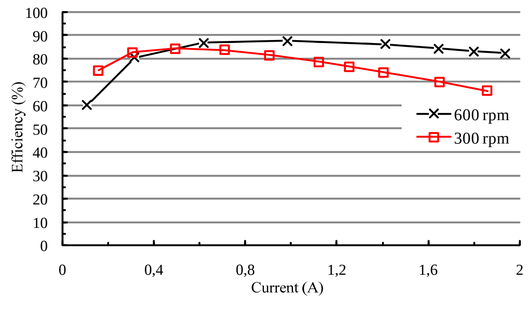




AC resistive load tests







Permanent magnet axial flux generators provide a viable solution to low speed direct driven conversion systems.

A simplified manufacturing process is achieved using a double sided structure with internal rotor.

Shifting one stator one half of the slot pitch with respect to the other reduces the harmonic content of the no load phase to neutral voltage.

Efficiency at rated operating condition is 86%.

Large end windings are responsible for high Joule losses

It should be considered the use of concentrated windings instead distributed windings in order to increase the efficiency.

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