Armature Reaction Field Adjustment in Permanent Magnet Synchronous Generators

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Permanent Magnet Synchronous Generator

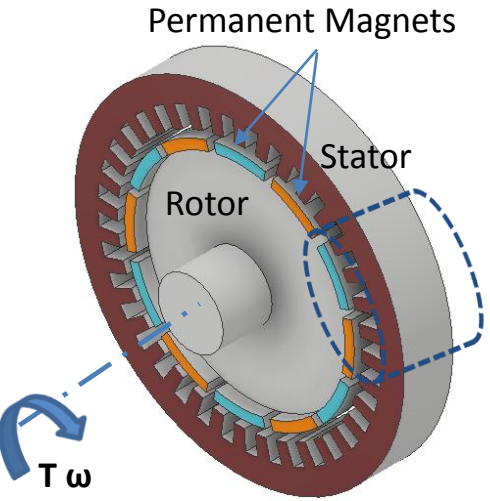
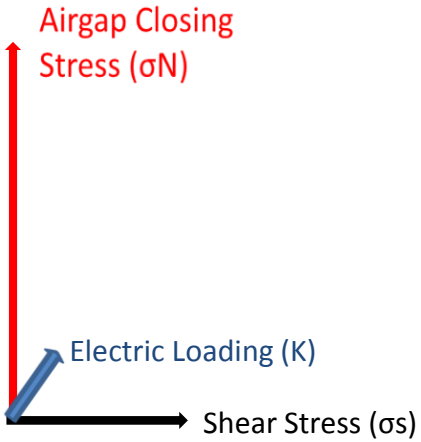


Fig: PMSG



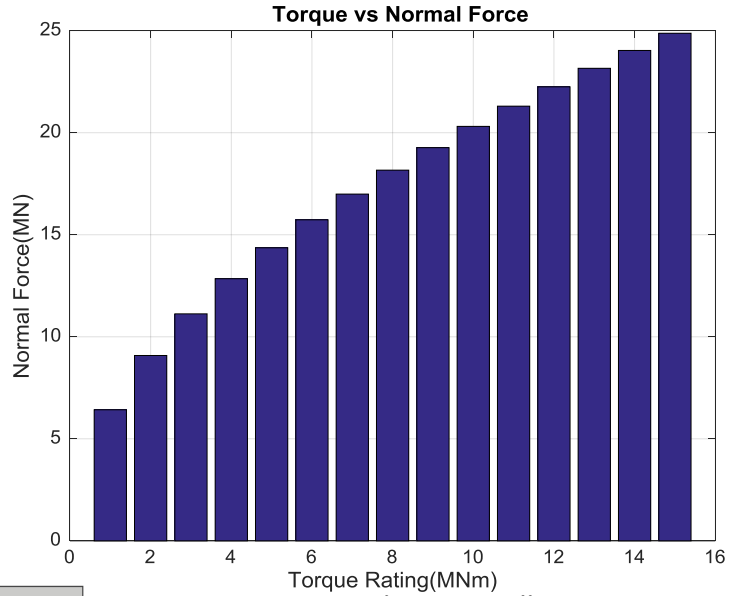


Fig: Normal Force Scalling

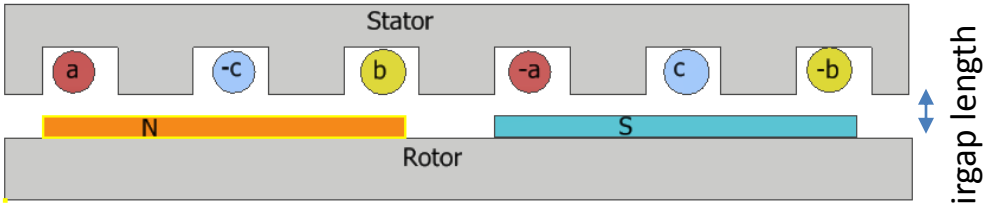
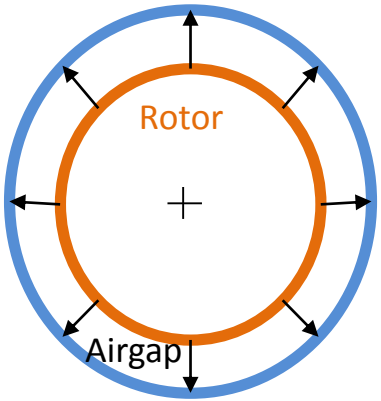


Fig: Linearised Pole Pair Section

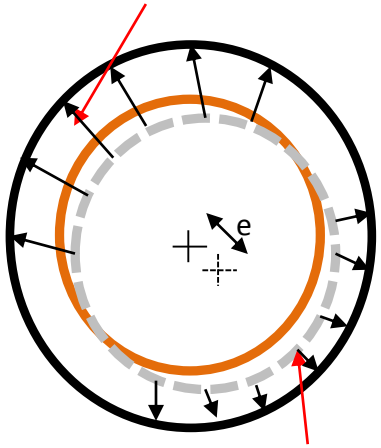
Problem (Unbalance Magnetic Pull)



Uniform Airgap Length and Uniform forces

Fig: Ideal Case

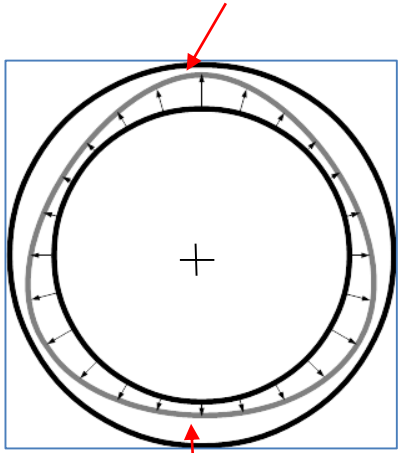
Large airgap region/ Small Force



Small airgap region/ Large Force

Fig: Due to Eccentricity

Small airgap region/ Large Force



Large airgap region/ Small Force

Fig: Due to Shape Deformation

Consequences (Unbalance Magnetic Pull)

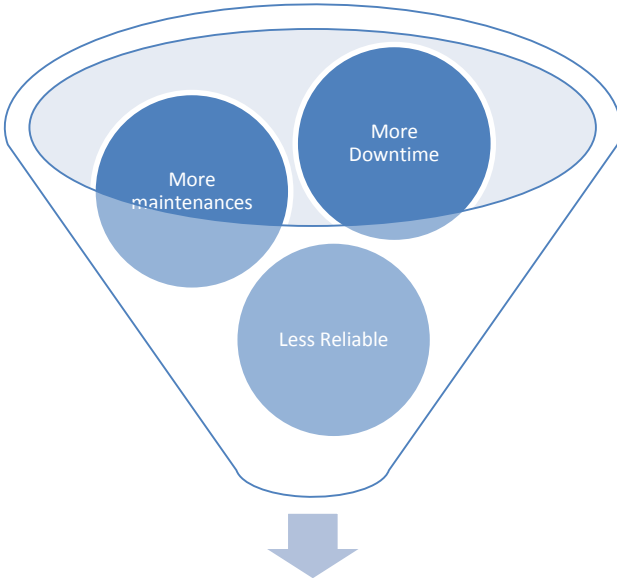
Unbalance Magnetic Pull

Bearing wears

Excessive Vibration

Additional Loss

Airgap Collapse



Loss of Revenue

Armature Field Adjustment

An electromagnetic approach to uniformize airgap forces.

- What?

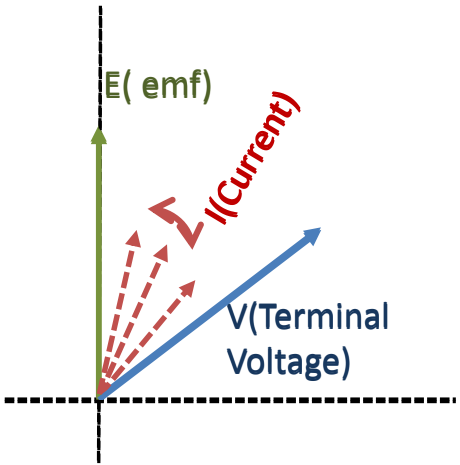


Fig: Phasor Diagram

- What is achieved?

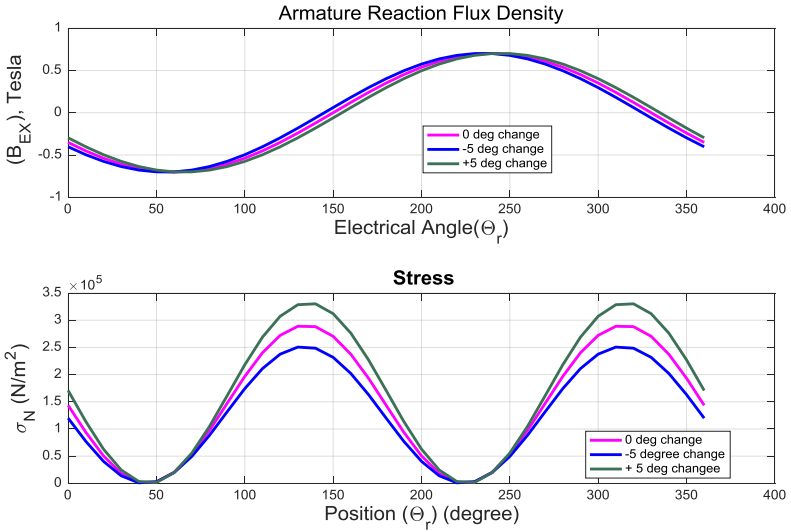
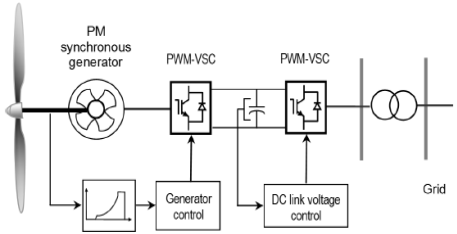


Fig: Airgap Closing Stress in a pole pair section

- How?



- Pulse width modulation of PEC
- We don't bother about power factor at generator side.

Implementation (A Concept of Modular Stator)

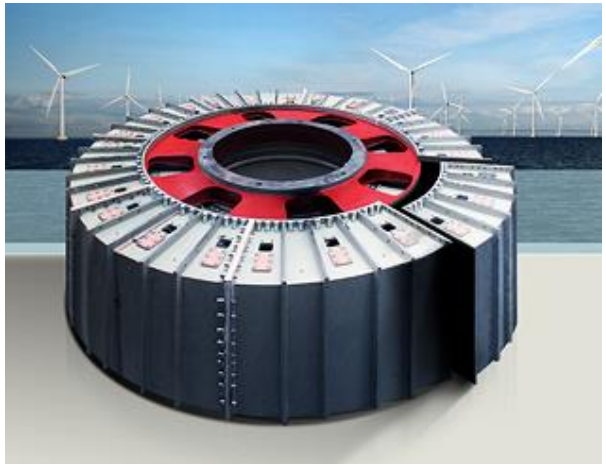


Fig: Siemens new Modular Generators [1]

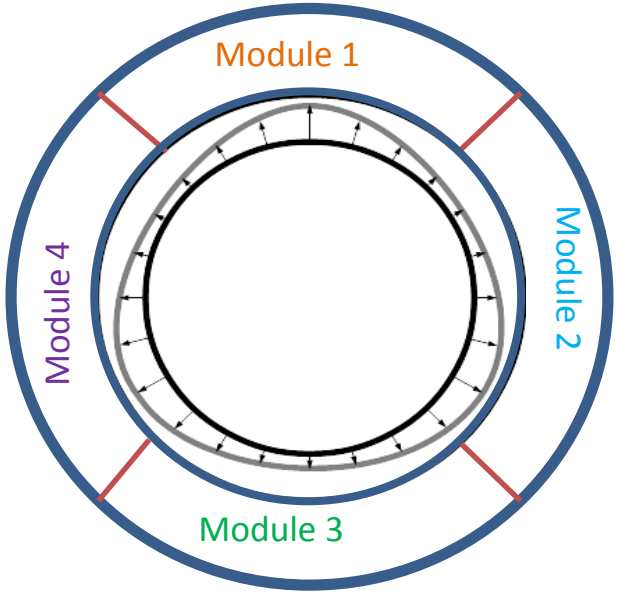


Fig: Single Rotor but many modules of stator.

Approximate Linear Modules in stator

Each Sections will be symmetrical and balanced 3 phase

AR can be adjusted independently

Over all can address higher modes of airgap defromation

[1]https://www.siemens.com/press/en/pressrelease/?press=/en/pressrelease/2012/industry/drive-technologies/idt2012094045.htm

Estimation of Airgap length for each Modules

(A Sensorless approach)

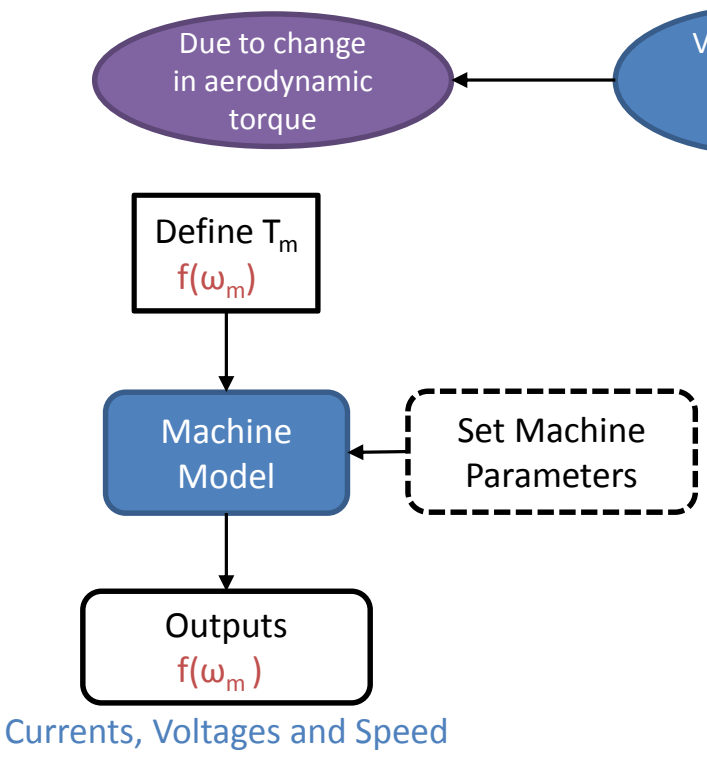


Fig: Fixed Airgap Model

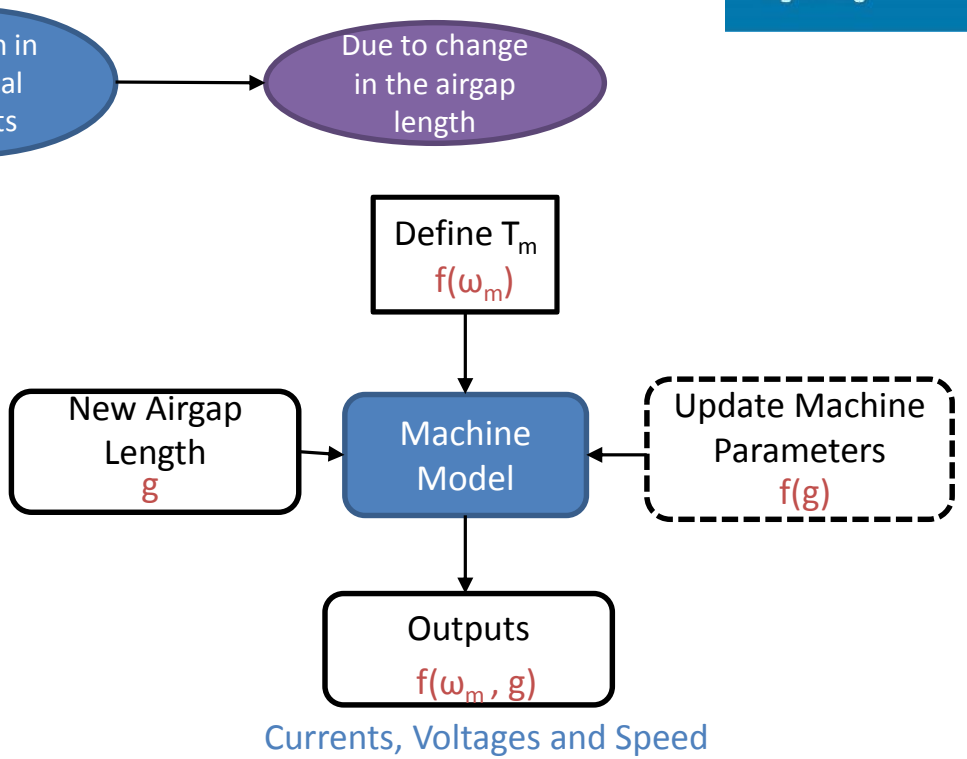


Fig: Updated Model - Variable airgap

Airgap estimation

New Airgap Length
g

→ Updated Machine Parameters
f(g)

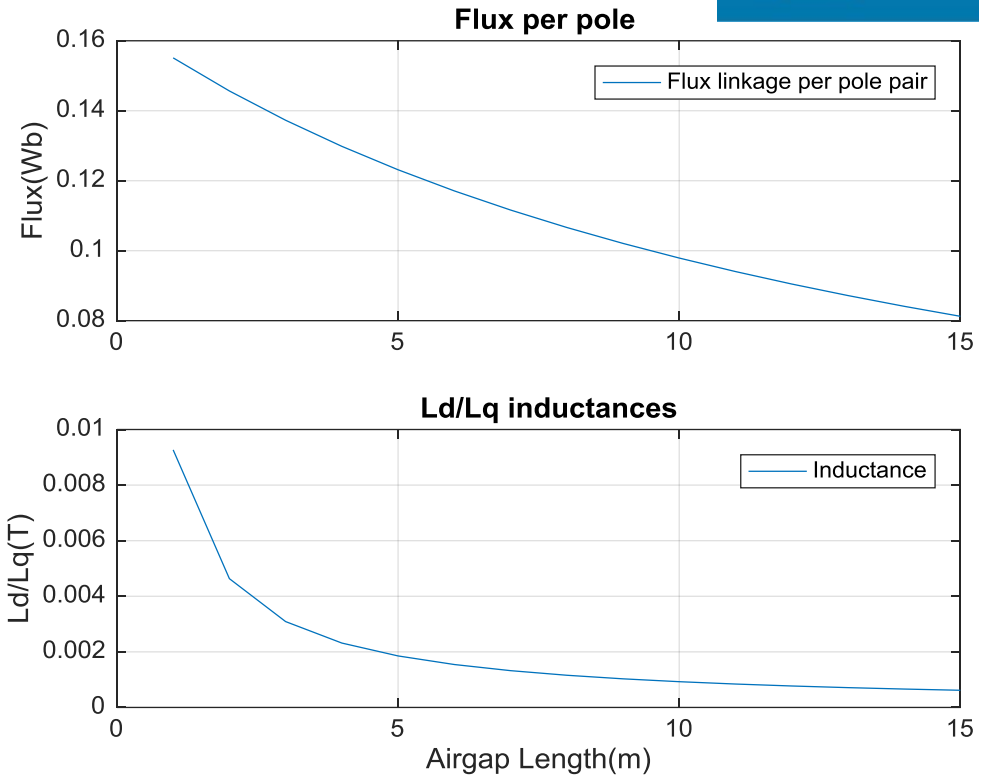
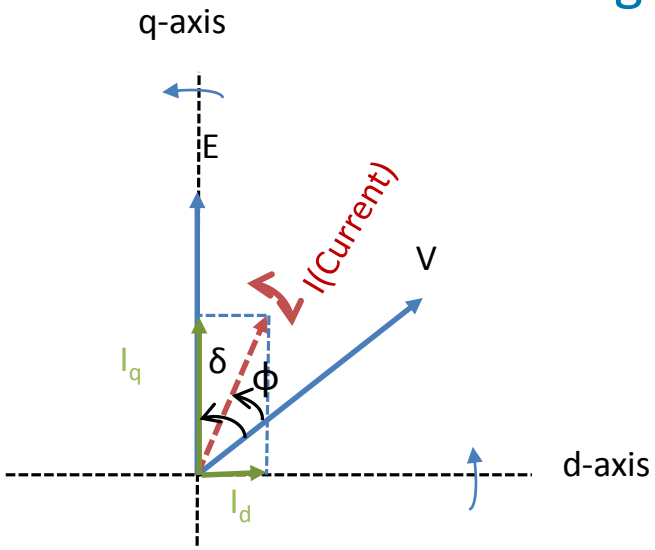


Fig: Correlation between airgap length and machine parameters

Airgap Estimator



D-Q Components of currents

I_q: Torque producing component

I_d: Flux controlling component

I_q and I_d determines phase angle

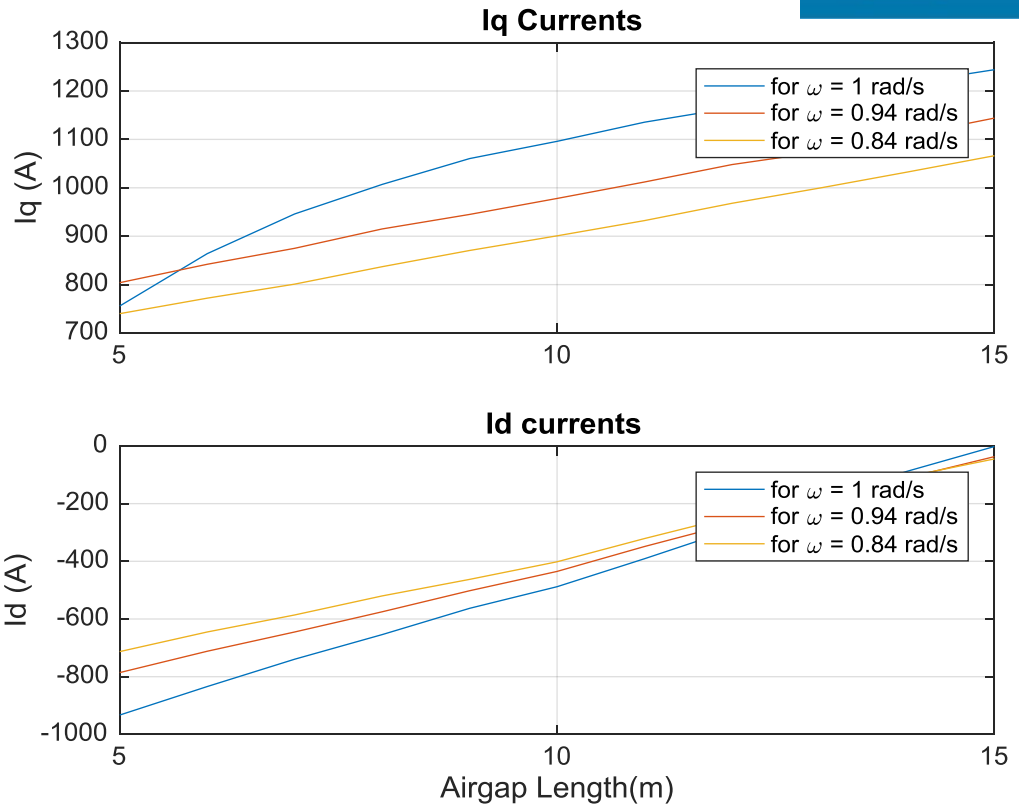


Fig: Correlation between airgap length and Current outputs

Experimental Model

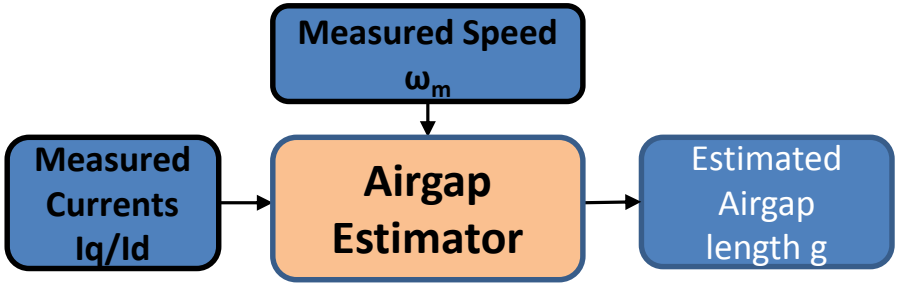


Fig: Airgap Estimator.

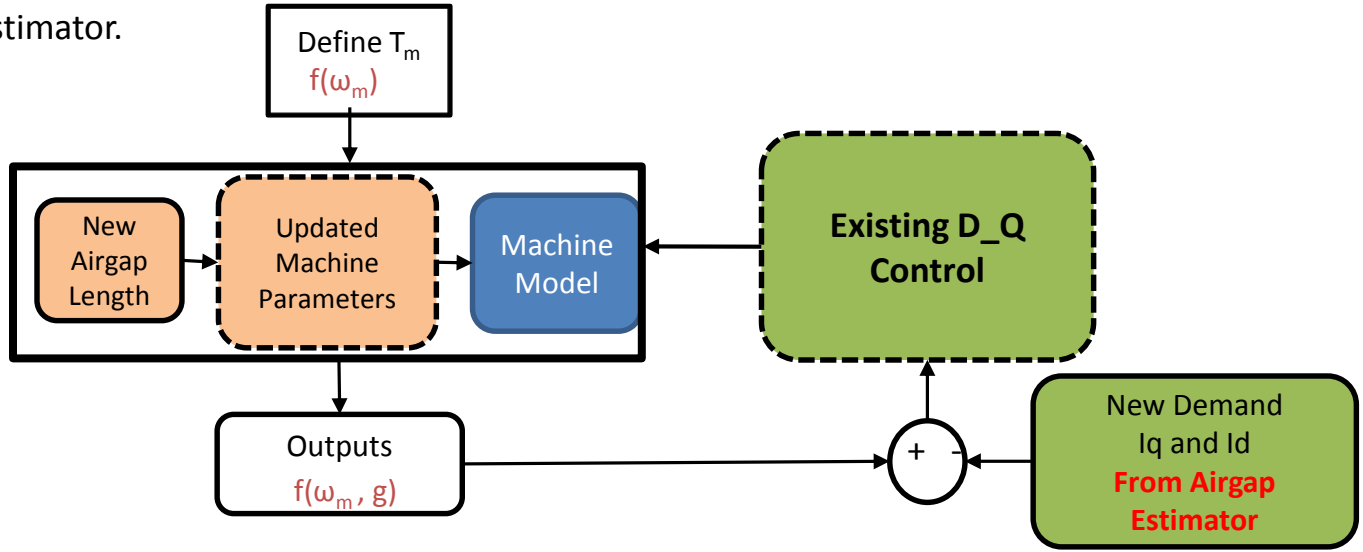


Fig: Control logic for correcting airgap length deviation.

Significance

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Less Mass and Saving in Capital cost

- Uses inherent machine's field to create magnetic bearing effects.
- No additional electromagnetic materials
- Introduces room for having less stiff materials.
- Sensorless approach to detect airgap length

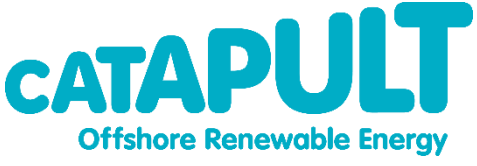
Simplicity

- Make use of existing control System

Updated Information

- Up to date information on airgap length and its deformations

Saving in O&M Cost

- Early detection of airgap anomalies ease maintenance task.
- Knowledge of magnitude of unbalance magnetic pull informs operator for severe damage warnings.
- Once Co-ordinated with all the segments, magnetic field in the airgap can be balanced at all time.

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