# **CHAPTER 3**

# **DESIGN OF PROPOSED GENERATOR**

In previous chapters, background about wind energy conversion systems and detailed overview of most used generator types are given. Then, challenges of modern wind turbine systems and fundamental equations are discussed. In chapter 2, direct drive axial flux permanent magnet generator is chosen for design in this thesis study because of its lower mechanical losses due to eliminated gearbox, high torque per volume and axial length advantages thanks to selected axial flux permanent magnet synchronous machine topology. In this chapter, electrical and mechanical design parameters of axial flux permanent magnet generator will be described. To do this, analytical design equations of proposed generator are given in the following sub-sections. These design equations will be used in following chapters for genetic algorithm optimization and electromagnetic design. Finally, a comparison of electromagnetic FEA and analytical calculation for given dimensions of proposed generator will be given to ensure the accuracy of the finite element analysis technique.

## Mechanical and Electrical Parameters

In previous chapter, it’s decided to use axial flux permanent magnet synchronous machine. In this machine, inner air-cored stator and outer rotor surface mounted permanent magnets will be used. General overview of proposed generator is given in Figure 1. In this figure, three axially stacked generator blocks are given. However, this image includes only 4 poles of proposed system. Permanent magnets are shown with blue and red colors, showing the direction of magnetization. Concentrated windings are shown with green colors. C-shaped steel rotor discs are shown with gray colors.

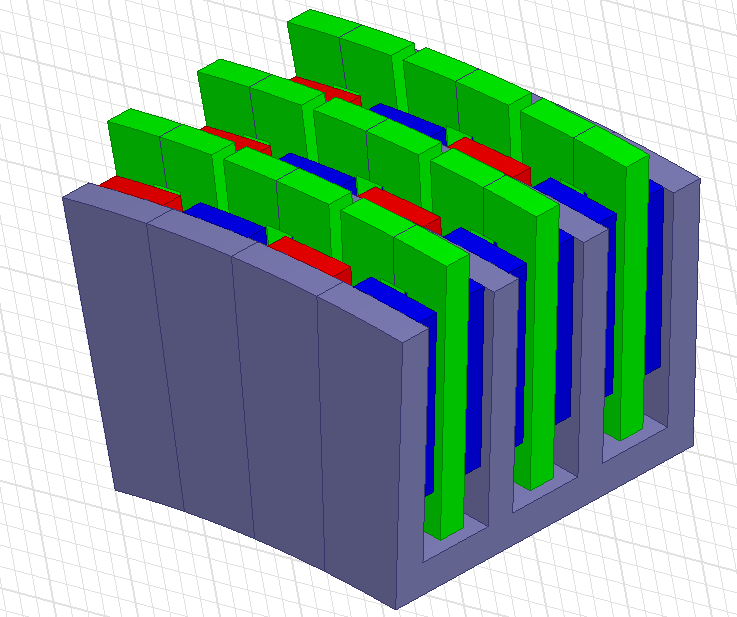


Figure-1. Proposed AFPM generator

## Sizing Equations

Per-phase equivalent circuit and phasor representation of synchronous machine is given Figure 2 and Figure 3, respectively. Output rms phase voltage (terminal voltage) of typical synchronous machine is calculated as follows,

(1)

Where, *Eph,rms*is the induced emf rms value and *Zph,rms* is the phase impedence under steady state temperature.



Figure-2. Equivalent circuit of the synchronous machine where Ea is the induced emf, Ia is the phase current, Xs is the synchronous reactance and Vt is the phase voltage



Figure 3. Phasor diagram of synchronous machine where δ is the load angle, Φ is the power factor angle

*Eph,rms* is calculated as follow,

(2)

(3)

Where *e* is the induced emf in one turn of conductor, *Nt* is the number of turns, is the pole pitch. First harmonic value of the air-gap flux density Bag is given as follows,

(4)

where is the magnet pitch-to-pole pitch ratio and is the flux density in the airgap.