DEPARTMENT OF ELECTRICAL ENGINEERING

C. V. RAMAN
COLLEGE OF ENGINEERING

WIND TURBINE

SUBMITTED BY
Er BHIBHUTI BHUSAN SAMANTARAY
Branch- electrical engineering(pse)
Roll no- MEE16003
Regd no- 1607227003

GUIDED BY:
Dr JAGADISH CHANDRA PATI

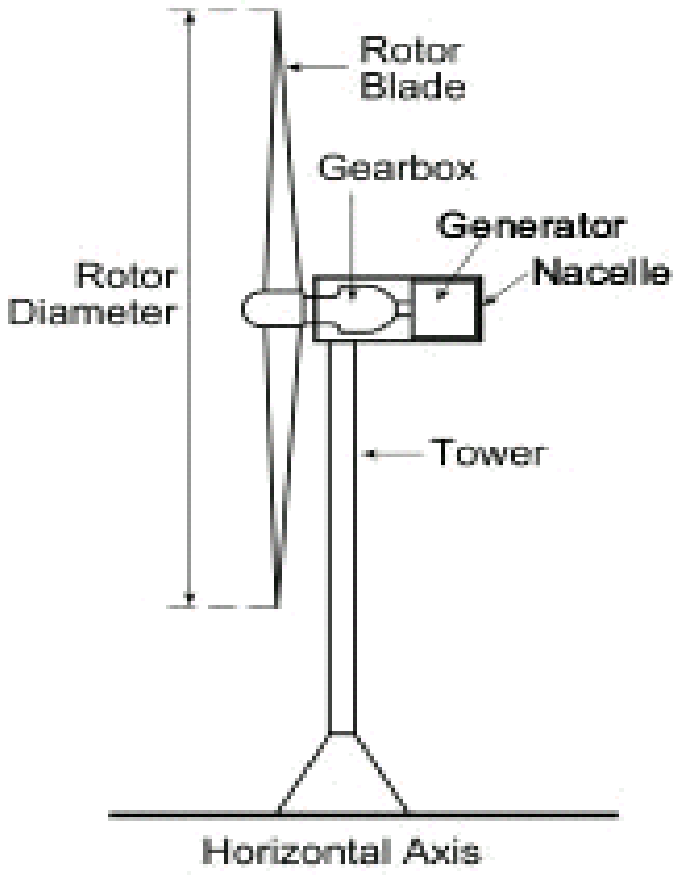
CONTENTS

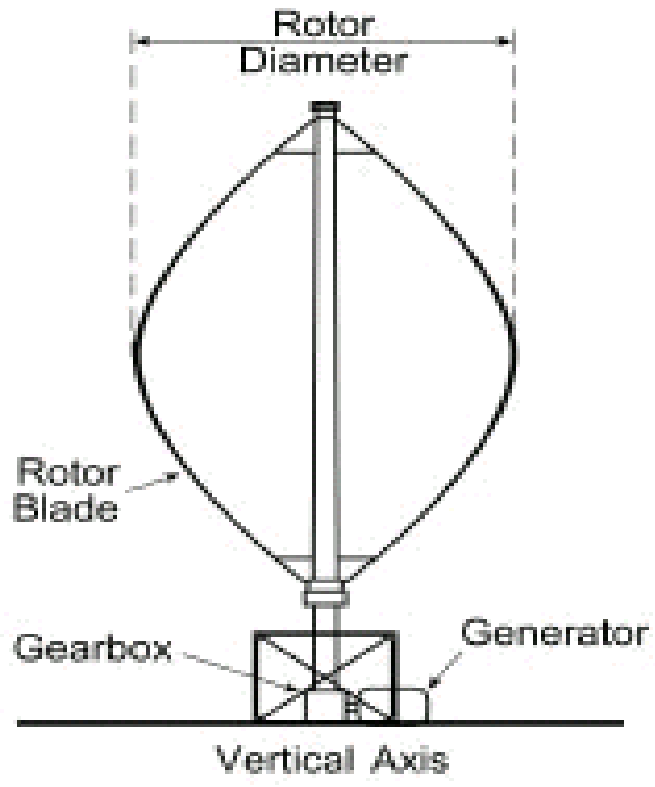
INTRODUCTION

- The objective of the work is :
- (i) To model a Variable Speed Wind Turbine with a Permanent Magnet Synchronous Generator.
- (ii) To study the Pitch Angle Control of Wind Turbine System.
- (iii) The model is then to be implemented in MATLAB/Simulink in order to validate it.
- (iv) The *Cp* curves and power-speed characteristics are to be obtained and optimum power is generated as a function of generator speed and wind speed.

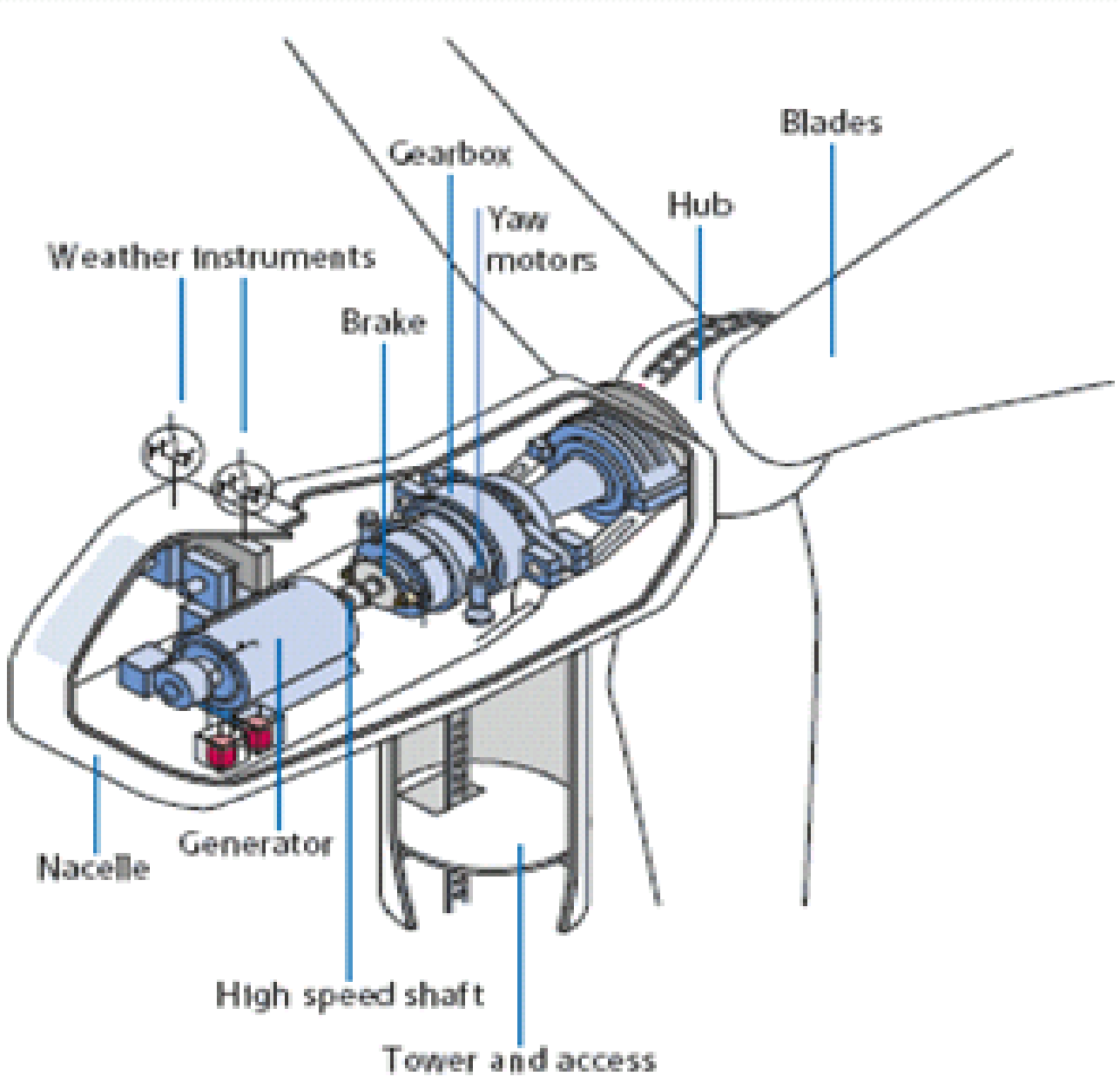
MODELLING OF WIND TURBINE

- *Aerodynamic Lift and Aerodynamic Drag Wind Turbines*
- *Horizontal-axis and Vertical-axis Wind Turbines*
- *Vari* *nes*





The major components of a modern horizontal-axis wind turbine are shown below :

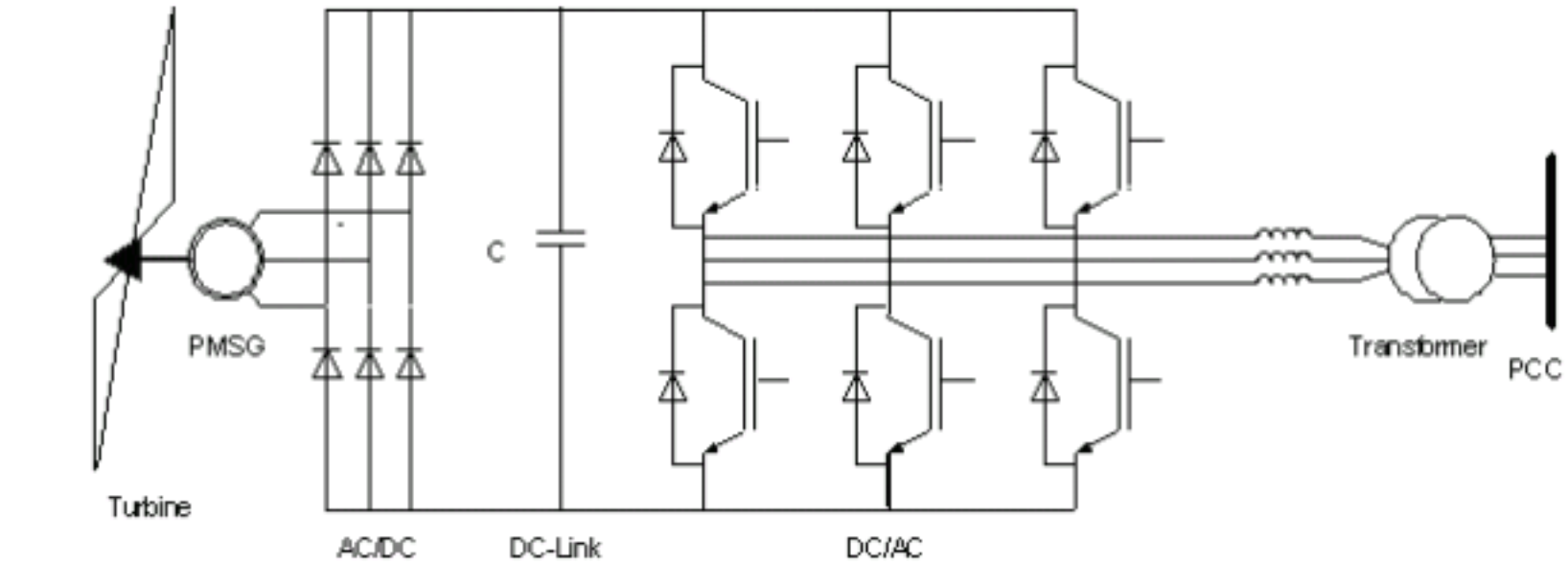


Key components of a horizontal-axis upwind turbine

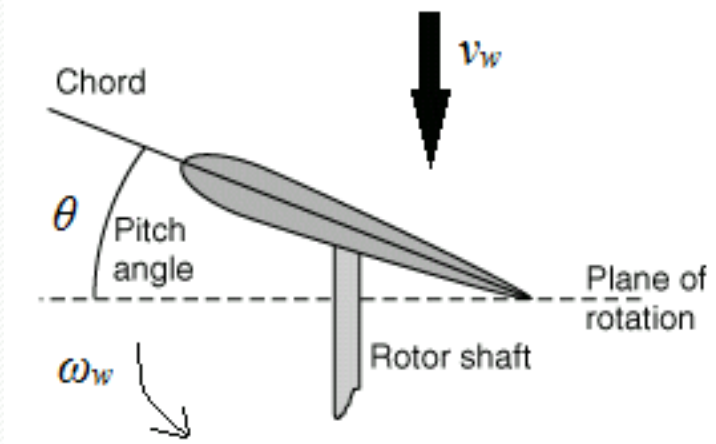
Modelling of VSWT with Direct-Drive PMSG

Wind Speed Model

Wind Turbine Model



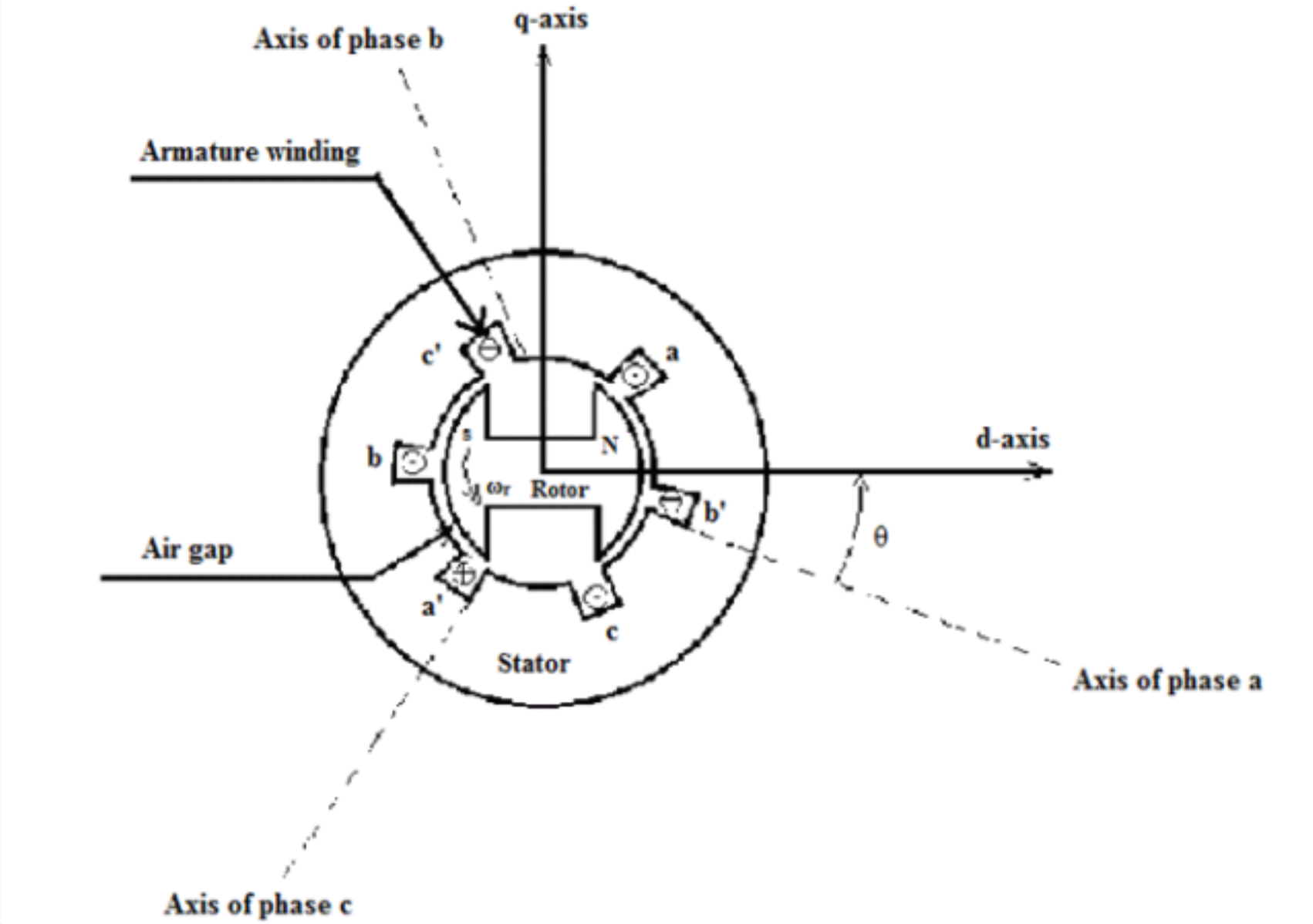
: Electrical Scheme of a variable speed wind turbine equipped with a direct-drive Permanent Magnet Synchronous Generator.



Blade Pitch Angle,

MODELLING OF PERMANENT MAGNET SYNCHRONOUS GENERATOR

- **Principle of operation of PMSG**

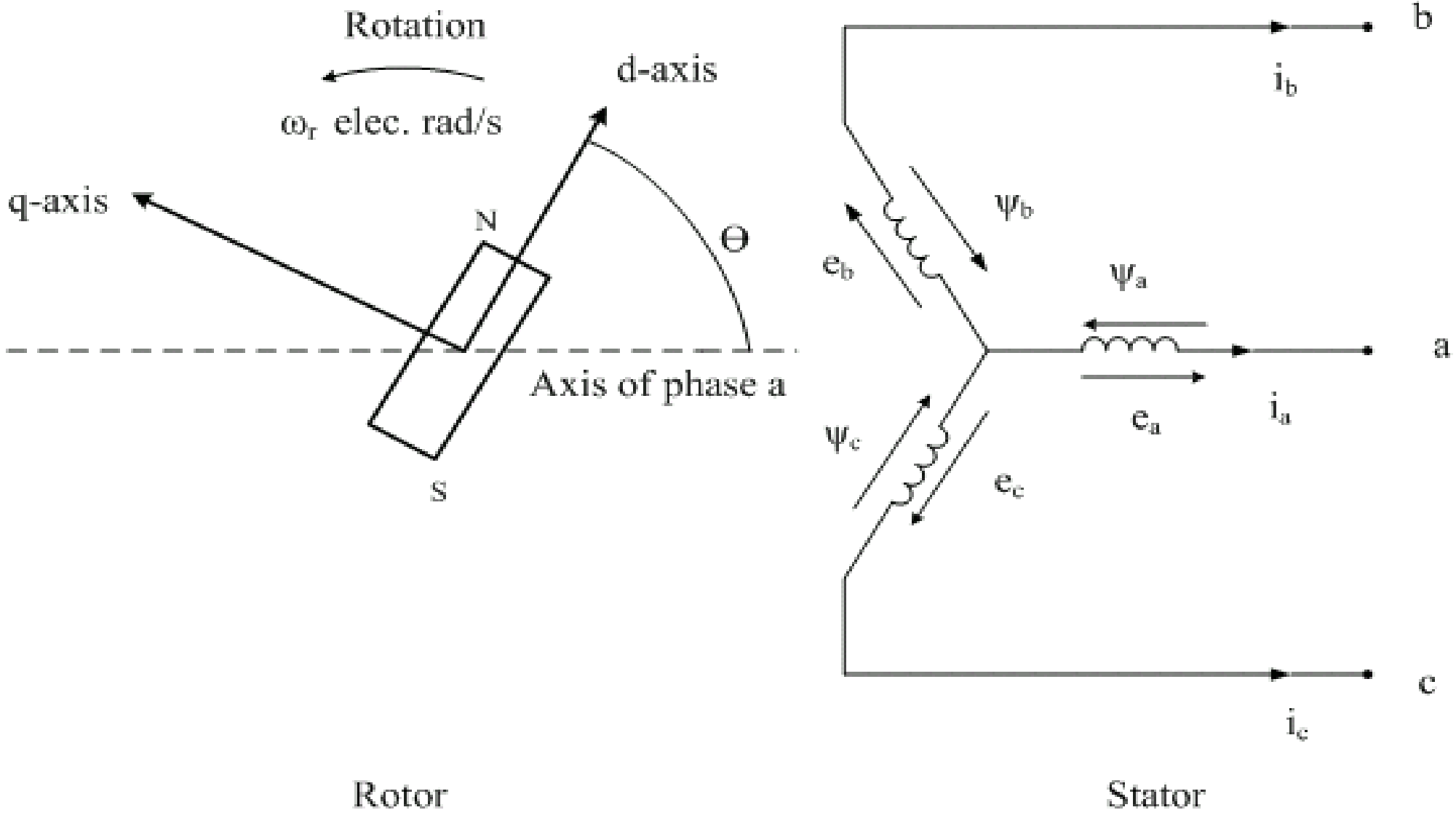


Cross-section of a 3-phase Permanent Magnet Synchronous

Advantages of PMSG

- Due to self excitation and absence of rotor winding there is no rotor copper loss. Hence, PMSG is more efficient compared to WRSGs.
- No need of external power supply.
- Due to the absence of brushes and slip rings, low maintenance is required.
- Operation costs are also relatively low.
- PMSG ś have high power-to-weight ratio, it leads to smaller size and weight.
- PMSG ś have a high coercive force and a high performance/cost ratio. Rare earth permanent magnets have the ability to produce large quantities of magnetic flux within a small volume and geometry.

Mathematical Modelling of PMSG



Circuit diagram of a PMSG

Torque equation of PMSG

$$P_{out} = \frac{3}{2}\left[i_d \frac{d}{dt}\psi_d + i_q \frac{d}{dt}\psi_q + 2i_0 \frac{d}{dt}\psi_0 \right] + \frac{3}{2}\left[\left(\psi_d i_q - \psi_q i_d \right) \omega_r \right] - \frac{3}{2} R_a \left[i_d^{\,2} + i_q^{\,2} + 2i_0^{\,2} \right]$$

= (rate of change of armature magnetic energy) + (Power transformed across airgap) + (armature copper loss)

Torque equation of a PMSG is :

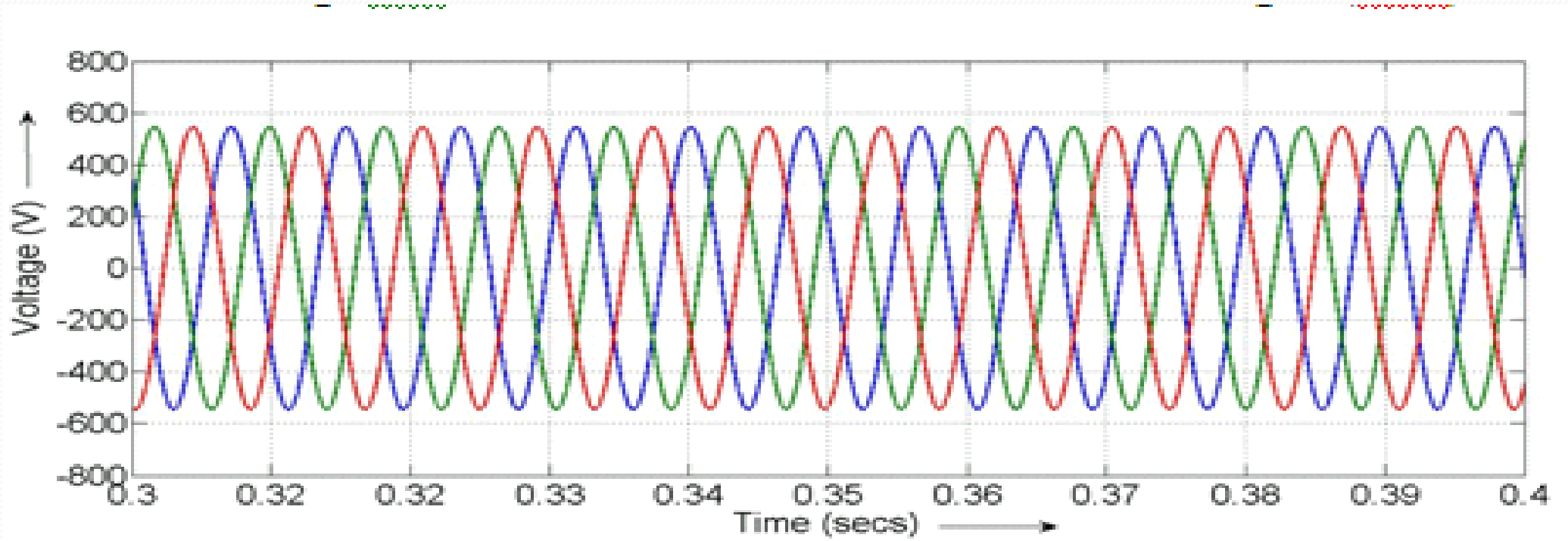
$$T_e = \frac{3}{2}\frac{P}{2}\left[\psi_{PM} i_q \left(L_q - L_d \right) i_d i_q \right]$

Pitch Angle Control in Wind Turbine

Wind Turbine Control Systems

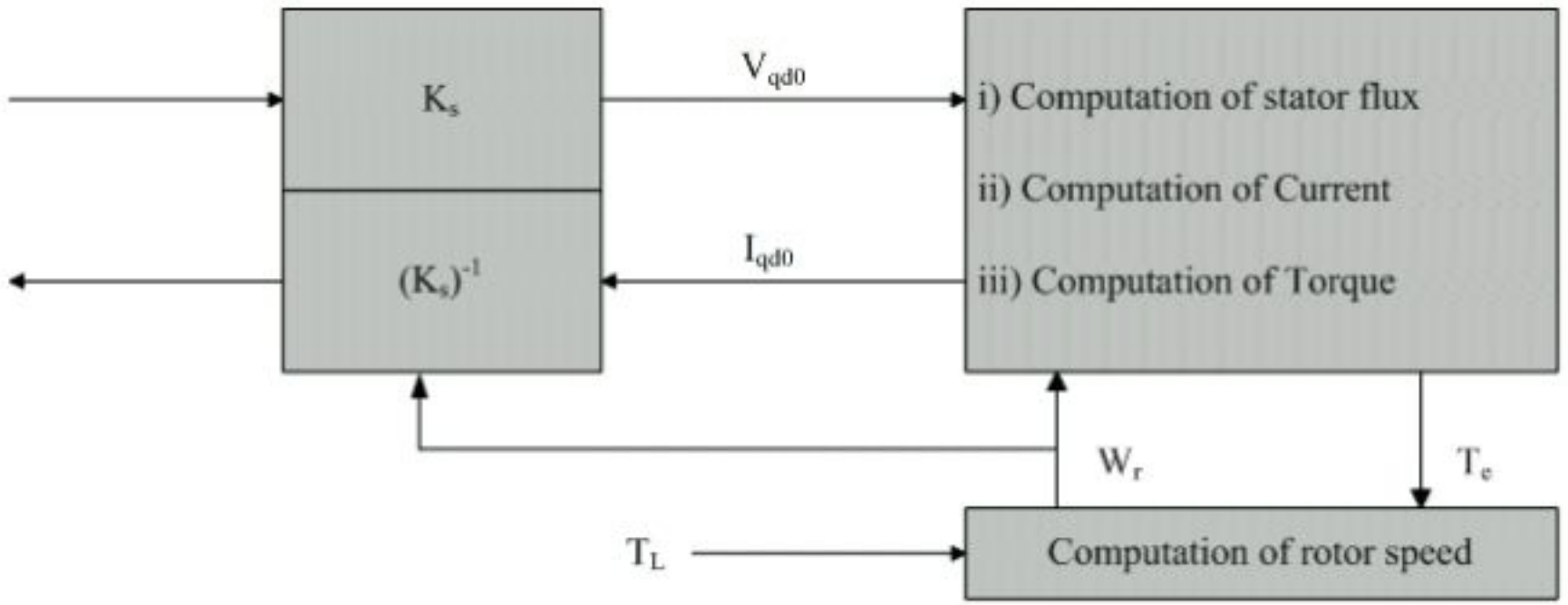
- *Pitch Angle Control*
- *Stall Control*
  - *Passive Stall Control*
  - *Active Stall Control*
- *Power Electronic Control*
- *Yaw Control*

Waveform



Double Zoomed Waveform for Phase Voltages (V_{abc})

RESULTS AND DISCUSSION



Simulation of PMSG in rotor reference frame shown in block diagram

CONCLUSION AND FUTURE SCOPE

- Further work on PMSG based wind turbines with techniques presented in this thesis are as following:
- In order to evaluate the performance of the developed model, several simulations in both steady and transient operating conditions should be carried out like changing the rotor speed reference value and by varying the wind speed.
- A Battery Energy Storage System for Variable Speed driven PMSG for Wind Energy Conversion System shall be studied.
- Grid Integration of PMSG based wind turbines can be carried out.
- This research work can be further enhanced to model an autonomous control wind turbine driven permanent magnetic synchronous generator (PMSG) which feeds alternating current (AC) power to the utility grid.

REFERENCES

- [1] Z. Lubosny. "Wind Turbine Operation in Electric Power Systems".Berlin: Springer, 2003.
- [2] T. Ackermann. Wind Power in Power Systems. New York: John Wiley & Sons, 2005.
- [3] S. Deve Gowda and S. Raja Pandian, "Simulation Of Simple Standalone Wind Energy System", Proceedings of India International Conference on Power Electronics, 2006.
- [4] Ming Yin, Gengyiin Li, Ming Zhou and Chengyong Zhao, "Modeling of the Wind Turbine with a Permanent Magnet Synchronous Generator for Integration", IEEE Power Engineering Society General Meeting, Tampa, Florida, 2007, pp. 1-6.

Thank you

ANY QUERIES???