



# A BRIEF REPORT ON PERMANENT MAGNET ASSISTED SYNCHRONOUS RELUCTANCE MOTORS

**Petr Zakopal**

*XP14DES*





## Structure of the report:

- Introduction,
- Design,
- Control,
- Comparison to other machines,
- Recent research interest.





## PMSynRelM

actively used in automotive and traction applications

control strategies based on known principles

may use relatively simple mathematical model for control





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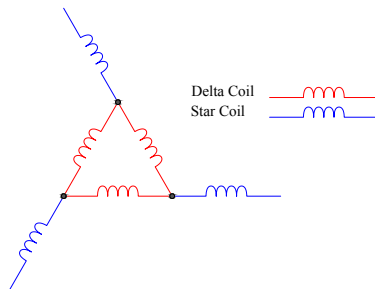


# Stator





- **Delta** winding
- **Star** winding
- **Star-Delta** hybrid winding





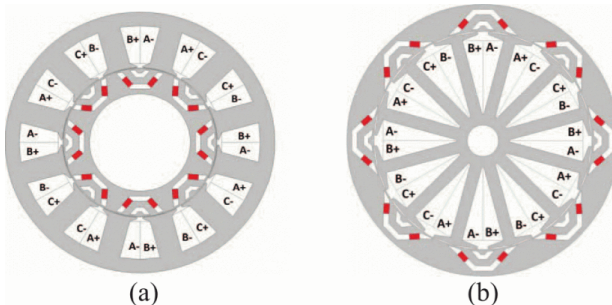


# Rotor





- internal/external
- power factor/wide power range  $\Rightarrow$  saliency ratio ( $L_d/L_q$ )
- shape/placement/number of flux barriers
- magnets - rare earth (with neodymium/dysprosium), non-rare earth (ferrites)

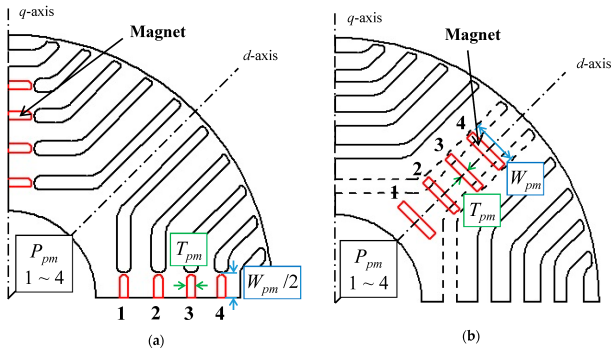


BONTHU, Sai Sudheer Reddy; CHOI, Seungdeog; GORGANI, Aida; JANG, Kibong. Design of permanent magnet assisted synchronous reluctance motor with external rotor architecture. In: 2015 IEEE International Electric Machines & Drives Conference (IEMDC). Coeur d'Alene, ID: IEEE, 05/2015, pp. 220–226. ISBN 978-1-4799-7941-7. Available from DOI: 10.1109/IEMDC.2015.7409063.





- embedded along the flux barriers, facing the  $q$ -axis (a)  
(improvement of torque)
- crossing the flux barriers, facing the  $d$ -axis (b)



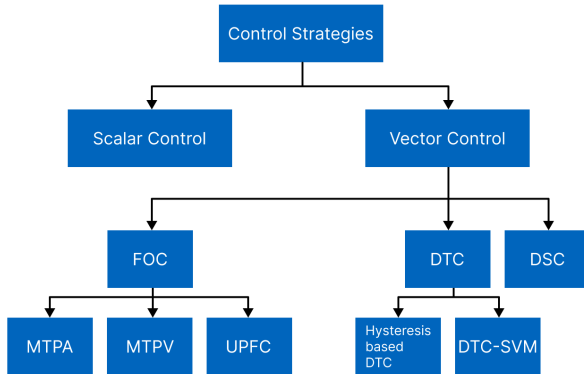
NGO; HSIEH. Performance Analysis of Synchronous Reluctance Motor with Limited Amount of Permanent Magnet. Energies. 09/2019, roč. 12, č. 18, p. 3504. ISSN 1996-1073. Available from DOI: 10.3390/en12183504.

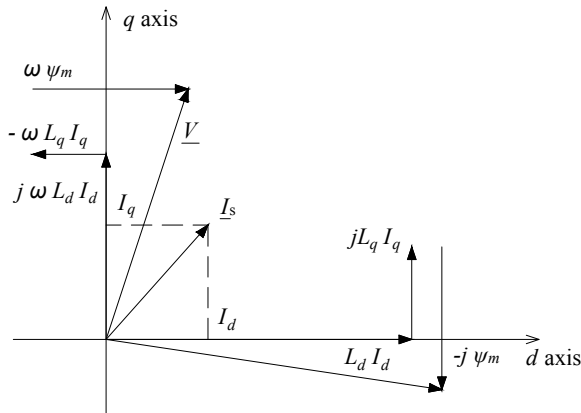




# Control







$$T = \frac{3}{2}p_p |\underline{\psi_{dq}} \times \underline{i_{dq}}| = \frac{3}{2}p_p (\psi_d i_q - \psi_q i_d). \quad (1)$$

$$T = \frac{3}{2}p_p (L_d i_d i_q - (L_q i_q - \psi_{PM}) i_d) = \frac{3}{2}p_p (L_d i_d i_q - L_q i_q i_d + \psi_{PM} i_d). \quad (2)$$





## Recent improvement was achieved:

- by using non-rare earth materials such as ferrites,
- by using novel hybrid stator winding structures,
- by analyzing rotor structure types and motor parameters based on the permanent magnet position and perfecting the design for the specific application,
- improving control strategies,
- variable flux motor (strategy).





**Thank you for your attention.**

