9th Student Symposium on Mechanical and Manufacturing Engineering, 2021

Advanced Motor Drive For Multiple Motor Configurations

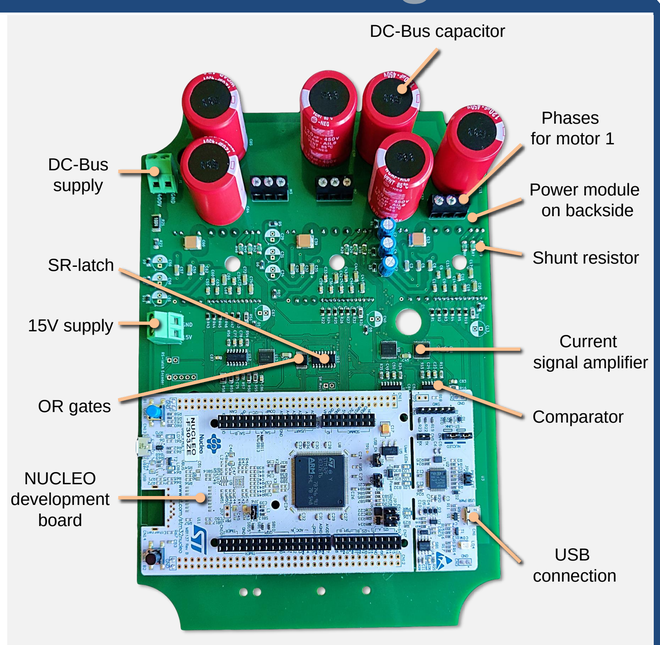
D. Steffensen, H. Johannesen, J. Mejdahl, F. Sanderhoff, R. Eliasen, S. Amstrup
Department of Materials and Production, Aalborg University, DK

1. Introduction

This project conducted a study on the design and construction of a motor drive, capable of controlling nine individually modulated AC phases. The motor drive is to be used in livestock ventilation, where reliability is a main concern. Hence the potential of using a multiphase motor is investigated, because of its inherent redundancy. The three main components of the study are the PCB, PMSM and FOC.

2. Printed Circuit Board Design

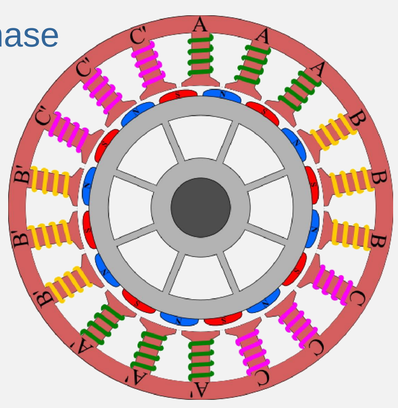
A versatile motor drive is designed capable of driving both induction motors and PMSMs with a DC supply of 400V. The main components is a microcontroller and three power modules. Beside this, there are a number of auxiliary com-ponents too. On the right is a figure of the PCB and some of its components and features.



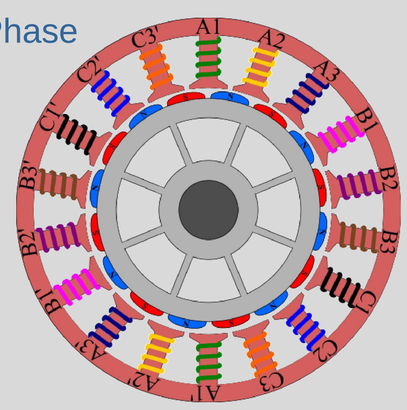
3. PMSM

In order to verify the performances of the inverters, several tests with 3- and 9-phase PMSMs are conducted. The 3-phase PMSM test, is to ensure, that the microcontroller is properly configured and to validate the functional performance of the position estimator. The 9-phase PMSM test aims to validate the drive's capability of driving a 9-phase PMSM. Given the 18 stator teeth and symmetry of the motor, it is possible to incorporate nine individual phases or run the PMSM with 3-phases. The winding configuration is seen below.

3-Phase



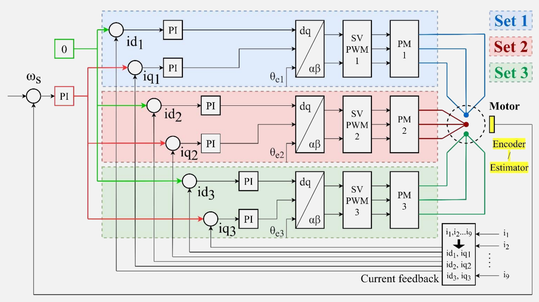
9-Phase



4. Control Strategy

The IMs are controlled with a simple scalar control, based on the rated motor voltage and frequency. The 3-phase PMSM is controlled using conventional FOC. The 9-phase PMSM is controlled as if it consisted of three individual symmetric 3-phasesystem.

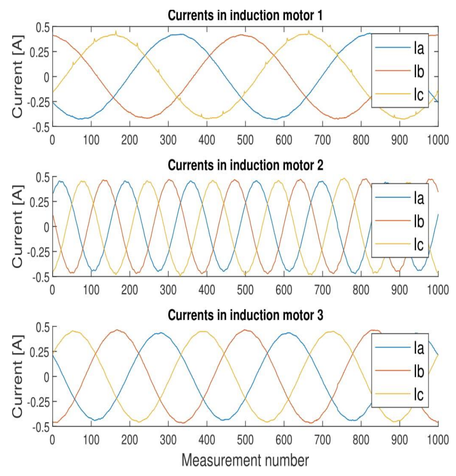
9-phase FOC

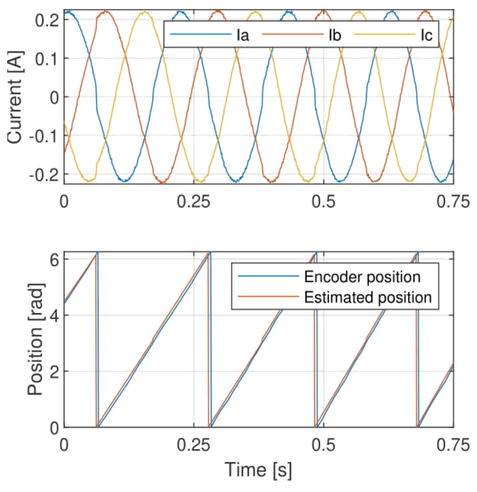


5. Test and Results

Three 3-Phase Induction Motors

- The currents in the three IM's while driving is compared.
- Sinusoidal currents indicates correct implementation of control and modulation.
- The different frequencies is a consequence of different speed references.
- Different phase sequences, is caused by motors running in different directions.



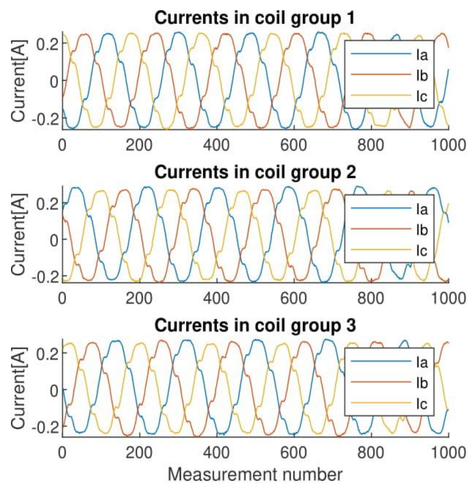


3-Phase PMSM

- The estimated position is compared to the signal from an encoder.
- The tests shows similar results, regardless of which power module is used.
- The currents are approximately sinusoidal, and the estimated position is close to the encoder position.
- The hardware and software is validated and ready for a high voltage 9-phase test.

9-Phase PMSM

- Complication with electromagnetic noise prevented a DC-bus voltage above 200V.
- Somewhat sinusoidal currents, but with periodic plateaus, possibly resulting from complex coupling.
- Validation of the drive's capability of controlling a 9-phase PMSM with a DC-bus voltage of 200V.
- Noise countermeasures may make a DC-bus voltage of 400V possible.



6. Conclusions

A versatile motor drive, capable of driving three 3-phase IM's, one 3-phase PMSM or a 9-phase PMSM, has successfully been designed, produced and tested. The motor drive shows good results when driving three 3-phase IMs with scalar control. The control strategy with the three separate *dq*-systems for FOC, allows it to operate three 3-phase PMSMs or one 9-phase PMSM. The test of the 9-phase PMSM showed a significant amount of noise, preventing a test of a 400V DC-bus and is therefore only tested with a 200V DC-bus. It is expected that small corrections would resolve the noise problem and enable the 9-phase PMSM to be driven on a 400V DC-bus.

Acknowledgement

The authors of this work gratefully acknowledge Grundfos for sponsoring the 9th MechMan Symposium

AALBORG UNIVERSITY
DENMARK

Department of Materials and Production
www.mp.aau.dk

GRUNDFOS