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3.Motor Control

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3. Motor Control

In the third chapter, the overall control method

The controlled system and the controller, wh

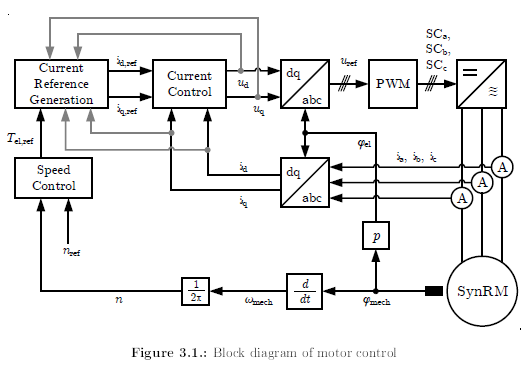
3. 1 Overview of Motor control system

3.1.1 Field-oriented control

Field-oriented control (DE: Feldorientierte Regelung), or vector control is a control method that is widley adopted for the control of three-phase motors. The control of the motor is performed by controlling the stator current vector on the rotational dq Coordinate system, which is defined according to the magnetic field of the rotor. During steady-state condition of the motor, these two orthogonal current components, i.e i\_d and i\_q, are direct current signals, rather that alternating signals. This characteristic of the control value being constant in steady -state condition gives us great advantage in control of the systems. However, real-time computation for the inverse dq transformation and the dq transformation for the control value are required, since the SynRm is drived with three-phased AC-current. The inverse dq transformation is performed while giving the control command to the motor, as the dq transformation is performed during the sampling of the output of the motor.

3.1.2 Control Block diagram

Fig? shows the block diagram of the overall control of the motor system. The control of the motor is performed through a set of cascade controllers, where the Torque controller serve as the superposed controller and the current controller serve as the Subordinate controller. The current controller is a feedback controller as the Torque controller is an open loop controller that generate current setpoints with the use of preprogrammed data (Look-up-Tables). Details of the controller are presented in the following chapter.



The controlled system is composed of the SynRm and the three-phase inverter. As mentioned in the previous chapter, inverse dq-Transformation is performed on the output of the controller. Through PWM( pulse width modulation) methods, the resulting voltage signals on the a,b and c axis are interpreted into switching commands and are fed to the DC-linked inverter, which drives the SynRm with tree-phase AC-current. These current components on the a,b and c axis are then sampled and transformed back to d-q coordinate system as he feed-back signals of the current controller.

For the sake of generating correct current reference, the torque controller requires the information of the motor speed. This required signal is measured through time derivation of the motor rotation angle measured be the encoder, which is mounted on the shaft of the motor. The equation for electrical angle and rotation speed is presented in …

3.1.13 parameter normalization

For the design of our controller systems and control parameters, the mathematical model introduced in chapter 2 should be consider. In this chapter, we define the normalized value for each electric and mechanical variable in Table ?

|  |  |  |
| --- | --- | --- |
| Synbol | Name | Value |
| I\_N | Normalized Current |  |
| U\_N | Normalized Voltage |  |
| M\_N | Normalized Torque |  |
| w\_N | Normalized Angular Frequency |  |

In this thesis, the maximum value for each parameter are chose as the moralization quantity.

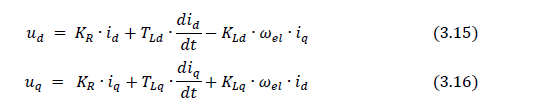
The normalization of the values are shown in equation? to equation ?

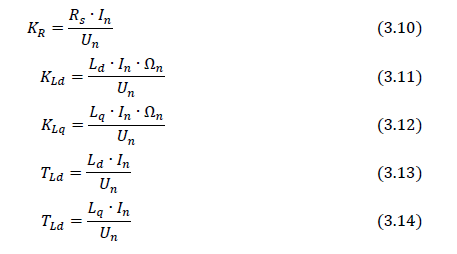
3.2 Synchronous reluctant motor

In this chapter, we define the Laplace representation in s-Domain and the block diagram of our controlled system based on normalization we defined in the previous chapter. Furthermore, a discrete representation of the motor equation should also be derived, since the controller of the motor should be a discrete time controller in order to be implemented on the test bench.

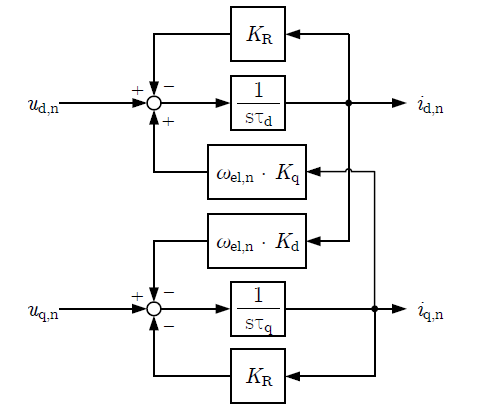
3.2.1 Model equations in s-domain

We start from the voltage equations in [equation number]. After normalization, we can derive the normalized voltage equation and its parameters in equation?





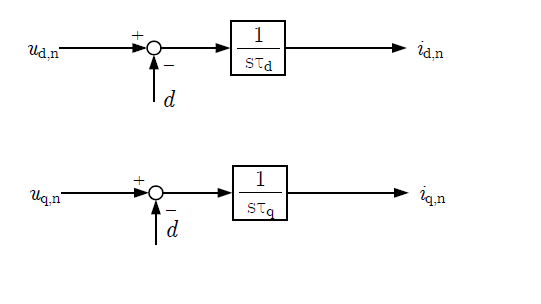
According to equation?, we are able to derive the block diagram representation of the motor in S-Domain, as shown in fig?



From the block diagram presented above, we can observe that the current of the d- and q-axis is cross-coupled***[literature num]***. Under high-velocity and high-dynamics operation, this characteristic can leads to deterioration in current control, since the cross-couple effect become more prominent with higher value of electric angular frequency. In some literature, a decoupling technique is adopted ***[literature num]***, where a decouple term is add into the output voltage value of the current controller to compensate the cross-coupling term of the motor.

For the design of our controllers, we can consider this cross-coupled term as disturbance and omit the signal for the sake of simplification. Also, the influence of resistance can be neglected. Thus, the simplified motor model can be view as an integrator with time constant T\_d and T\_q, as shown in equation?

The block diagram from fig? is reduced to the one in Fig?



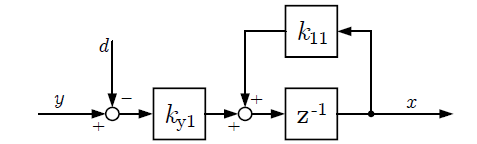
3.2.2 Model equations in z-domain

[reason for discrete time control: Reglungtechnik II Prof. Roth-Stielow]

[introducaiton to smapling time T\_A (Abtastzeit)]

In equation? , we modelled the motor as an integrator. Thus, equation? can be adopted, where z represent a delay for one time step.

The block diagram for the d-axis current is shown in fig ?



For the transfer function for the d-axis, the parameter k\_y1 and k11 can be derived using the following procedure shown in equation?

The same applies to the transfer function for the q-axis. Hence, we derived the transfer function for the motor in z-Domain as shown in eeqution?

3.3 Current Controller

This chapter present the current controller both in time-continuous form and time-discrete form.

3.3.1 Time-continuous current controller

3.3.2 Time-discrete current controller

3.3.3 Anti-windup

Literature

Decoupled dq-axis Current Control for PMLSM based on Variable-Gain Adaptive Internal Model