PhD Public Defence

Title: Interharmonics Analysis and Mitigation in Adjustable Speed Drives

Location: Pontoppidanstræde 111, auditorium

Time: Thursday 28 April 2016 at 13.00

PhD defendant: Hamid Soltani

Supervisor: Professor Frede Blaabjerg

Moderator: Associate Professor Huai Wang

Opponents: Associate Professor Kaiyuan Lu, Dept. of Energy Technology, Aalborg University (Chairman)  
JJ Liu, Power Electronics and Renewable Energy Center, Xi’an Jiaotong University, Xi’an, Shaanxi 710049 China  
Enrique Romero-Cadaval, University of Extremadura, Badajoz, Spain

All are welcome. The defence will be in English.

After the public defence there will be an informal reception in Pontoppidanstræde 111 (coffee room).
Abstract:

With the growing use of power electronics technology in different applications, many efforts have simultaneously been devoted to improve the grid quality issues. In this respect, harmonic and interharmonic distortions are among the most important criteria, which are needed to meet the required standards. Meanwhile, issues related to interharmonics have recently gained more attention besides classical harmonics, due to their specific negative effects as well as those common with harmonics. Interharmonic distortions can seriously hamper the normal operation of the power system by means of side effects such as excitation of undesirable electrical and/or mechanical resonances, misoperation of control devices, and so forth. Adjustable Speed Drive (ASD) based on double-stage AC-DC-AC converter is considered as one of the main sources of interharmonics in the grid. Literature survey shows that most of the works focus on analyzing and reducing the harmonics in power system and motor drives, while less attempts are devoted to interharmonic-related issues. In this respect, this Ph.D. project has investigated and evaluated the adjustable speed drive input current interharmonics caused by different sources, and proposed some appropriate solutions to enhance the grid quality. The main scopes of this research work can be introduced as: 1) General study of interharmonic sources and identification in Voltage-Source Inverter (VSI-) fed ASD, 2) Input current interharmonic characterization in a double-stage VSI-fed ASD, and 3) Mitigation of ASD's input current interharmonics due to motor current imbalance.

Chapters 2 and 3 present a general study on the harmonic and interharmonic sources and detections in the ASD. The study is particularly performed with respect to a VSI-fed ASD with very low switching frequency and a naturally sampled Sinusoidal Pulse Width Modulation (SPWM) strategy in Chapter 2. Then, some practical challenges associated with interharmonics detection are followed in Chapter 3. A thorough discussion introduces the existing desynchronized interharmonics detection method, which in this thesis is applied as highly accurate measurement strategy.

Thereafter, the ASD input current interharmonics are evaluated in Chapters 4 and 5 with respect to the inverter’s modulation strategy, and to the ASD's passive filter effects. In Chapter 4, the symmetrical regularly sampled SPWM, Space Vector Modulation (SVM), and Discontinuous Pulse Width Modulation (DPWM2), and also the asymmetrical regularly sampled SVM modulation techniques are chosen as the most popular modulation strategies applied in the motor drive applications. A frequency mapping characterizes the ASD’s input current interharmonic locations. Then, it recommends the suitable strategy associated with the fixed frequency switching methods (e.g., SPWM, SVM, and DPWM2) in order to reduce the drive input current interharmonic components. Chapter 5 investigates the effects of the ASD’s passive filters (AC choke, DC choke, and DC-link capacitor) on the input current interharmonics caused by motor current imbalance. This investigation has been carried out in both cases of the balanced and the unbalanced load conditions.

In Chapter 6, some active compensation methods are proposed in order to mitigate the ASD's input current interharmonics generated by the motor current imbalance. In the case of partially-controlled ASD, where an inverter is connected to the front-end diode rectifier back-to-back sharing a common DC link, the AC- and/or DC-side active compensators are proposed for input current interharmonics reduction. Moreover, in the case of a fully-controlled ASD (a back-to-back converter), the drive input current interharmonics are mitigated by proposing an appropriate control strategy.

The contribution of this research work is a better understanding of the drive input current interharmonics with respect to different modulation techniques. It investigates the interharmonics issue both in cases of balanced and unbalanced load conditions. Appropriate solutions are proposed in order to reduce the drive input current interharmonics. It is expected that the outcome of this work would be helpful for people investigating the origin of interharmonics, and looking for new potential strategies for their reduction.