Damping of torsional vibrations in mechatronic systems using different control strategies

Krzysztof Szabat, Seiichiro Katsura, Tomasz Pajchrowski

Abstract
Transmission systems are fundamental elements of modern technological processes. They consist of different components, such as shafts, gears, timing-belts and couplings. Due to the market pressure, the productivity of technological lines is expected to grow. It can be achieved by setting higher gains of controllers in order to shorten the transition times. However, the higher controller's coefficients can excite torsional vibrations. This phenomenon influences the whole process in a negative way, since it can decrease the quality of the product and may, in some cases, lead to the breakdown of the system.
The torsional vibrations have been recognized in drives for a few decades. Originally, this phenomenon has been described in traditional big drives used in industry, such as rolling-mill drives, conveyer-belt drives and machines used in textile and paper industries. Large inertias of motor and load machines and long couplings create a visible model of the so called two-mass system. The first mass refers to the inertia of the driving motor, whereas the second mass represents the inertia of the load machine, and the long shaft acts as a flexible connection.
Due to the progress of power electronic and microprocessor techniques, which shorten the regulation time of driving torque, torsional vibrations are nowadays recognised in a variety of modern applications with bigger (computerized numerical controlled machines, robot-arms, wind mills, deep space antenna drives, electric cars and others) and smaller power (hard disc drives, mechanical beams, micro electromechanical systems and others mechatronic structures).
The tutorial is recommended for researchers, industrial engineers and students interested in recent trends in motion control algorithms, especially taking into account vibrations damping problems. It may be also interesting for researchers from related areas, such as: electrical machines, drives and mechanical as well as mechatronic systems.
In this Tutorial, three speakers will give lectures about vibrations control in motion systems using different control techniques.

Krzysztof Szabat received the Ph.D. and D.Sc. degrees from the Electrical Engineering Faculty of Wroclaw University of Technology, Wroclaw, Poland, in 2003 and 2008, respectively. In 2016 he was awarded with the title Professor of Technical Sciences. Currently he is Head of the Department of Electrical Machines, Drives and Measurements at Wroclaw University of Science and Technology. He is the author and coauthor of over 100 journal and conference papers. His main field of interest is the application of the control theory, artificial intelligence methods, and microprocessor techniques to motion control. Prof. K. Szabat had scientific/didactic stays in universities in Germany, Ireland, UK, Croatia and Russia.

Seiichiro Katsura (S'03-M'04) received his B.E. degree in system design engineering and his M.E. and Ph.D. degrees in integrated design engineering from Keio University, Yokohama, Japan, in 2001, 2002 and 2004, respectively. From 2003 to 2005, he was a Research Fellow of the Japan Society for the Promotion of Science

(JSPS). From 2005 to 2008, he worked at Nagaoka University of Technology, Nagaoka, Niigata, Japan. Since 2008, he has been at Department of System Design Engineering, Keio University, Yokohama, Japan. Currently, he is working as a Professor. In 2017, he was a Visiting Researcher with the Laboratory for Machine Tools and Production Engineering (WZL) of RWTH Aachen University, Germany. His research interests include applied abstraction, human support, data robotics, wave system, systems energy conversion, and electromechanical integration systems. He has been active in the IEEE IES. He serves as Associate Editor of the IEEE Transactions on Industrial Electronics, Associate Editor of the IEEE Journal of Emerging and Selected Topics in Industrial Electronics, and Technical Editor of IEEE/ASME Transactions on Mechatronics. He is a Member of Technical Committees on Sensors and Actuators, and Motion Control. He is an author or a co-author of more than 152 journal papers, 420 international conference papers with review and 32 patents. He was the recipient of The Institute of Electrical Engineers of Japan (IEEJ) Distinguished Paper Awards in 2003 and 2017, The European Power Electronics and Drives-Power Electronics and Motion Control Conference, (EPE-PEMC'08), Best Paper Award in 2008, IEEE Industrial Electronics Society (IES) Best Conference Paper Award in 2012, and JSPS (Japan Society for the Promotion of Science) Prize in 2016.

Tomasz Pajchrowski received the Ph.D. degree and the D.Sc. degree in in control of electrical drives from Poznan University of Technology (PUT), Poznań, Poland, in 2005 and 2016, respectively. He is currently an Assistant Professor with the Faculty of Control, Robotics and Electrical Engineering , PUT and deputy director of the Institute of Robotics and Machine Intelligence. He is an author and co-author of over 100 scientific papers and 1 patent. His research interests include control of synchronous permanent-magnet motors, especially control for Multi-Mass System With Variable Mechanical Parameters, where control systems, the nonlinear, adaptive, and robust control algorithms, as well as computational intelligence methods are applied. Dr. Tomasz Pajchrowski is a Member of the Polish Society of Theoretical and Applied Electrical Engineering. He was a Member of the Local Organising Committee of the 13th Power Electronics and Motion Control Conference EPE-PEMC 2008, held in Poznań.