Control techniques in power electronics and power systems

Syllabus

This course will present several representative instances of the application of control theory to power converters, drives and AC generators. It is intended for MSc and PhD students at the School of Electrical Engineering, Tel Aviv University. The final mark will be 80% for the exam and 20% for lab work on a brushless DC motor drive.

The subjects discussed are:

1. A brief review of linear systems and feedback. Mathematical notation and terminology. Transfer functions. Stable transfer functions and the H^∞ norm. LTI systems in state space. The feedback connection of two LTI systems. The small gain theorem.

2. Introduction to H^∞ control theory. The weighted sensitivity problem. The weighted robust stability problem. The standard H^∞ problem, reformulation of other problems as standard H^∞ problems. Loop transformations. The solution of the standard H^∞ problem via two Riccati equations.

3. Control of DC/DC power converters. Short review of basic topologies (buck, boost, flyback etc). Average models and their linearization. Voltage mode control, current mode control, H^∞ control, MPPT control. Application in power factor compensators. H bridges and the control of a pair of H bridges using phase shift.

4. Control of DC/AC (three phase) inverters. Construction and operation of two and three level inverters. The neutral leg and its control. Space vector modulation. The Park transformation, active and reactive power. The decomposition into negative, zero and positive sequence. Current source inverters and voltage source inverters, and their control using d, q coordinates and nested feedback loops. Space vector modulation. Phase locked loops and their use in the control of inverters.

5. Control of synchronous machines. Construction and modelling. Position and speed control for a "brushless DC motor". Internal model based rejection of torque disturbances. The synchronous machine as a grid-connected generator. Control of the active power and voltage using the d, q coordinates.

References (books only):

[1] R. Best, *Phase-Locked Loops*, McGraw-Hill, New York, 1999.

[2] J. Grainger and W. Stevenson, *Power System Analysis*, TATA McGraw-Hill, New Delhi, 1994.

[3] M. Green and D. Limebeer, *Linear Robust Control*, Prentice Hall, Englewood Cliffs, 1995.

[4] J. Kassakian, M. Schlecht and G. Verghese, *Principles of Power Electronics*, Addison-Wesley, Reading, MA, 1991.

[5] J. Maciejowski, *Multivariable Feedback Design*, Addison-Wesley, Wokingham, 1989.

[6] N. Mohan, T. Underland, W. Robbins, *Power Electronics*, John Wiley & Sons Inc., New York, 1995.

[7] A. Pressman, *Switching Power Supply Design*, McGraw-Hill, New York, 1991.

[8] M. Rashid, *Power Electronics*, Prentice-Hall Inc., Englewood Cliffs, NJ, 1993.