

Digital Control Techniques in Power Management Converters (PMCs)		
Module	Major topics & hours	Content overview
Module 1	An overview of modulation and control techniques in PMCs (4 hrs)	• Popular power management converters and control objectives • Fixed-frequency and variable frequency control techniques • Feedback and feedforward control techniques • Some recent trends of commercial digital control solutions
Module 2	Modeling techniques in PMCs (4 hours)	• Switching power converters – A form of switched linear systems • State space modeling and averaging technique • PWM switch modeling and circuit averaging • Linearization and derivation of small-signal transfer functions • Phase plane analysis and concept of eigenvector
Module 3	Nonlinear control techniques in PMCs (4 hours)	• Ripple-based and hysteresis control techniques in PMCs • Switching dynamics under various modulation techniques • Overview of variable structure system and sliding mode control • Design of sliding mode control in buck and boost converters • Control design to achieve the fastest (time-optimal) performance
Module 4	Digital architectures in PMCs (3 hrs)	• An overview of digital control product segments • Levels of digitization, associated systems, and circuits • Fixed and variable frequency digital voltage control architectures • Fixed and variable frequency digital current control architectures
Module 5	Small-signal modelling and design of digitally controlled PMCs (4 hrs)	• Continuous-time modelling of digitally controlled PMCs • Discrete-time modelling and small-signal transfer functions • A comparative study of different modelling techniques • Design of digital voltage control techniques • Design of digital current control techniques
Module 6	Advanced digital control techniques in PMCs (5 hrs)	• Light load control techniques • Multimode control techniques for wide operating range • Time optimal control and critical performance limits • Large-signal based digital control design • Nonlinear control techniques for fast transient performance • Some case studies with simulation
Module 7	Digital Control Implementation and FPGA prototyping (6 hrs)	• Fixed point implementation and top-down design methods • Introduction to Verilog HDL and modelling techniques • Verilog HDL implementation of digital voltage mode control • Verilog HDL implementation of digital current mode control • Steps for FPGA prototyping • Some experimental case studies of FPGA-based digital control

Reference book and material:

- [1] S. Kapat and P. T. Krein, "A Tutorial and Review Discussion of Modulation, Control and Tuning of High-Performance DC-DC Converters based on Small-Signal and Large-Signal Approaches" *IEEE Open Journal of Power Electronics*, vol. 1, pp. 339 - 371, Aug. 2020
- [2] R. W. Erickson and D. Maksimovic, *Fundamentals of Power Electronics*, 3rd Ed., Springer, 2020
- [3] YouTube course by S. Kapat, "Control and Tuning Methods in Switched Mode Power Converters", 2021
- [4] YouTube course by S. Kapat, "Digital Control in Switched Mode Power Converters and FPGA Prototyping", 2022