

20VL022 - POWER MANAGEMENT CIRCUITS

Course Outcomes

CO1: To develop understanding of why power management circuits are needed in a VLSI system.

CO2: What are different components of a power management system with focus on dc-dc converters.

CO3: How to design a chip level dc-dc converter from a given system level specifications.

CO4: Investigate new power techniques for future design.

UNIT-1

Introduction to Power Management and Voltage Regulators Need of power management, power management applications, classification of power management, power delivery of a VLSI system, power conversion, discrete vs. integrated power management, types of voltage regulators (switching Vs linear regulators) and applications, converter's performance parameters (voltage accuracy, power conversion efficiency, load regulation, line regulation, line and load transient response, settling time, voltage tracking), local Vs remote feedback, kelvin sensing, Point-of-Load (POL) regulators.

UNIT-2

Linear Regulators Low Drop-Out Regulator (LDO), Source and sink regulators, shunt regulator, pass transistor, error amplifier, small signal and stability analysis, compensation techniques, current limiting, power supply rejection ratio (PSRR), NMOS vs. PMOS regulator, current regulator.

UNIT-3

Switching DC-DC Converters and Control Techniques Types (Buck, boost, buck-boost), power FETs, choosing L and C, PWM modulation, leading, trailing and dual edge modulation, Losses in switching converters, output ripple, voltage Vs current mode control, CCM and DCM modes, small signal model of dc-dc converter, loop gain analysis of un-compensated dc-dc converter, type-I, type-II and type-III compensation, compensation of a voltage mode dc-dc converter, compensation of a current mode dc-dc converter, hysteretic control, switched capacitor dc-dc converters.

UNIT-4

Top-down Design Approach of a DC-DC Converter Selecting topology, selecting switching frequency and external components, sizing power FETs, segmented power FET, designing gate driver, PWM modulator, error amplifier, oscillator, ramp generator, feedback resistors, current sensing, PFM/PSM mode for light load, effect of parasitic on reliability and performance, current limit and short circuit protection, soft start control, chip level layout and placement guidelines, board level layout guidelines, EMI considerations.

UNIT-5

Introduction to Advanced Topics in Power Management Digitally controlled dc-dc converters, digitally controlled LDOs, adaptive compensation, dynamic voltage scaling (DVS), Single-Inductor Multiple-Outputs (SIMO) Converters, dc-dc converters for LED lighting, Li-ion battery charging circuits.

References

1. Switch-Mode Power Supplies: SPICE Simulations and Practical Designs by Christophe P. Basso, BPB Publications, 2010
2. Fundamentals of Power Electronics, 2nd edition by Robert W. Erickson, Dragan Maksimovic, Springer (India) Pvt. Ltd, 2005
3. Power Management Techniques for Integrated Circuit Design ByKe-Horng Chen, Wiley-Blackwell, 2016