EE504

Power Management for VLSI Systems

Ayman Fayed, Associate Professor
Director, Power Management Research Lab
Electrical & Computer Engineering, Iowa State University
◆ Ayman Fayed, Assistant Professor
Director, Power Management Research Lab
Dept. of Electrical & Computer Engineering
Iowa State University

Office: 2117 Coover Hall, Ames, Iowa 50011
Email: aafayed@iastate.edu
Phone: 515-294-6112
Web: http://home.eng.iastate.edu/~aafayed/
Topics Covered

◆ Introduction to Power Management
  ➢ Definitions, mains tasks, and challenges in VLSI systems
  ➢ Power delivery schemes in VLSI systems
  ➢ Programmability and configurability

◆ Power regulation performance parameters
  ➢ Typical load profiles in VLSI systems
  ➢ DC and Transient parameters
  ➢ Small-signal AC parameters

◆ Linear Power Regulators
  ➢ Basic topologies and implementation techniques
  ➢ Control loop small-signal analysis and stability
  ➢ Power supply rejection considerations
  ➢ Fully integrated linear power regulators
Topics Covered

♦ Inductor-Based Switching Power Regulators
  ➢ Basic step-down (buck) topology
  ➢ Loss Mechanisms
  ➢ PWM & PFM Control
  ➢ Small-signal linearized analysis
  ➢ Stability analysis and compensation techniques
  ➢ Other control techniques: current-mode, hysteretic, gated oscillator
  ➢ Implementation examples and performance review

♦ Other Inductor-Based Switching Power Regulators
  ➢ Step-up (boost) topology
  ➢ Buck-Boost topology
  ➢ Forward topology
  ➢ Flyback topology
Topics Covered

◆ **Selected topics in power regulation circuits**
  - Noise coupling through power circuits in large Systems-on-Chip (SoCs)
  - Switching noise spectral characteristics and impact on Analog/RF circuits
  - Switching noise and Electromagnetic Interference (EMI) mitigation techniques
  - High frequency switching regulators

◆ **Battery Chargers**
  - Battery types and discharging profiles
  - Charging profiles and memory effects
  - Linear and switching charger topologies
  - Implementation examples
  - Fuel Gauging
  - Multi-cell chargers
Lab & Project

◆ In some years, the project will involve the design of a step-down switching regulator (Buck Converter) in 0.35um technology. The type of converter will vary by year
  - The design will be divided into small circuit building blocks that will be implemented serially each in a separate sub-project assignment
  - The collection of the sub-projects will be added together towards the end of the semester to build the full regulator

◆ In other years, the project will involve the full design of a step-down switching regulator (Buck Converter) with type-III compensation using discrete components
  - The design will be built using discrete power FETs, driver and compensation circuits, and ramp generator
  - A full PCB implementation of the design is required and the converter must be tested in the lab

◆ Lab will involve measuring and characterizing several performance aspects of switching regulators
Lab & Project

◆ This class has a substantial hands-on laboratory section. Students will be using expensive, sensitive, and potentially hazardous test equipment. Safety in the lab is a number one priority for students and instructors and to ensure a safe laboratory experience, a brief safety presentation will be given the first day of lab. It is mandatory that all students attend this presentation. Moreover, it is expected that students follow any and all posted safety guidelines. For reference, a copy of the University Laboratory Safety Manual can be found at:

Prerequisite

◆ The course requires EE435 and EE501 unless instructor approves otherwise. You are expected to be familiar with

- MOS transistor operation, characteristics, and parameters
- Op-amp transistor/system level design, stability, and compensation
- Different classes of amplifier output stages
- Basic comparator design
- Basic current mirror design
- Basic signal processing, frequency and s-domain analysis, spectral analysis

◆ Contact the instructor if you are not sure
Course Information: Reference Texts

- This class will not have a specific text book assigned and will depend mainly on the lecture notes and material I will provide.
- There are some books that are a great resource but not mandatory.

McGraw-Hill, 2009

Elsevier, 2006

Course Information: Reference Texts

Springer, 2001