

## Switch-Mode DC-DC Converters – Course Outline

### Part 0. Introduction

- a. Scope of course
- b. Linear Regulator
- c. Modern Power Conversion Systems Requirements

### Part 1. PWM

- a. Inductor

### Part 2. Basic topologies: BUCK, BOOST, BUCK-BOOST, DCM operation

- a. Buck converter
  - i. Operation modes
  - ii. Voltage transfer function
  - iii. Current modes (CCM, DCM)
- b. Capacitor current
- c. Boost converter
  - i. Operation modes
  - ii. Voltage transfer function
- d. Buck-Boost converter
- e. Comparison between topologies
- f. Average Simulation of PWM Converters
  - i. The Switched Inductor Model (SIM) (CCM)
  - ii. The Generalized Switched Inductor Model (GSIM) Model
  - iii. Implementation (BUCK, BOOST, BUCK-BOOST)
  - iv. Parasitics
  - v. SPICE compatibility
  - vi. Discontinuous Model (DCM)
  - vii. Combined GSIM model

### Part 3. Magnetics Design

- a. Important magnetic equations
  - i. Faraday's law
  - ii. Ampere's law
- b. Magnetic losses

- c. Ideal Transformer
- d. Skin effect
- e. Proximity effect
- f. Transformer design
- g. Inductor design
- h. Cores
- i. Distributed gap core

#### Part 4. Isolated Converters (FORWARD and FLYBACK)

- a. DC current issue
- b. Forward Converter
  - i. Voltage transfer function
  - ii. Magnetizing Inductance Problem
  - iii. Transformer Reset
  - iv. Reset of Forward
- c. Coupled inductor
- d. Flyback converter
  - i. Voltage across primary
  - ii. Voltage transfer function
  - iii. Multiple outputs
  - iv. Features

#### Part 5. Losses and Efficiency

- a. Conduction Losses
- b. Switching Elements
- c. Diodes
  - i. Conduction losses
  - ii. Recovery
  - iii. Power Switches
  - iv. MOSFET
  - v. IGBT
- d. Capacitors
  - i. Practical Caps

- ii. Philips ceramic capacitors
- iii. Specifications
- iv. Implications
- v. Losses

#### Part 6. Output Voltage Ripple, Parasitic Effects, Snubbers

- a. Output voltage ripple
- b. Diodes reverse recovery
- c. Diode forward recovery
- d. Parasitic effects: Internal delay
- e. Snubbers
  - i. Designing the Snubber Components
  - ii. Diode Snubber (clamp)
  - iii. Switch Snubbers
  - iv. Reset
  - v. Lossless snubbing

#### Part 7. Advanced topologies (Half Bridge, Full Bridge, Push-Pull, C'uk, SEPIC)

- a. Half Bridge - HB
- b. Full Bridge - FB
- c. Reset of Forward, HB, FB
- d. Push-Pull
- e. Forward, HB, FB, PP
- f. C'uk Converter and Isolated C'uk
- g. SEPIC Converter

#### Part 8. Drivers

- a. Driver Requirements
- b. Required Drive
- c. Gate Drivers
  - i. Commercial drivers
  - ii. High-Side Drive
  - iii. Potential offset + floating C supply
  - iv. Turn "off"

## Part 9. Current Sensing

- a. Resistor
- b. Current transformer
- c. Pulse Current transformer Design
  - i. Resistor reset
  - ii. Reset – Clamp
  - iii. Measuring DC current
- d. DC Current transformer

## Part 10. Power Converters Control Technique

- a. The Dynamic Problem
  - i. Control
  - ii. Modulator
  - iii. Oscillator
- b. Complete controller Voltage Mode (VM)
- c. Bode Plot
  - i. Design problem
  - ii. Stability
- d. Current Feedback
- e. PCM & ACM
- f. Parasitic effects: PCB trace resistance
  - i. Interfering signal injection
  - ii. Inductive coupling
  - iii. Stray inductance