

9.7 Power electronics introduction

Name: _____ Class: _____ Date: _____

Total: 24 marks

KEY WORDS buck converter

Objective

Design buck and boost converters: duty cycle, current ripple, component choice and the efficiency accounting that decides the topology.

1 Key knowledge and worked examples

■ The two canonical converters

Buck: $V_{out} = D \cdot V_{in}$. Boost: $V_{out} = V_{in}/(1 - D)$. Continuous conduction needs the inductor current to stay positive: $\Delta I_L/2 < I_{load}$.

■ Ripple

$\Delta I_L = V_{out}(1 - D)/(L \cdot f)$ (buck); output ripple $\Delta V = \Delta I/(8Cf)$. Ripple sets L and C; the switch sets f – tens to hundreds of kHz.

■ Worked example: where the loss goes

20 V at 2 A out (40 W): switch 1.2 W, diode 0.8 W, control 0.3 W $\rightarrow \eta = 40/42.3 = 94.6\%$. A synchronous rectifier (MOSFET replacing the diode) recovers most of the diode term – the reason mid-90s efficiency is routine.

2 Practice

2.1 A buck converter drops 24 V to 9 V at 100 kHz with $L = 150 \mu\text{H}$. Compute D and the ripple current. [3]

2.2 A boost converter must raise 12 V to 48 V. Compute the duty cycle. [3]

2.3 A 20 V, 2 A supply dissipates 1.2 W in the switch, 0.8 W in the diode and 0.3 W in the control. Compute the efficiency. [3]

3 Exam-style questions

3.1 Design a buck converter: 24 V input, 5 V at 2 A output, switching at 200 kHz, target ripple current 20% of the load.

Compute the duty cycle. Choose L for the ripple target. Verify continuous conduction. Compute the output voltage ripple with $C = 220 \mu\text{F}$, and state one consequence of halving the switching frequency. [8]

3.2 A boost converter feeds 60 W into a 30 V load from a 12 V source; $L = 100 \mu\text{H}$, $f = 100 \text{ kHz}$, efficiency 95%.

Compute the duty cycle and the input current. Compute the inductor ripple current and the peak switch current. Recompute the input current at 95% efficiency and state where the extra 3.2 W goes. [7]
