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MANIPAL INSTITUTE OF TECHNOLOGY
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II SEMESTER M.TECH (POWER ELECTRONICS AND DRIVES)

END SEMESTER EXAMINATIONS, MAY 2019

SUBJECT: ADVANCED POWER ELECTRONIC CONVERTERS [ELE 5222]

REVISED CREDIT SYSTEM

Time: 3 Hours **Date: 4 May 2019** **Max. Marks: 50**

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitably assumed.

1A. Design a buck converter that has an input voltage of 3.3 V and an output voltage of 1.2 V. The output current is 4 A. The output voltage ripple must not exceed 2%. Specify the inductor value such that peak-to-peak variation in inductor current does not exceed 40% of the average value. Assume ideal components and switching frequency of 500 kHz. ***(05)***

1B. A boost converter has the following parameters: V_g = 20 V, D = 0.6, L = 100 μH, R = 50 Ω, C = 100 μF and f_s = 15 kHz. Comment on the nature of inductor current and hence find the output voltage. ***(05)***

2A. Design a flyback converter to produce an output of 36 V from a 3.3 V source. The output current is 0.1 A and the turns ratio N_2/N_1 is 16. The magnetizing current ripple should not exceed 40% of the average and the output voltage ripple to be limited to 2%. Assume continuous current mode, ideal components and switching frequency of 100 kHz.

What should be the new load resistance so as to make the converter operate in discontinuous current mode? ***(06)***

2B. A full bridge dc-dc converter has the following parameters: V_g = 30 V, N_P/N_S = 2, D = 0.3, L = 0.5 mH, R = 6 Ω, C = 50 μF and f_s = 10 kHz. Determine average output voltage, minimum value of inductor current and the percentage output voltage ripple. Assume all components to be ideal. ***(04)***

3A. A zero current switching dc-dc converter has the following specifications: P_o= 30 W, V_o = 15 V, Z_o = 2.5 Ω, C_r = 0.02 μF, the time between diode turn-off and the switch turn-off is 4 μsec. Find the input voltage and the switching frequency for suitable implementations. ***(05)***

3B. The Parallel loaded Resonant dc - dc converter has following parameters: V_g = 15 V, L_r = 1.3 μH, C_r = 0.12 μF, R_L = 10 Ω, f_s = 500 kHz. Determine output voltage of the converter. Estimate the new output voltage if the load resistance is changed to 5 Ω. ***(05)***

4A. Discuss in detail the basic constraints for the design of a high frequency inductor when the core geometrical factor K_g method is employed for the design. ***(05)***

4B. A filter inductor is to be designed for the following specifications: Inductance L = 50 μH, peak current I_{max} = 11 A, RMS current I_{rms} = 10 A, maximum allowed power loss P_{max} = 2 W. The ferrite core material available for this design has a saturation flux density B_{sat} = 0.4 T, but engineering margin requires that the maximum flux density B_{max} should not exceed 0.3 T. The cores that can be used in this design are listed in **Table 1.** The copper wires that can be used in this design are listed in **Table 2**. The inductor winding is expected to reach a temperature of 100°C, so the appropriate resistivity of copper ρ is 2.3 x 10^{-8} Ω-cm. Assuming the fill factor K_u of the core as 0.5, core loss and skin and proximity effect to be neglected, select the smallest core whose K_g satisfies the design requirement. Also, determine the required length of the air gap, number of turns and an appropriate wire for this inductor. ***(05)***

5A. Assuming ideal components and continuous conduction mode, develop the canonical circuit model of a buck-boost converter. ***(07)***

5B. For the small-signal model of the buck-boost converter developed in Q 5A, derive the open loop control to output transfer function. ***(03)***

Table 1

Core #	K_g (m^5)	A_c (cm^2)	W_A (cm^2)	(MLT) (cm)
1	2.2 x 10^{-12}	0.62	0.256	4.4
2	3.4 x 10^{-12}	0.62	0.384	4.4
3	8.4 x 10^{-12}	1.19	0.333	5.62
4	12.5 x 10^{-12}	1.18	0.503	5.62
5	20.3 x 10^{-12}	1.7	0.471	6.71
6	38.4 x 10^{-12}	1.61	0.995	6.71
7	82.2 x 10^{-12}	1.96	1.61	7.52
8	120 x 10^{-12}	2.01	2.5	8.39

Table 2

AWG #	Aw (cm^2)
14	20.02 x 10^{-3}
15	16.51 x 10^{-3}
16	13.07 x 10^{-3}
17	10.39 x 10^{-3}
18	8.23 x 10^{-3}
19	6.53 x 10^{-3}
20	5.19 x 10^{-3}
21	41.2 x 10^{-3}