EE6314E SWITCHED MODE POWER CONVERSION – Winter 2023-24
ASSIGNMENT – 2

1. A half-bridge converter running from 300V DC employs 35μH inductance and 220μF capacitor as filter components at output and the switches switch at 50kHz. 300V DC is split into two 150V sources by means of two 4.7μF capacitors. The output voltage is maintained at 12V. Turns ratio of primary winding to one-half of secondary winding is 9. Primary winding has 2.7mH self inductance.
   (a) Find and plot the currents flowing through the 4.7μF input splitting capacitors when the converter is delivering 10A at its output. Assume ideal components.
   (b) If the transformer has 3% leakage inductance, find the duty ratio required in the converter to maintain 12V at output while delivering 10A load. You may ignore all other non-idealities.

2. As a part of a SMPS project, you instructed your technical assistant to design and test a Flyback Converter in CCM mode with a suitable voltage clamp assuming 3% leakage inductance to satisfy the following specifications: Input : 250V – 400V, Output: 12V, 2A – 5A, Output Ripple : <2% peak to peak, Switching frequency : 100kHz. MOSFET Voltage Rating = 900V. She designed the unit and tested it with no load applied across output and applied a small fixed duty ratio of 10%. She did so since her Professor had told her that when she tests a SMPS unit first time she must do it in open loop with minimum load and lowest input voltage. However, on testing like this with 250V input, 10% duty ratio and 0 A load current, she ended up with a blown capacitor and blown switch. (i) Explain to her what went wrong. (ii) Did her Professor teach her wrong? Discuss.

3. The EE 65/32/13 core from CEL has the following parameters. Core area = 266 sq.mm, Window area = 537 sq.mm, Mean turn length = 150 mm, Magnetic path length = 146.3 mm, Relative permeability = 2200, A_L value = 4833 nH/T^2. Find the maximum value of inductance that can be designed using this core if the inductor is to carry 30 A ± 3A ? Assume that B_{max} = 0.2 Wb/sq.m , J = 4 A/sq.mm and space factor is 0.36. Also, calculate the air gap that is required when designed for this value of inductance.

4. Design a Forward Converter to satisfy the following specifications
   Input : 108V – 135V, Output: 12V, 2A – 5A, Output Ripple : <1% peak to peak, Inductor Current Ripple : <1A peak to peak, Magnetising current in Transformer : < 20% of load component (peak), Switching frequency : 40kHz
   Specify the MOSFET and Diodes completely. Use 40us Electrolytic capacitors and specify the capacitor completely including ripple rms current rating. Design the transformer and inductor using ferrite EE cores and round enameled copper wire. Use B_m = 0.2 Wm/sq.m, J = 3A/sq.mm, k_s = 0.35 for transformer and 0.4 for inductor. Take the coil former thickness as 1mm and creepage distance as 2mm. **Estimate the core loss and copper loss in inductor and transformer.**

5. Design a Push-Pull Converter to satisfy the following specifications
   Input : 200V – 280V, Output: 24V, 2A – 5A, Output Ripple : <2% peak to peak, Inductor Current Ripple : <1A peak to peak, Magnetising current in Transformer : < 20% of load component (peak), Switching frequency : 75kHz
   Specify the MOSFETs and Diodes completely. Use 30us Electrolytic capacitors and specify the capacitor completely including ripple rms current rating. Design the transformer and inductor using

ferrite EE cores and round enameled copper wire and use bifilar secondaries. Use B_m = 0.2 Wm/sq.m, J = 3A/sq.mm, k_s = 0.35 for transformer and 0.4 for inductor. Take the coil former thickness as 1mm and creepage distance as 2mm.

6. Design a Half Bridge Converter to satisfy the following specifications
   Input : 250V – 400V, Output: 12V, 5A – 20A, Output Ripple : <2% peak to peak, Inductor Current Ripple : <4A peak to peak, Peak Magnetising current in Transformer Primary < 20% of load current component, Switching frequency : 50kHz, Permitted peak to peak ripple in voltage-splitting capacitors and DC Blocking capacitor : 5%
   Specify the MOSFETs and Diodes completely. Use 50us Electrolytic capacitor for output filter and specify the capacitor completely including ripple rms current rating. Specify the rms current rating needed in voltage splitting capacitors and DC Blocking capacitor.
   Design the transformer and inductor using ferrite EE cores and round enameled copper wire for inductor and transformer primary and use bifilar foil winding for transformer secondaries. Use B_m = 0.2 Wm/sq.m, J = 3A/sq.mm, k_s = 0.35 for transformer and 0.4 for inductor. Take the coil former thickness as 1mm and creepage distance as 2mm.
   Estimate the core loss and copper loss in inductor and transformer.

7. Design a Flyback Converter in DCM mode with a suitable voltage clamp assuming 4% leakage inductance to satisfy the following specifications
   Input :250V – 400V, Output: 12V, 2A – 5A, Output Ripple : <2% peak to peak, Switching frequency : 100kHz. MOSFET Voltage Rating = 900V
   Specify the MOSFET and Diode completely. Use 30us Electrolytic capacitors and specify the capacitor completely including ripple rms current rating. Design the transformer using ferrite EE cores and round enameled copper wire. Use B_m = 0.25 Wm/sq.m, J = 3A/sq.mm, k_s = 0.35 for transformer. Take the coil former thickness as 1mm and creepage distance as 2mm.
   Estimate the core loss and copper loss in the transformer.

8. Design a Flyback Converter in CCM mode with a suitable voltage clamp assuming 3% leakage inductance to satisfy the following specifications
   Input :250V – 400V, Output: 12V, 2A – 5A, Output Ripple : <2% peak to peak, Switching frequency : 100kHz. MOSFET Voltage Rating = 900V
   Specify the MOSFET and Diode completely. Use 30us Electrolytic capacitors and specify the capacitor completely including ripple rms current rating. Design the transformer using ferrite EE cores and round enameled copper. Use B_m = 0.25 Wm/sq.m, J = 3A/sq.mm, k_s = 0.35 for transformer. Take the coil former thickness as 1mm and creepage distance as 2mm.
   Estimate the core loss and copper loss in the transformer.

9. A Boost Converter operating from an input voltage that is between 10.8V to 13.6V to generate 24V at the output uses 25µH inductance 680µF capacitor of 40µs family and switches at 50kHz. The load current can vary between 1A and 4A. Design a CT using a suitable toroidal ferrite core to sense the

current in the switch with a sensing gain of 0.125 V/A. Explain the design considerations and design equations clearly.

10. Design a CT using a suitable toroidal ferrite core to sense the current in the primary winding in the transformer of half-bridge converter described in Problem-1 with a sensing gain of 0.125 V/A. Explain the design considerations and design equations clearly.

11. A Push-Pull Converter operating from an input voltage that is between 180V to 240V to generate 12V at the output uses a transformer with turns ratio 6 and magnetizing inductance of 0.5mH and switches at 40kHz. It uses 40µH inductance 680µF capacitor of 40µs family at the output. The load current can vary between 4A and 10A. Design a CT using toroidal ferrite core to sense the current in the input line with a sensing gain of 0.5 V/A. Explain the design considerations and design equations clearly.

SWG	Dia with enamel (mm)	Area of copper (sq.mm)	R/km @ 20°C (Ohms)
32	0.307	0.0591	291.7
30	0.351	0.07791	221.3
28	0.417	0.111	155.3
26	0.505	0.164	105
24	0.612	0.245	70.3
22	0.77	0.397	43.4
20	0.978	0.657	26.3
19	1.082	0.811	21.3
18	1.293	1.167	14.8
17	1.501	1.589	10.8
16	1.709	2.075	8.3
15	1.92	2.627	6.6
14	2.129	3.243	5.3
13	2.441	4.289	4
12	2.756	5.48	3.1
11	3.068	6.818	2.5

Core	Ac (mm^2)	Aw (mm^2)	Ap (mm^4)	AL ($nH/Turn^2$)
T10	6.2	19.6	2940	765
T12	12	44.2	6756	1180
T16	20	78.5	13440	1482
T20	22	95	21307	1130
T27	42	165	31150	1851
T32	61	165	52658	2427
T45	93	616	111180	2367