NPTEL Online Certification Course
<Design of Power Electronics converter>
<Assignment Number 5>: Detailed Solution
Indian Institute of Technology Guwahati

Note the following important instructions for entering answer:

- Enter values exactly as given in the datasheet.
- Enter answers upto two decimal places. For example: 3.00
- Apply rounding off. For example: enter 5.375 as 5.38 and 5.374 as 5.37
- Solve all problems dependent on answers of previous steps, using values obtained after rounding off upto two decimal places in previous steps.
- Do not enter the unit.

A buck converter is designed using MOSFETs - IRF540NPBF. Following can be noted for the converter:
Input voltage: 40 V
Output voltage: 30 V
Switching frequency(f_s): 100 kHz Ambient temperature: 60 $^\circ C$
Average inductor current, I_L: 8 A
Assume switch current $I_{sw} = I_L$

From the datasheet of the MOSFET, note the following:

1. The value of ON state resistance, R_{D-on} ... ($m\Omega$)

   Ans: 44

2. Typical turn ON time of MOSFET ... (ns)

   Ans: $t_{d(on)} + t_r = (11 + 35) = 46$

3. Typical turn OFF time of MOSFET ... (ns)

   Ans: $t_{d(off)} + t_f = (39 + 35) = 74$

4. Maximum junction temperature ... ($^\circ C$)

   Ans: 175

5. Junction to case resistance, $R_{\theta jc}$ ... ($^\circ C/W$)

Ans: 1.15

6. Case to sink resistance, $R_{\theta cs}$ ... ($^\circ C/W$)

Ans: 0.50

Calculate the following:

7. Conduction loss ... (W)

Solution:
From the given values of all parameters ($V_{in} = 40V$, $V_{out} = 30V$, $I_L = 8A$, $R_{D-on} = 44m\Omega$), $D = V_{out}/V_{in} = 0.75$.

MOSFET conduction loss = $I_L^2 \times R_{D-on} \times D = 2.11\ W$

Ans: 2.11

8. Switching loss ... (W)

Solution:
$I_{sw} = I_L = 8A$, $f_s = 100kHz$
Switching loss = $V_{in} \times I_{sw} \times (t_{on} + t_{off}) \times f_s/2 = 1.92\ W$

Ans: 1.92

9. Total power loss ... (W)

Solution:
Total power loss = conduction loss + switching loss = (2.11 + 1.92) = $4.03W$

Ans: 4.03

10. Sink to ambient resistance, $R_{\theta sa}$ ... ($^\circ C/W$)

Solution:
$T_j = (R_{\theta jc} + R_{\theta cs} + R_{\theta sa}) \times P_{diss} + T_a$
From here, $R_{\theta sa} = 26.89\ ^\circ C/W$

Ans: 26.89

11. Select the most appropriate heat sink for the design if natural cooling is performed:

(a) Manufacturer part no: **ICK SMD A 10 SA** ($75\ ^\circ C/W$)

(b) Manufacturer part no: **217-36CTE6** ($55\ ^\circ C/W$)

(c) Manufacturer part no: **ICK 14/16 L** ($46\ ^\circ C/W$) (d) Manufacturer part no: **FK 243 MI 247 O** ($18.7\ ^\circ C/W$)

Solution:

As calculated $R_{\theta sa}$= 26.89° C/W, the $R_{\theta sa}$ of the heat sink has to be less than 26.89° C/W

Ans: d

12. Let the heat sink **217-36CTE6** is used with forced air cooling. A fan of 200 LFM is used. At 200 LFM, $R_{\theta sa}$ of the heat sink is 16 $^\circ$ C/W. Calculate the rise in temperature. ... ($^\circ$ C)

Solution:

The rise in temperature = $T_j = (R_{\theta jc} + R_{\theta cs} + R_{\theta sa}) \times P_{diss} + T_a$ = 131.13 $^\circ$ C

Ans: 131.13