Sample: Topics in Power Electronics and Distributed Generation – Test 2 **Points 20**

Open book test. You can make use of a one page formulae sheet. Make reasonable assumptions where necessary. No clarifications to questions will be provided during the test. Spend some time thinking about the questions before you start answering. ***Write the answers clearly and legibly so that they can be graded.***

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1. A buck converter is operated as a solar charger for a battery as shown in Figure 1. The open circuit voltage is $14V$, the MPPT voltage of the solar panel is $8V$, and the battery voltage is $6V$. Power from the PV panel at MPPT condition is $30W$. The MOSFET (S_M) has and resistance of $13m\Omega$ and the diode characteristics is obtained by operation of MOSFET as a synchronous rectifier (S_D) and has equivalent characteristics of $V_{don} = (0.1 + 13m\Omega i_d)V$. The switching frequency is $280kHz$ and the switching loss data for the MOSFET and Diode at $V_{dc} = 13V$ and $I_{out} = 8.5A$ is as follows: $E_{ON} = 1\mu J$, $E_{OFF} = 0.3\mu J$, and $E_{rr} = 0.17\mu J$. Switching power loss exponent k_v and k_i = 1, and the $T_{amb} = 60^oC$. Also, assume all the other passive components are ideal.

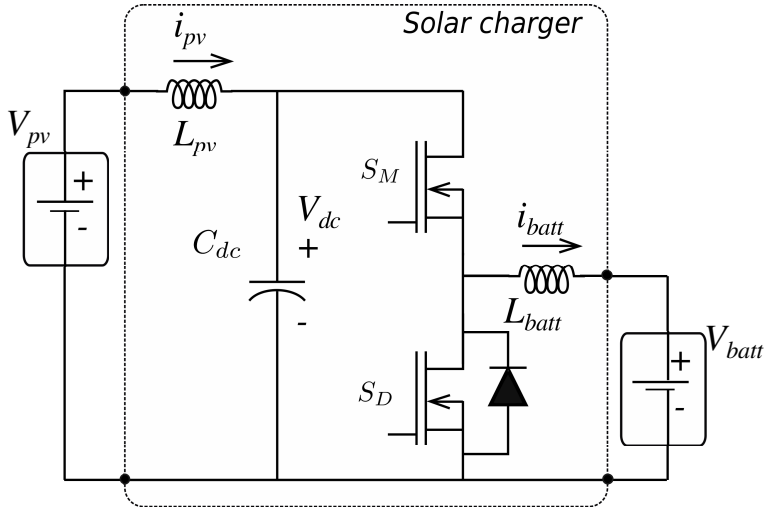

Figure 1: Solar battery charger.

(a) What is the duty cycle required for the switch S_M when the PV panel is charging the battery under MPPT conditions? *(2 points)*

(b) What is the conduction loss and switching loss in S_M and S_D under MPPT conditions? What is the corresponding charging power? *(3 points)*

(c) What is the maximum $R_{\theta(ja)}$ that the semiconductors can have so as to keep $T_j < 130^oC$? *(1 point)*

(d) What is the reduction in power loss that can be obtained by using two parallel MOSFETs for the switch S_M? *(1 point)*

(e) What is the rms current in C_{dc} neglecting ripple current in the inductors? *(2 points)*

(f) The solar charger cost is Rs.1000/- and the cost of the MOSFET is Rs.25/- and is operated daily for 8hrs at MPPT conditions. Compare the EIC of using 1 or 2 parallel MOSFETs considering factors for initial cost and power loss. Assume that the interest rate is 10%, cost of electricity is Rs.7/kWhr, and ten years of equipment operational life. *(2 points)*

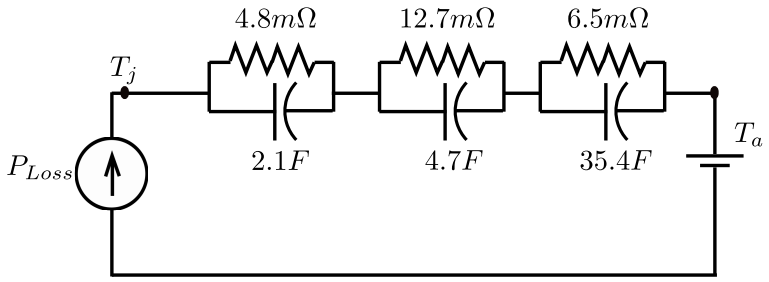

Figure 2: Thermal equivalent network.

2. The Foster network model of a thermal system is shown in Figure 2. Convert this to an equivalent Cauer network. Write the expressions for $P_i(s)/Q_i(s)$ for each stage of the transformation. *(6 points)*

3. A designer would like to use electronic equipment that was designed for commercial environment in an automotive application. In the commercial environment, the equipment would experience a daily semiconductor junction cycle of 20^oC. In the automotive environment, the equipment would experience daily four semiconductor junction cycles 80^oC. Assume both components are exposed to similar average temperatures. The Coffin-Manson exponent for the semiconductor, $q = 4$.

   (a) What is the ratio of the cycles to failure (N_f) for the commercial / automotive equipment due to thermal cycling. *(2 points)*

   (b) What is the ratio of the expected time to failure (MTTF) for the commercial / automotive equipment. *(1 point)*