SEPIC Converter Calculations For Fixed Output Voltage

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1 Introduction

This document makes calculation to design a SEPIC converter. Calculations are based on "AN-1484 Designing A SEPIC Converter" by Dongbing Zhang from *Texas Instruments*.

2 Parameters

- Minimum input voltage, $V_{IN(min)} = 7$ V
- Maximum input voltage, $V_{IN(max)} = 24$ V
- Output voltage, $V_{OUT} = 14.2$ V
- Maximum out current, $I_{OUT} = 4$ A
- Switching frequency, $f_{sw} = 100.0$ kHz

2.1 MOSFET (IRLZ44N)

- Static Drain-to-Source On-Resistance, $R_{DS(ON)} = 22.0$ mΩ
- Gate-to-Drain ("Miller") Charge, $Q_{GD} = 25.0$ nC
- Gate drive current, $I_G = 350.0$ mA

2.2 Diode (1N5825)

- Forward voltage drop of diode, $V_D = 0.38$ V

3 Duty Cycle

Maximum duty cylce is given by

$$D_{max} = \frac{V_{OUT} + V_D}{V_{IN(min)} + V_{OUT} + V_D}$$

then, $D_{max} = 67.56\%$

Minimum duty cylce is given by

$$D_{min} = \frac{V_{OUT} + V_D}{V_{IN(min)} + V_{OUT} + V_D}$$

then, $D_{min} = 37.79\%$

4 Inductor Selection

Ripple current is given by

$$\Delta I_L = I_{IN} \times 40\% = I_{OUT} \times \frac{V_{OUT}}{V_{IN(min)}} \times 40\%$$

The inductor vaue is given by:

$$L1 = L2 = L = \frac{V_{IN(min)}}{\Delta I_L \times f_{SW}} \times D_{max}$$

then, L1 = L2 = L = 14.6 µH

For coupled inductor, value will be 2L = 29.1 µH

The peak current in the inductor is given by:

$$I_{L1(peak)} = I_{OUT} \times \frac{V_{OUT} + V_D}{V_{IN(min)}} \times \left(1 + \frac{40\%}{2}\right)$$

$$I_{L2(peak)} = I_{OUT} \times \left(1 + \frac{40\%}{2}\right)$$

5 Power MOSFET Selection

Peak switch current is given by:

$$I_{Q1(peak)} = I_{L1(peak)} + I_{L2(peak)}$$

then, $I_{Q1(peak)}$=14.8 A

The RMS current through the switch is given by:

$$I_{Q1(rms)} = I_{OUT}\sqrt{\frac{(V_{OUT} + V_{IN(min)} + V_D) \times (V_{OUT} + V_D)}{V_{IN(min)}^2}}$$

then, $I_{Q1(rms)} = 10.14$ A

The MOSFET power dissipation is given by:

$$P_{Q1} = I_{Q1(rms)}^2 \times R_{DS(ON)} \times D_{max} + (V_{IN(min)} + V_{OUT}) \times I_{Q1(peak)} \times \frac{Q_{GD} \times f_{SW}}{I_G}$$

then, $P_{Q1} = 10.14$ Watts

6 Output Diode Selection

Peak current is 14.8 A.

The minimum peak reverse voltage the diode must withstand is:

$$V_{RD1} = V_{IN(max)} + V_{OUT(max)}$$

then, $V_{RD1} = 38.2$ V

Power dissipation by diode is given by:

$$P_{D1} = V_D \times I_{OUT}$$

then, $P_{D1} = 1.52$ Watts

7 SEPIC Coupling Capacitor Selection

The selection of SEPIC capacitor, Cs, depends on the RMS current, which is given by:

$$I_{Cs(rms)} = I_{OUT} \times \sqrt{\frac{V_{OUT} + V_D}{V_{IN(min)}}}$$

then, $I_{Cs(rms)} = 5.77$ A

The peak-to-peak ripple voltage on Cs (assuming no ESR):

$$\Delta V_{Cs} = \frac{I_{OUT} \times D_{max}}{C_S \times f_{SW}}$$

then, $C_S = 270.3$ µF

8 Output Capacitor Selection

The RMS current in the output capacitor is:

$$I_{Cout(rms)} = I_{OUT} \times \sqrt{\frac{V_{OUT} + V_D}{V_{IN(min)}}}$$

then, $I_{Cout(rms)} = 5.77$ A

Output capacitance,

$$C_{out} \geq \frac{I_{OUT} \times D}{V_{ripple} \times 0.5 \times f_{SW}}$$

then, $C_{out} = 540.5$ µF

9 Input Capacitor Selection

The RMS current in the input capacitor is given by:

$$I_{Cin(rms)} = \frac{\Delta I_L}{\sqrt{12}}$$

then, $I_{Cin(rms)} = 3.2$ A