MASSACHUSETTS INSTITUTE OF TECHNOLOGY

DEPARTMENT OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

6.622 Power Electronics Assessment #5

Due: Thursday March 30, 2023 at 11:00 pm (Cambridge time)

YOUR NAME Solutions

YOUR KERBEROS ID

General Instructions:

1. You must complete this assessment on your own with no consultation or discussion with any other person, excepting 6.622 staff, of whom you may ask clarifying questions. Do not discuss your solutions with anyone until the solutions have been released.

2. You may use a calculator and review the course lectures, notes and textbook (Principles of Power Electronics) when completing this assessment. Please do not use other computational tools or reference materials.

3. Please do all of your work in the space provided. In particular, try to do your work for each question within the boundaries of the question, or on the additional pages at the end of the uploaded document, clearly marking those pages to indicate what problem they relate to. Place the answer to each question within the appropriate answer box.

4. The assessment must be completed and uploaded by the indicated date/time to receive credit.

5. Please make sure to show all of your work. This is important both for you to receive credit for a correct answer and to receive partial credit when an answer is wrong or incomplete.

 Name:______________________________

Problem 1

This problem considers the cooling of a Cree C3M0016120D SiC MOSFET. This MOSFET is in a TO-247 package which has a thermal contact area of 2.5 cm^2. Information from the device datasheet is shown in Fig. 1. The MOSFET is mounted to an Ohmite R2V-CT4-38E heatsink through a Bergquist Sil-Pad900S silicone insulation pad. The silicone insulation pad has a *thermal resistance-area product* of 4.0°C-cm^2/W. The heat sink is used with natural convection. The heat sink characteristics are shown in Fig. 2; the plot in Fig. 2 indicates a sink-to-ambient thermal resistance $R_{th,SA}$ = 10°C/W for dissipation levels below 8 W under natural convection.

CREE

C3M0016120D

Silicon Carbide Power MOSFET
C3M™ MOSFET Technology
N-Channel Enhancement Mode

V_{DS}	1200 V
I_D @ 25°C	115 A
$R_{DS(on)}$	16 mΩ

Features

- 3rd generation SiC MOSFET technology
- High blocking voltage with low on-resistance
- High-speed switching with low capacitances
- Fast intrinsic diode with low reverse recovery (Q_{rr})
- Halogen free, RoHS compliant

Benefits

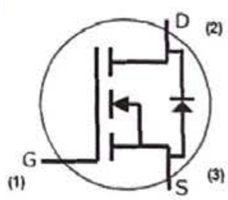
- Reduce switching losses and minimize gate ringing
- Higher system efficiency
- Reduce cooling requirements
- Increase power density
- Increase system switching frequency

Applications

Package

Halogen-Free

RoHS



Thermal Characteristics

Symbol	Parameter	Typ.	Unit	Test Conditions	Note
$R_{\theta JC}$	Thermal Resistance from Junction to Case	0.27	°C/W		Fig. 21
$R_{\theta JA}$	Thermal Resistance From Junction to Ambient	40			

Figure 1 C3M0016120D SiC MOSFET characteristics

R2 Series

For TO-247 and TO-264

Ohmite's R2 Series (patent pending) heatsink provides a large surface area along with our C Series clipping mechanism to attach to a TO-247 or TO-264 package. The self-aligning features of the clip assure secure attachment and enhanced thermal performance. Because no screws are required for device mounting, additional fins can be added to the rear side of the heatsink for increased total surface area in a more compact space.

FEATURES

- **Reduced Assembly Cost:** C Series camming clips make fasteners and fixtures obsolete, along with stray metal filings from tapped holes.
- **Maximum Repeatability:** clamping force of the clip is not degraded by repeated loading and unloading.
- **Maximum Heat Transfer per Unit Space:** maximum surface area per unit volume and consistent mounting force reduces thermal resistance
- **Maximum Resistance to Shock and Vibration:** light weight, resilient clips lock the component in place and are highly resistant to shock and vibration
- **Maximum Reliability:** helps prevent short circuits by eliminating metal particles from thread tapping
- **RoHS compliant**

HEAT DISSIPATION

TO-247 with no thermal interface material

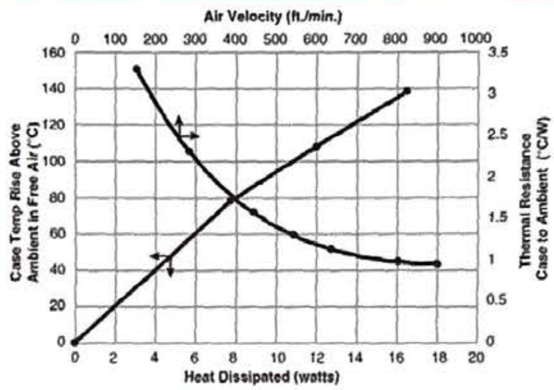


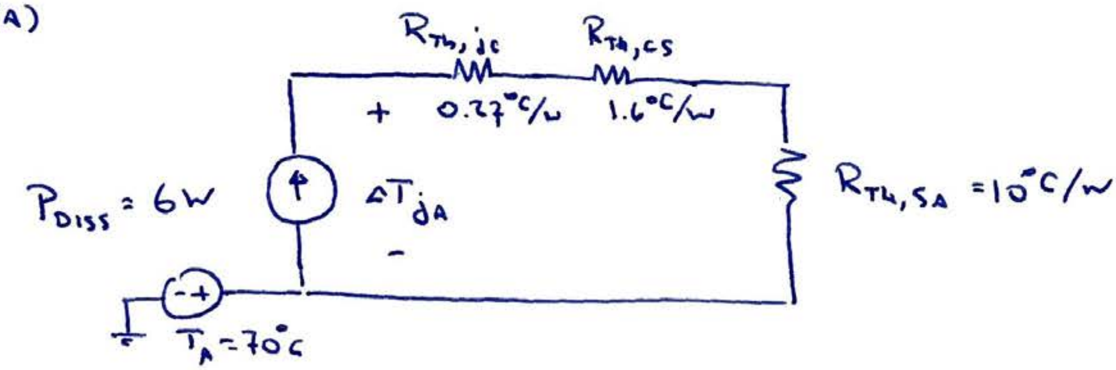
Figure 2 Ohmite R2V-CT4-38E TO-247 Heat Sink Characteristics. The sink-to-ambient temperature rise vs. power dissipation under natural convection is shown in the curve referenced to the bottom and left axes.

(a) The MOSFET dissipates $P_{diss} = 6$ W, and the system is operated in an ambient temperature of 70 °C. Draw a thermal model for the system and indicate the numerical values of the model parameters.

(b) What is the expected junction temperature T_j of the MOSFET under this operating condition?

we can reference our model to $T_A = 70^\circ C$:

(A)



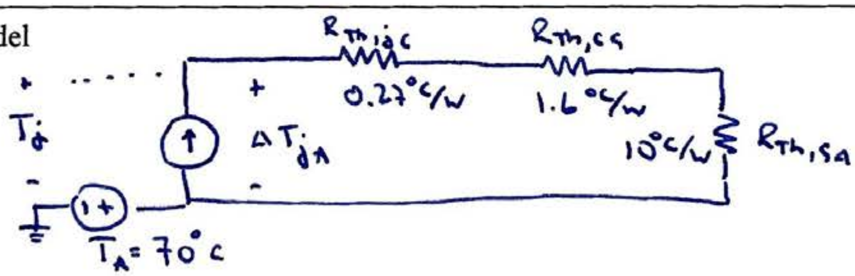
$$R_{Th,cs} = 4.0\,^\circ C\text{-}cm^2/W \,/\, 2.5\,cm^2 = 1.6\,^\circ C/W$$

$$\Delta T_{jA} = P_{DISS}\left(R_{Th,jc} + R_{Th,cs} + R_{Th,SA}\right)$$
$$= (6W)(11.87\,^\circ C/W) = 71.22\,^\circ C$$

$$\boxed{T_j = T_A + \Delta T_{jA} = 141.22\,^\circ C}$$

Name:______________________________

(a) Model



(b) T_j = 141 °C