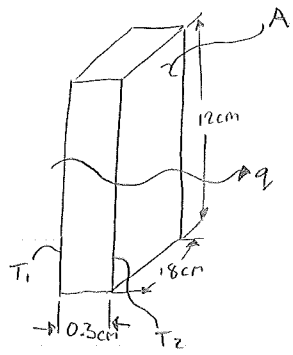
Scott Brown

MECH 262 - THERMO II - ASSIGNMENT 2

8-148 GIVEN:



80 chips

$q = 0.04 \frac{W}{chip}$

$K = 20 \frac{W}{m \cdot °C}$

$T_\infty = 40°C$

$h = 50 \frac{W}{m^2 \cdot °C}$

FIND: (a) T_1 & T_2

(b) T_1 & T_2 WITH 0.2cm THICK ALUMINUM PLATE, $K = 237 \frac{W}{m°C}$ & 664 2cm PINS $d = 0.25cm$ & 0.02cm epoxy $K = 1.8 W/(m°C)$

(SEE FIGURE ON Q'N SHEET)

a) $R_o = R_{BOARD} + R_{CONV.}$

$$R_o = \frac{L}{KA} + \frac{1}{hA} = \frac{0.003m}{\left(20 \frac{W}{m \cdot °C}\right)(0.0216m^2)} + \frac{1}{\left(50 \frac{W}{m^2 \cdot °C}\right)(0.0216m^2)}$$

$$R_o = 0.006944 \frac{°C}{W} + 0.9259 \frac{°C}{W}$$

$$R_o = 0.9329 \frac{°C}{W}$$

$$q = (80 chips)\left(0.04 \frac{W}{chip}\right) = 3.2 W$$

$$q = \frac{T_1 - T_\infty}{R_o} = \frac{T_1 - T_2}{R_{BOARD}}$$

5/5

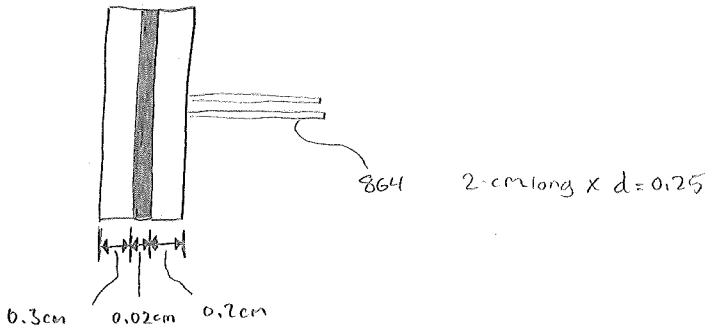
$$T_1 = q R_o + T_\infty = (3.2 W)\left(0.9329 \frac{°C}{W}\right) + 40°C$$

$T_1 = 42.99 °C$

$$T_2 = T_1 - q R_{BOARD} = 42.99°C - 3.2W(0.006944)$$

$$\boxed{T_2 = 42.96\ °C}$$ ✓

b)



$$\eta_{fin} = \frac{\tanh m L_c}{m L_c}$$ ✓

where, $m = \sqrt{4h/KD} = \sqrt{4\left(50 \frac{W}{m^2 \cdot °C}\right) / \left(237 \frac{W}{m \cdot °C}\right)(0.0025m)}$

$m = 18.373 m$

$L_c = L + \frac{D}{4} = 0.02m + \frac{0.0025}{4} = 0.0206m$ ✓

$$\eta_{fin} = \frac{\tanh(18.373 \cdot 0.0206)}{0.0206 \cdot 18.373}$$

$A = \pi D L_c = \pi (0.0025m)(0.0206m)$

$\eta_{fin} = 0.955$ ✓

$$R_{FINS} = \frac{1}{\eta_{FIN} h A} = \frac{1}{(0.955)\left(50 \frac{W}{m^2 \cdot °C}\right)\left(864 \times 0.000162 m^2\right)}$$

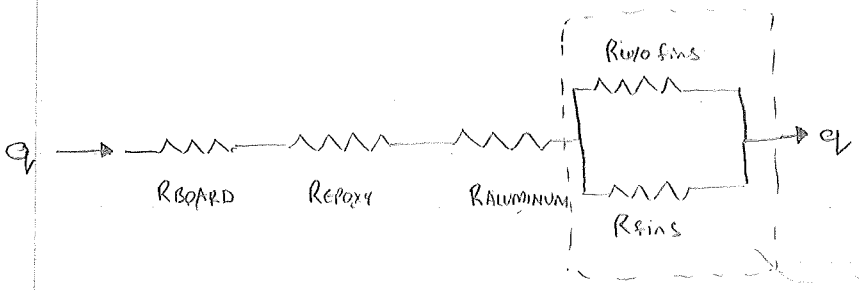
$R_{FINS} = 0.1498 \frac{°C}{W}$

$$R_{W/O\ FINS} = \frac{1}{hA} = \frac{1}{\left(50 \frac{W}{m^2 \cdot °C}\right)\left(0.0216m^2 - 864\left(\frac{\pi (0.0025m)^2}{4}\right)\right)}$$

$R_{W/O\ FINS} = 1.152 \frac{°C}{W}$

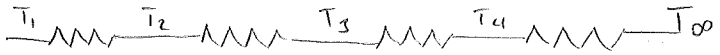
$$R_{ALUMINUM\ PLATE} = \frac{L}{KA} = \frac{0.002m}{\left(237 \frac{W}{m \cdot °C}\right)(0.0216m^2)} = 0.000391 \frac{°C}{W}$$

$$R_{EPOXY} = \frac{L}{KA} = \frac{0.0002m}{\left(1.8 \frac{W}{m \cdot °C}\right)(0.0216m^2)} = 0.00514 \frac{°C}{W}$$



$$R_{EQ} = \left(\frac{1}{R_{w/o}} + \frac{1}{R_{fin}}\right)^{-1}$$

$$R_{EQ} = \left(\frac{1}{1.152} + \frac{1}{0.1498}\right)^{-1} = 0.1326\ \frac{^\circ C}{W}$$



$R_{BOARD} = 0.006944\ \frac{^\circ C}{W}$ $R_{EPOXY} = 0.00514\ \frac{^\circ C}{W}$ $R_{ALUMINUM} = 0.000391\ \frac{^\circ C}{W}$ $R_{EQ} = 0.1326\ \frac{^\circ C}{W}$

$$R_0 = \sum R_i = 0.1451\ \frac{^\circ C}{W}$$

$$q = \frac{T_1 - T_\infty}{R_0} = \frac{T_1 - T_2}{R_{BOARD}}$$

$$T_1 = qR_0 + T_\infty = (3.2\,W)\left(0.1451\ \frac{^\circ C}{W}\right) + 40^\circ C$$

$$\boxed{T_1 = 40.46\ ^\circ C}$$

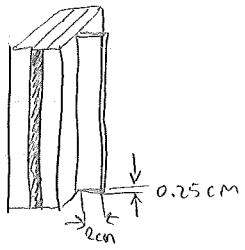
$$T_2 = T_1 - qR_{BOARD} = 40.46^\circ C - (3.2\,W)\left(0.006944\ \frac{^\circ C}{W}\right)$$

$$\boxed{T_2 = 40.44\ ^\circ C}$$

GOOD

5/5

8-149 GIVEN: SAME AS 8-148 but WITH 2cm FINS AS shown



$K_{COPPER} = 386 \frac{W}{M^2 °C}$

19 fins

$$\eta_{FIN} = \frac{\tanh mL_c}{mL_c}$$

where, $m = \sqrt{2h/kt} = \sqrt{2\left(50 \frac{W}{M^2 °C}\right) / \left(386 \frac{W}{M °C}\right)(0.0025M)} = 10.1797\ M^{-1}$ ✓

$L_c = L + t/2 = 0.02M + \frac{0.0025}{2} = 0.02125\ m$ ✓

$$\eta_{FIN} = \frac{\tanh(10.1797 \cdot 0.02125)}{10.1797 \cdot 0.02125} = 0.9847$$ ✓

$A_{FIN} = 2WL_c = 2(0.12M)(0.02125M) = 0.0051M^2$

$$R_{FINS} = \frac{1}{\eta_{FIN}\ h\ A_{FIN} \times \#FINS} \qquad R_{FINS} = \frac{1}{(0.9847)\left(50 \frac{W}{M^2 °C}\right)\left(0.0051M^2\right)(19)}$$

$R_{FIN} = 0.2096 \frac{°C}{W}$

$$R_{PLATE} = \frac{L}{kA} = \frac{0.002\ M}{\left(386 \frac{W}{M °C}\right)(0.0216M^2)} = 0.00024 \frac{°C}{W}$$

$$R_{W/O\ FIN} = \frac{1}{hA} = \frac{1}{\left(50 \frac{W}{M^2 °C}\right)\left(0.0216M^2 - (19 \times 0.0025M \times 0.12M)\right)} = 1.2579 \frac{°C}{W}$$

$R_{EPOXY} = 0.00514 \frac{°C}{W}$

$R_{BOARD} = 0.006944 \frac{°C}{W}$

$$R_o = R_{BOARD} + R_{EPOXY} + R_{PLATE} + \left(\frac{1}{R_{FINS}} + \frac{1}{R_{W/OFINS}} \right)^{-1}$$

$$R_o = 0.006944 + 0.00514 + 0.00024 + \left(\frac{1}{0.2096} + \frac{1}{1.2579} \right)^{-1}$$

$$R_o = 0.1920 \frac{^\circ C}{W}$$

$$q = \frac{T_1 - T_\infty}{R_o} = \frac{T_1 - T_2}{R_{BOARD}}$$

5/5

$$T_1 = q R_o + T_\infty = (3.2\,W)\left(0.1920 \frac{^\circ C}{W}\right) + 40^\circ C$$

$$\boxed{T_1 = 40.61\,^\circ C}$$ ✓

$$T_2 = T_1 - q R_{BOARD} = 40.61^\circ C - (3.2W)\left(0.006944 \frac{^\circ C}{W}\right)$$

$$\boxed{T_2 = 40.59\,^\circ C}$$ ✓

8-142 GIVEN: $R = 25 \frac{°C}{W}$

T CANNOT EXCEED 80°C

$T_\infty = 30°$

$q \leq 15\ W$

FIND: q_{MAX}

$$q = \frac{T_1 - T_\infty}{R} = \frac{80°C - 30°C}{25 \frac{°C}{W}}$$

5/5

$\boxed{q_{MAX} = 2\ W}$ ✓

8-143 GIVEN: $q = 40\ W$

T CANNOT EXCEED 90°C

$T_\infty = 20°C$

FIND: A HEAT SINK THAT IS APPROPRIATE FROM TABLE 8-6

ASSUME THE TRANSISTOR IS MOUNTED HORIZONTALLY

$$q = \frac{T_1 - T_\infty}{R}$$

$$R = \frac{T_1 - T_\infty}{q} = \frac{90°C - 20°C}{40\ W} = 1.75 \frac{°C}{W}$$ ✓

THERMAL RESISTANCE CANT EXCEED $1.75 \frac{°C}{W}$

HS 6115 HAS AN $R = 1.3 \frac{°C}{W}$ (HORIZONTAL) ✓

THIS WOULD RESULT IN A CASE TEMPERATURE OF:

$$T_1 = Rq + T_\infty = \left(1.3 \frac{°C}{W}\right)(40\ W) + 20°C$$

$$T_1 = 72°C$$

5/5

THIS SPECIFICATION IS ASSUMING AN CONSTANT AND RELIABLE POWER SUPPLY.