Setup TEC module controler calcs

TEC Module - 03103

3.5V 3.5A, Qmax 7.2watts
dims 20 x 20 x 4.7mm
max temp difference = 67'C

laser diode heat output $P_{diode} := 2.5W$

ADN8831 TEC controller IC, Run cooler at 2.0A, 2.0V max

Min (heat) TEC current $I_{min} := 2.0A$

Max (cool) TEC current $I_{max} := 2.0A$

supply voltage $V_{in} := 5V$

Max TEC voltage $TEC_V := 2.0V$

PWM switching frequency

kHz vs kΩ

$$f_{op} := \begin{pmatrix} 250 & 484 \\ 500 & 249 \\ 750 & 168 \\ 1000 & 118 \end{pmatrix} \qquad R_{freq} := 124k\Omega$$

Current sense resistor $R_{sense} := 0.02\Omega$

Current sense resistor power $P_{sense} := I_{max}^{2} \cdot R_{sense} = 0.08 \cdot W$ Keep under 0.5W

TEC series resistance $R_{TEC} := \frac{3.8V}{3.6A} = 1.056 \cdot \Omega$ estimate

Soft start capacitor $C_{ss} := 0.1\mu F$

Soft start power-up time $t_{ss} := 150ms \cdot \frac{C_{ss}}{\mu F} = 15 \cdot ms$

Voltage reference $V_{REF} := 2.5V$

Supply voltage $V_{DD} := 5V$

Temperature set point $T_{set} := 25\Delta°C$

Heatsink setup

http://www.myheatsinks.com/calculate/round-pin-heat-sink-calculator/#

Control voltage - Cooling & Heating

$V_{VLIM} := 0.39V$

$TEC_{VC} := V_{VLIM} \cdot 5 = 1.95\,V$

$\begin{cases} \text{"FAIL"} & \text{if } TEC_{VC} \geq TEC_V \\ \text{"PASS"} & \text{otherwise} \end{cases} = \text{"PASS"}$

Voltage monitoring conversion

$V_{VTEC} := 1.5V$

TEC voltage from monitor voltage $V_{TEC} := (V_{VTEC} - 1.25V) \cdot 4 = 1\,V$

Set output current limits - Cooling

Current control voltage $V_{ILIMC} := 2.2\ V$

Current limit $I_{TECC} := \dfrac{V_{ILIMC} - 1.25V}{25R_{sense}} = 1.9\,A$

$\begin{cases} \text{"FAIL"} & \text{if } |I_{TECC}| \geq I_{max} \\ \text{"PASS"} & \text{otherwise} \end{cases} = \text{"PASS"}$

Cooling electrical power $P_{cool} := |I_{TECC}| \cdot TEC_{VC} = 3.705\,W$

Set output current limits - Heating

Current control voltage $V_{ILIMH} := 2.2\ V$

Current limit $I_{TECH} := \dfrac{1.25V - V_{ILIMH}}{25R_{sense}} = -1.9\,A$

$\begin{cases} \text{"FAIL"} & \text{if } |I_{TECH}| \geq I_{max} \\ \text{"PASS"} & \text{otherwise} \end{cases} = \text{"PASS"}$

Heating electrical power $P_{heat} := |I_{TECH}| \cdot TEC_{VC} = 3.705\,W$

Current monitoring conversion

$V_{ITEC} := 1.27V$

TEC current from monitor voltage $I_{TEC} := \frac{V_{ITEC} - 1.25V}{25 \cdot R_{sense}} = 0.04\,A$

TEC cooler selection procedure
http://www.marlow.com/resources/knowledgebase/iii-tec-selection-procedure.html

2. Active heat load $P_{diode} = 2.5\,W$

3. Radiation - insignificant
4. Convection - insignificant
5. Conduction - insignificant

6. Combined convection & conduction

enclosure external area $A_{surf} := 4cm \cdot 4cm \cdot 2 = 3.2 \times 10^{-3}\,m^2$

thickness of material $x_{ins} := 5mm$

thermal conductivity of material $k_{ins} := 0.25 \frac{W}{m \cdot K}$ nylon

convective heat transfer coefficient $h_{conv} := 15 \frac{W}{m^2 \cdot K}$

temperature change $dT := 5K$

Heat load from outside enclosure $Q_{passive} := \frac{(A_{surf} \cdot dT)}{\left(\frac{x_{ins}}{k_{ins}} + \frac{1}{h_{conv}}\right)} = 0.185\,W$

$Q_{total} := Q_{passive} + P_{diode} = 2.685\,W$

E. Select appropriate TEC

ratio of dT/dtmax $ratio := \frac{5K}{64K} = 0.078$

opt Q/Qmax = 0.15

max Q/Qmax = 0.9

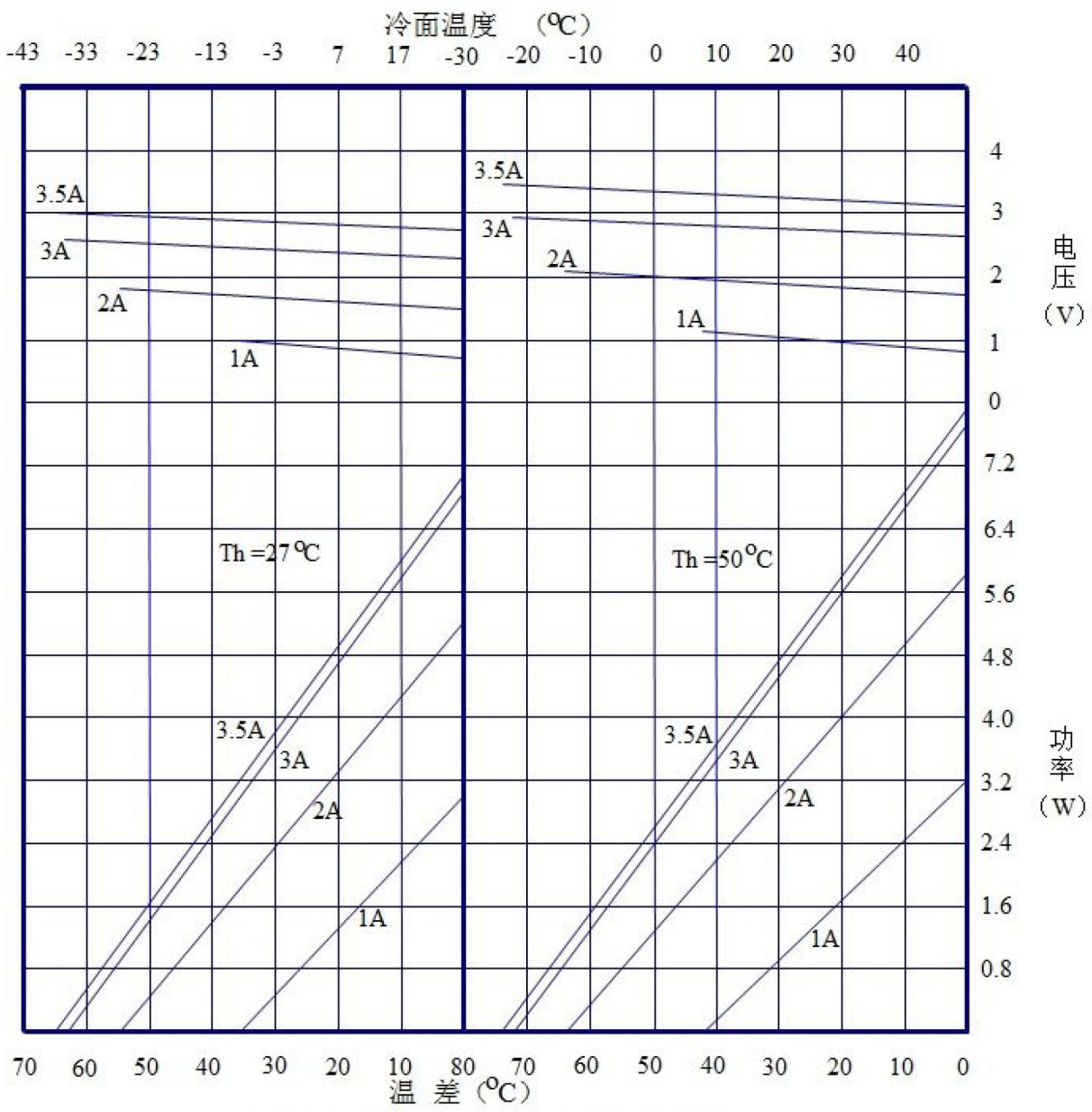
$optQ := \frac{Q_{total}}{0.15} = 17.897\,W$

$maxQ_{max} := \frac{Q_{total}}{0.9} = 2.983\,W$

03103 Qmax = 7.2W > maxQmax < optQ

3. Performance Curves

Tc (℃)



Th-Tc (℃)

Reading 27'C hot side chart. $\max Q_{max} = 2.983\,W$ So current required is ~ 1.3A

Th-Tc = 27 - 25 = 2C

Then Tc = 25'C So voltage required is ~1.3V

I = 1.3A

PID controller roughing-out

$sumError := 511$

$lastProcessValue := 1023$

$vControl := 1023$

cool = < 511
heat = > 511

$temp_{set} := 668$

$temp_{curr} := 562$

20 'C = 770
25 'C = 668
30 'C = 575

$P_{factor} := 2$

$I_{factor} := 0$

$D_{factor} := 0$

$error := temp_{set} - temp_{curr} = 106$

$$p\_term := \begin{cases} 511 & \text{if } error > 511 \\ -511 & \text{if } error < -511 \\ P_{factor} \cdot error & \text{otherwise} \end{cases} = 212$$

$temp := sumError + error = 617$

$$i\_term := \begin{cases} 511 & \text{if } temp > 511 \\ -511 & \text{if } temp < -511 \\ I_{factor} \cdot temp & \text{otherwise} \end{cases} = 511$$

$d\_term := D_{factor} \cdot (lastProcessValue - vControl) = 0$

$lastProcessValue := vControl = 1.023 \times 10^{3}$

$vControl := 511 - (p\_term + i\_term + d\_term) = -212$

$$vControl := \begin{cases} 1023 & \text{if } vControl > 1023 \\ 0 & \text{if } vControl < 0 \\ vControl & \text{if } 1023 > vControl > 0 \end{cases} = 0$$