Aluminium Extruded Heat Sink Optimization

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HEATSINK OPTIMIZATION

Introduction

Optimal design of a heatsink, meeting program targets for cost, weight, size, and performance, is one of the more challenging activities within most electronics engineering teams. Without a dedicated solver, designers or thermal engineers can be involved in a game of ‘opinioneering’, which typically involves overdesign, or initiate an expensive and time-consuming physical design of experiments that provides limited results. In the case study below, we worked to optimize an extruded aluminum heat sin k for an IGBT module in a low-cost, high-volume design. Reliability requirements (10-year life), harsh environments (vibration, elevated temperature), limited ability to perform maintenance (consumer household), and cost constraints eliminated forced air cooling as a practical solution. The focus was instead to optimize the design within the dimensional constraints provided by the end-user.

IGBT Module

Optimization was requested because the IGBT module starts to behave intermittently at 60°C and shuts down completely at 65°C. The module shutdowns due to a thermal cutoff limit of 100°C at the internal thermistor. The data sheet for the IGBT module indicates that the cutoff temperature of the IGBT junction temperature is 150°C. The module thermal resistances are supplied by the manufacturer and are shown in Figure 1. The goal of this analysis was to reduce the thermistor temperature during operation such that the module achieves stable operation at 60°C and shutdown at or above 65°C. To achieve this goal, the case temperature of the IGBT must be decreased. This increase in the operating margin will be achieved by modifying the relevant heatsink parameters. The baseline heatsink dimensions are displayed in Figure 2.

Symbol	Parameter	Min	Typ	Max	Units	Conditions
$R_{th(j-c)}$	Thermal resistance, per IGBT	---	4.2	4.7	°C/W	Flat, greased surface. compound thermal co 1W/mK
$R_{th(j-c)}$	Thermal resistance, per Diode	---	5.5	6.5		
$R_{th(c-s)}$	Thermal resistance, C-S	---	0.1	---		

Figure 1: Thermal resistance of IGBT module

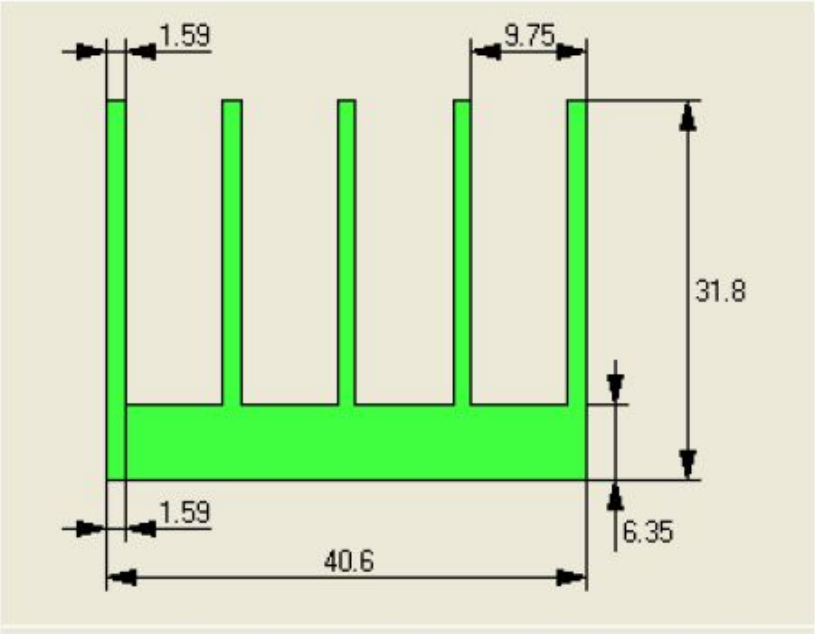
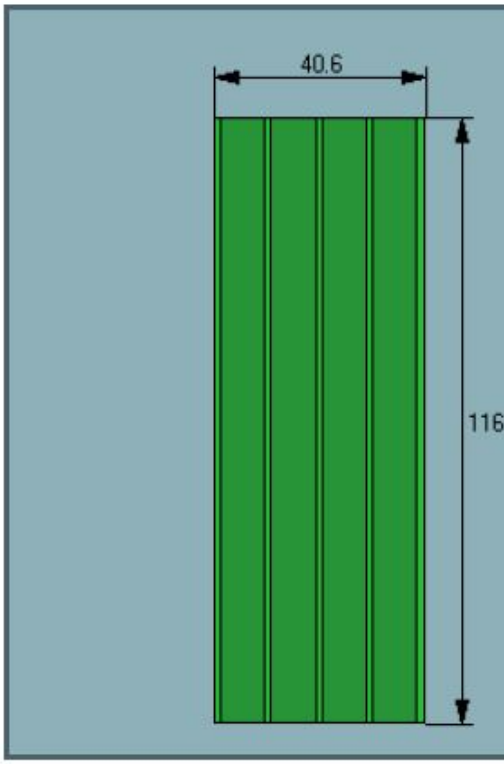
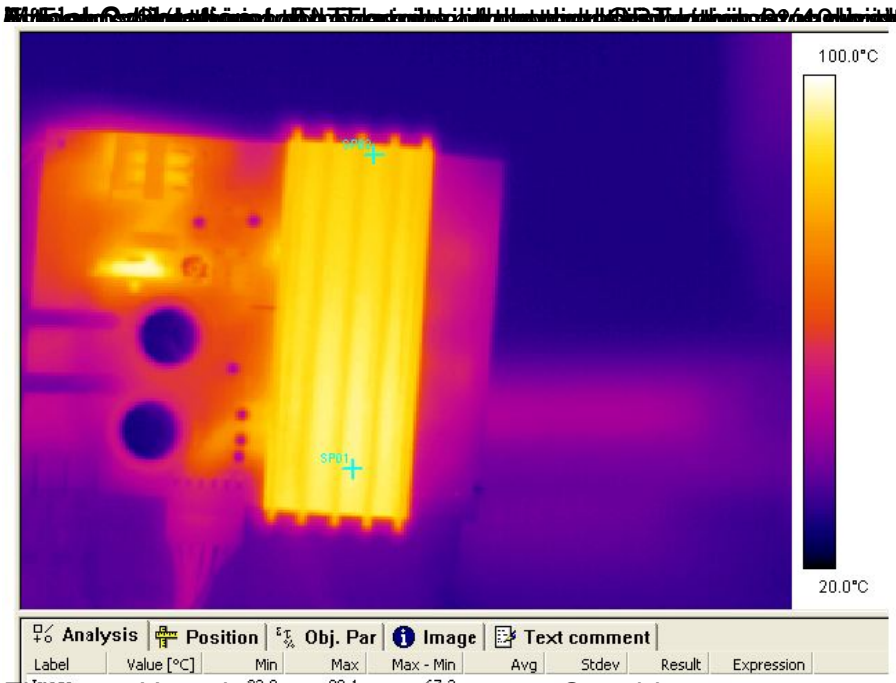
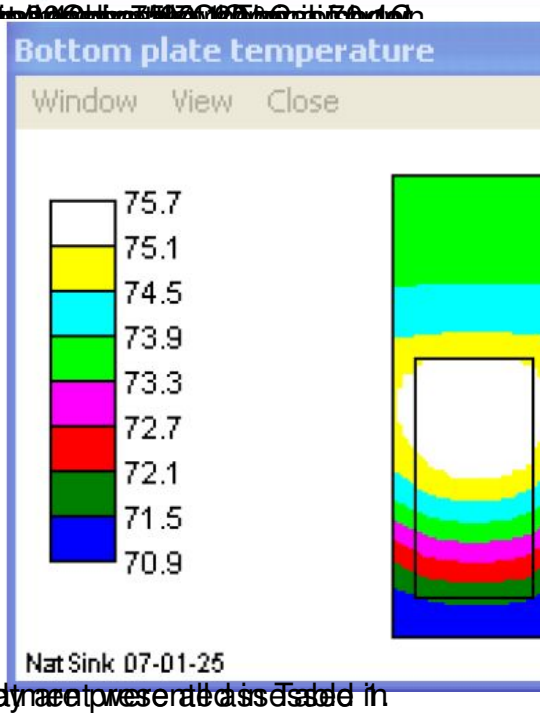


Figure 2: Dimensions of heatsink







[illegible] Table 1 [illegible]

Base Thickness	Height	Width	Length	Fin Thickness	Fin Pitch	Fin #	
6.35 mm	31.8 mm	40.6 mm	116 mm	1.6 mm	9.75 mm	5	
6.35 mm	31.8 mm	40.6 mm	116 mm	1.6 mm	7.8 mm	**6**	
6.35 mm	**38.1 mm**	40.6 mm	116 mm	1.6 mm	9.75 mm	5	
6.35 mm	**44.5 mm**	40.6 mm	116 mm	1.6 mm	9.75 mm	5	
6.35 mm	31.8 mm	40.6 mm	116 mm	1.6 mm	9.75 mm	5	**C**
6.35 mm	31.8 mm	40.6 mm	116 mm	1.6 mm	9.75 mm	5	**A**

No	Pitch	Fin count	Fin thick	Heat diss	Tdiff in	Rth	Equ velo	dT Air	Fin eff	Vol eff	Warning
(6)	[mm]	[----]	[mm]	[W]	[K]	[K/W]	[m/s]	[K]	[%]	[%]	[--]
1	19.5	3	1.59	20.0	54.1	2.71	0.356	24.4	99	98	--
2	13.0	4	1.59	20.0	46.7	2.33	0.288	33.5	99	122	--
3	9.8	5	1.59	20.0	43.1	2.16	0.209	48.4	99	138	--
4	7.8	6	1.59	20.0	44.4	2.22	0.146	68.6	98	132	--
5	6.5	7	1.59	20.0	49.3	2.46	0.110	85.1	98	113	--
6	5.6	8	1.59	20.0	56.1	2.81	0.086	98.2	97	93	--
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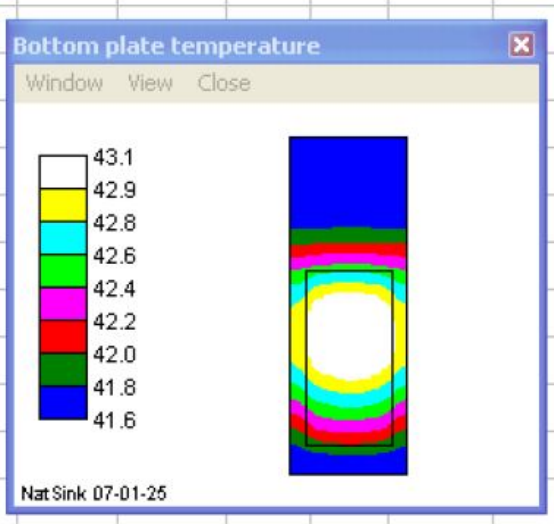

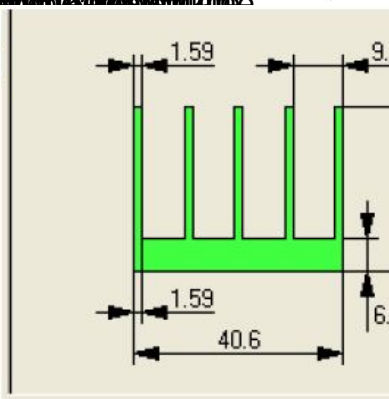

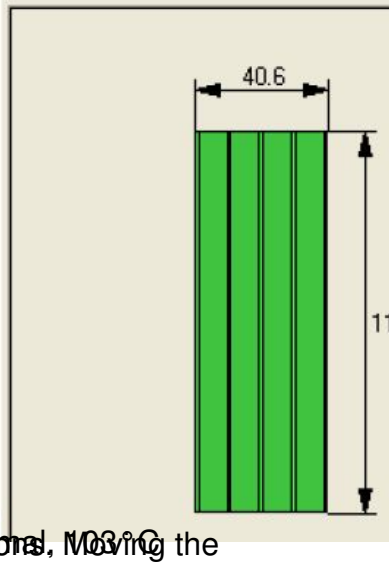

Figure 4: Bottom heat sink analysis at 20 watts 60°C ambient temperature (no fan). Moving the heat source to the heat sink center was attempted and found to be not optimal, 103°C