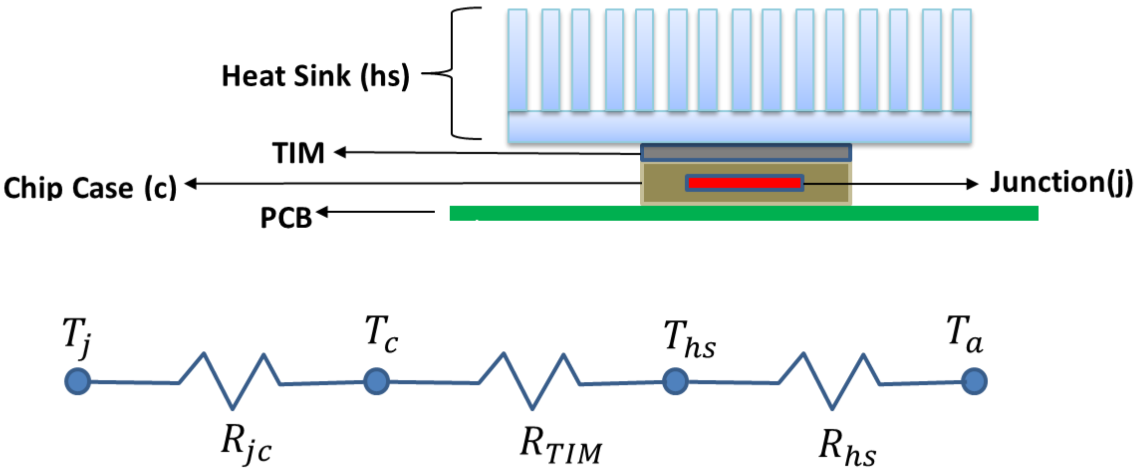
REPORT



$$R_{total} = R_{jc} + R_{TIM} + R_{hs}$$

$$Where,$$
$$R_{hs} = R_{cond} + R_{conv}$$

Schematic diagram for the Heat Sink

Step 1: Given Data and Assumptions

Processor Die Dimensions:

processor specification				
Die Length	52.5	mm	0.0525	m
Die width	45	mm	0.045	m
Die thickness	2.2	mm	0.0022	m
Die Area	2362.5	mm2	0.002363	m2

Thermal Design Power (TDP): Q=150 W

Heat Sink Specifications:

Sink Length	90	mm	0.09	m
sink width	116	mm	0.116	m
base thickness	2.5	mm	0.0025	m
base area	10440	mm	0.01044	m2
No. of Fins	60			
Fin Thickness	0.8	mm	0.0008	m
overall height	27	mm	0.027	m
Fin Height	24.5	mm	0.0245	m
Fin Spacing	1.152542	mm	0.001153	m

Assumptions:

- Heat sink material: **Aluminum (Al 6061-T6)** With Thermal conductivity, k_{Al} = 167 $W/m \cdot K$

- Thermal interface material:
- **Thermal grease with thermal conductivity** k_{TIM}=4 $W/m \cdot K$
- Assuming a **thermal grease layer** of **0.1 mm thickness**
- Cooling Medium: Air at 25^{0}C
- At 25^{0}C, properties of Air are

Thermal Conductivity	0.0262	W/mk
Kinematic viscosity	$1.57E-05$	$m2/s$
Prandtl Number	0.71	
Velocity of Air	1	m/s

Step 2: Define the Thermal Resistance Network

The **total thermal resistance** R_{total} from the processor junction to ambient consists of:

$$R_{total} = R_{jc} + R_{TIM} + R_{hs}$$

where:
R_{jc} is the Junction to case resistance within the processor.
R_{TIM} is the resistance due to thermal interface material (TIM)
R_{hs} is the thermal resistance due to heat sink, which consist of $R_{conduction}$, conduction resistance through heat sink base and $R_{convection}$ accounts for heat loss through forced convection.

Step 3: Junction-to-Case Resistance calculation (R_{jc})

For modern processors, **junction-to-case resistance** is often provided in datasheets.
A typical value: R_{jc} = 0.1 $°C/W$

Step 4: Case-to-TIM Resistance

The resistance of the thermal interface material (TIM) is given by:

$$R_{TIM} = \frac{t_{TIM}}{k_{TIM} A_{die}}$$

Where
t_{TIM} = Thickness of TIM
A_{die} = Area of die

Step 5: Thermal resistance due to heat sink R_{hs}

Conduction Resistance through Heat Sink Base ($R_{conduction}$)

The conduction resistance through the **aluminum base** is:

$$R_{cond} = \frac{t_b}{k_{Al} A_{die}}$$

Where t_b is thickness of base.
And A_{die} = Area of die

Convection Resistance ($R_{convection}$)

Reynolds number is given by:

$$Re = \frac{VL}{\upsilon}$$

Where
V = Air velocity
L = Characteristic length, here Fin spacing S_f

$$S_f = Heat\ sink\ Width - \frac{\left(N_{fins}\ \times Fin\ Thickness\right)}{N_{fin} - 1}$$

υ = Kinematic viscosity

The heat sink fins create channel flow**,** similar to flow between parallel plates.
For low Re (< 2300), flow remains laminar and developing, **so** Sieder-Tate is applicable.

$$Nu = 1.86\left(Re \times Pr \times \frac{2S_f}{L}\right)^{\frac{1}{3}}$$

For higher Re (> 2300), the flow transitions to turbulent, where the Dittus-Boelter equation is more appropriate so Nusselt Number is:

$$Nu = 0.023Re^{0.8}Pr^{0.3}$$

So
Convective Heat transfer coefficient

$$h_{convection} = \frac{Nu \times k_{air}}{2S_f} \quad W/m^2K$$

Now,

$$R_{convection} = \frac{1}{h_{convection}\ \times A_{total}}$$

Where
$A_{total} = Total\ area\ for\ convection$

And Thermal resistance through Heat sink,

$$R_{hs} = R_{conduction} + R_{convection}$$

Step 6: Total Thermal Resistance

$$R_{total} = R_{jc} + R_{TIM} + R_{hs}$$

Step 7: Calculation Junction Temperature

$$T_{junction} = T_{ambient} + QR_{total}$$

Result from excel: (Reference)

Excel Results		
Total Heat Sink Resitance	0.373043	degC/W
Junction Temperature	80.95652	degC