SUPPORT NOTE

SN035 | Information on Heatsinks WE-HTO & WE-HIC

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1. INTRODUCTION AND THEORETICAL BACKGROUND

Thermal management is a critical aspect of electronic design, directly impacting performance, reliability, and longevity. This guideline serves as a practical resource for engineers and designers who need to select and design-in the WE-HTO, WE-HTOI, WE-HIC and WE-HICI series heatsinks in different use-case scenarios.

Electronic components such as processors, power transistors, and LEDs generate heat during operation. If not properly dissipated, excessive heat can lead to:

- Performance throttling (reduced speed or efficiency);
- Premature failure (thermal stress on materials);
- Safety hazards (overheating in high-power systems).

Heatsinks address these challenges by dissipating heat from electronic components into the surrounding environment through conduction, convection, and, to a lesser extent, radiation. The process begins when heat generated by an IC or power transistor flows into the heatsink base via conduction, facilitated by direct contact or thermal interface materials such as Würth Elektronik's WE-TGF, WE-TINS, WE-PCM and WE-TTT series. The heat then spreads through the base and into the fins, where it is transferred to the ambient air primarily through forced or natural convection.

Heatsinks address this challenge by providing a passive (or active) cooling solution that transfers heat away from critical components into the surrounding environment (Figure 1) They work by:

1. Conduction: influenced by heatsink material (typically aluminum or copper) and base thickness, which determines how efficiently heat spreads from the contact area to the fins.
2. Convection: Dominates the cooling process, where airflow (natural or forced) carries heat away from the fin surfaces. The fin geometry (spacing, length, thickness) directly impacts convective efficiency.
3. Radiation: Plays a minor role, contributing < 10 % of heat dissipation in most scenarios, though surface treatments (e.g., anodization) can enhance radiative cooling.

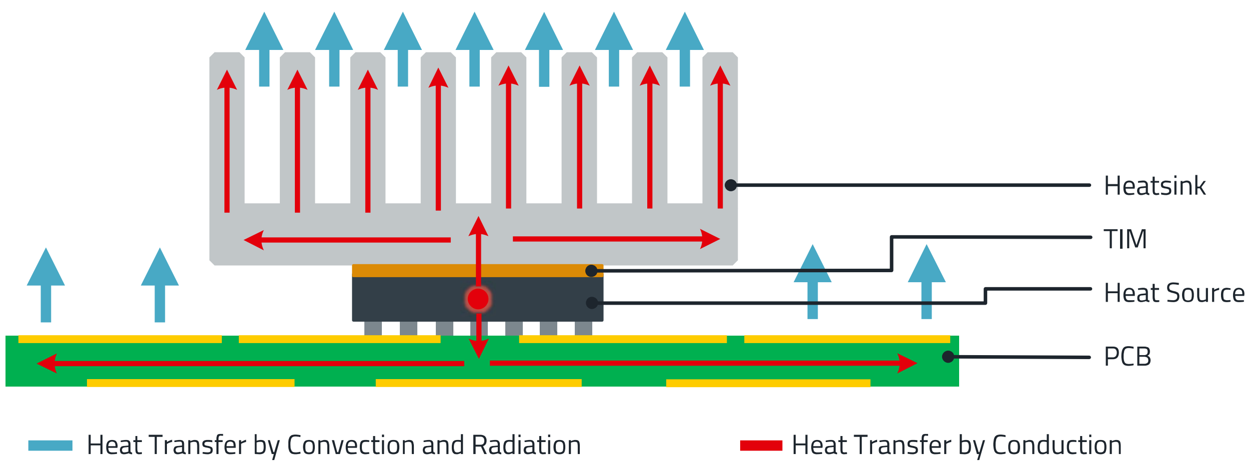


Figure 1: Heat transfer inside a heatsink.

2. CHARACTERISTICS & SPECIFICATIONS

Each heatsink, depending on its geometry, material, location within the PCB and method of attachment, may perform differently in the application.

The following two tables help to illustrate the thermal resistance of the different heatsinks:

2.1 WE-HTO

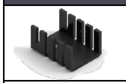
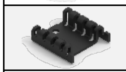
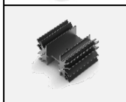
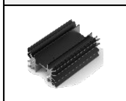
Type	Order code	Topology	Surface Area (mm²)	Thermal Resistance (K/W)
	40902100191409	simple	1252	22
	40902100191909	simple extended	1433	21
	40903100191412	clip on	658	16
	40901100242307	curved	1767	21
	40901100243007	curved extended	2073	20
	40904110384125	extruded for TO220	13222	9
	40904110634125	extruded for TO247	20971	7

Table 1: Comparison table thermal resistance HTO.

2.2 WE-HIC

Type	Order code	Base size (mm)	Surface Area (cm²)	Thermal Resistance (K/W)
	40905110102020	20x20	3.88	17…6
	40905110092424	24x24	5.00	15…6
	40905110163030	30x30	11.71	11…4
	40905110254040	40x40	21.61	8…3
	40906110102020	20x20	3.00	17…6
	40906110092424	24x24	4.99	15 …5
	40906110163030	30x30	10.16	11…4
	40906110254040	40x40	19.56	7…3

Table 2: Comparison table thermal resistance HIC.

Thermal resistance values of WE-HTO (Table 2) have been obtained in natural convection, while thermal resistance values of WE-HIC have been obtained in natural and forced convection.

It is true that there is a close relationship between the surface area available of a heatsink and its thermal resistance.

The larger the area, the more aluminum is available to dissipate the heat generated in the design. This can be clearly observed in the WE-HIC series, where an increase in the surface area decreases thermal resistance. However, it is key to understand that the type and design of the heatsink also directly affects performance; this is why in the WE-HTO series, not only surface area affects the thermal resistance value, but also heatsink topology.

Although the thermal resistance value is very useful for determining which heatsink fits the design, it is important to consider other parameters, such as the heatsink attachment method, correct contact between the heatsink and the component, design, and available surface area. The thermal resistance value is a reference value obtained under conditions explained below and may vary depending on the application (**Design-In Examples**).

3. DESIGN CONSIDERATIONS

When transferring energy to the ambient, air contact area and topology play a major role in electronics cooling. For this purpose, Würth Elektronik's heatsink product family is divided into two major areas.

- WE-HIC heatsinks are designed to interface with flat elements such as ICs or other SMD SMT electronic components.
- The WE-HTO series is designed for use with through hole TO packages such as TO-220 and TO-247 to name a few.

3.1 WE-HTO

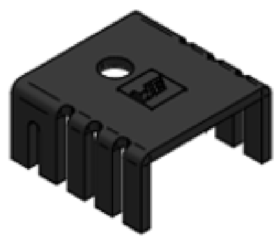


Figure 2: WE-HTO.

Stamped aluminum heatsinks provide an entirely different approach to thermal management, prioritizing lightness and simplicity over maximum cooling performance. Created by punching and bending thin aluminum sheets, these heatsinks feature shallow, widely spaced fins and minimal base thickness. While less efficient at heat dissipation than their extruded counterparts, stamped heatsinks offer advantages for low-power applications.

For small packages like TO-220 and TO-247 transistors, stamped heatsinks provide adequate cooling at minimal cost and weight. Their simple design allows for easy integration with clip-on, adhesive or mechanical mounting methods, though these attachment techniques may introduce reliability concerns in high-vibration environments. The thin construction limits their thermal mass, making them unsuitable for high-power applications, but their low profile makes them valuable where space is at a premium.

3.2 WE-HIC

Extruded heatsinks represent one of the most common and cost-effective solutions for thermal management. Manufactured by forcing heated aluminum through a shaped die, these heatsinks feature parallel fins running along their length, creating an optimal balance between surface area and structural integrity. The extrusion process allows for relatively complex cross-sectional profiles while maintaining excellent thermal conductivity. For IC packages, extruded heatsinks are particularly effective when mounted directly onto heat-generating components using thermal interface materials. The manufacturing process enables high-volume production at low cost, though the designs are somewhat limited to two-dimensional profiles.

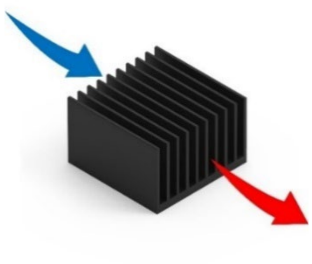


Figure 3: Unidirectional heatsink for consistent, directional airflow.

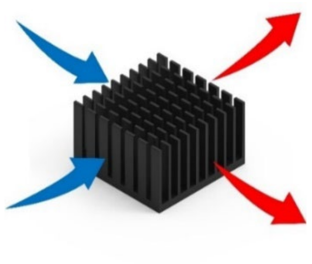


Figure 4: Bidirectional heatsink for ambiguous airflows.

Their long, continuous fins promote efficient heat dissipation through natural convection, making them well-suited for applications where consistent, directional airflow can be maintained (Figure 3).

The crosscut of the fins allows the heatsink to dissipate energy to the ambient in applications where the airflow is ambiguous and can come from any direction (Figure 4), but it should be noted that, depending on the orientation of the fins, the performance can decrease by around 25 % in natural convection environments. This should be considered in the design phase. Reduced performance results from limited air circulation between fins that are unfavorably oriented with respect to the upward buoyant airflow. This may lead to increased component temperatures or a reduced allowable power dissipation.

3.3 Application Cases

Best for	Avoid when	Typ. application
▪ Low-power TO packages (<10W) ▪ Minimal space availability ▪ High-volume production	▪ Power >15W ▪ Precision thermal mgmt. ▪ Critical reliability needs	▪ TO transistors ▪ Consumer adapters ▪ Small signal circuits ▪ Low-power LEDs

Table 3: Overview of the applications and areas of use for TO-compatible heatsinks.

Best for	Avoid when	Typ. application
▪ Compact IC packages ▪ Space-constrained designs ▪ Forced convection systems	▪ Pure natural convection ▪ Very high vibration environments	▪ SMT-ICs (QFN, BGA) ▪ Telecom equipment

Table 4: Use cases for unidirectional heatsinks.

Best for	Avoid when	Typ. application
▪ Medium-low power (10W-200W) ▪ Turbulent/ unpredictable airflow: Natural & forced convection	▪ Space-constrained design ▪ Very high power (>300W)	▪ DC/DC converters ▪ Power regulators ▪ LED drivers ▪ CPU/GPU

Table 5: Use cases for bidirectional heat sinks.

3.4 Attachment methods

Several attachment methods are available, depending on the area of application. Screw mounting is appropriate for high-current applications that are subject to strong vibration, whereas thermal adhesive tapes, for example, are particularly well suited for space-constrained applications. An **Attachment Methods** can be found in the appendix at the end of the support note.

3.5 Importance of TIM

Thermal interface materials maximize the contact area between the heat source and the heatsink by removing any air from the contact surfaces and filling large and small gaps. It is paramount to choose a suitable interface that fulfils application requirements such as surface roughness and gaps to fill while maintaining thermal performance needs, since it can be a choke point for a thermal system. Please find in the appendix an **Overview of Thermal Interface Materials -- Choosing the Right TIM**, including key specifications of each material.

To simplify the otherwise time-consuming process of applying TIM to heatsinks for electronics manufacturers, Würth Elektronik offers pre-assembled heatsinks with integrated TIM in the WE-HTOI and WE-HICI product groups, providing optimal thermal heat dissipation.

Specifically, WE-HTOI heatsinks are equipped with TIMs from the WE-TINS product group, while heatsinks of the WE-HICI series use TIMs from the WE-TTT product line.

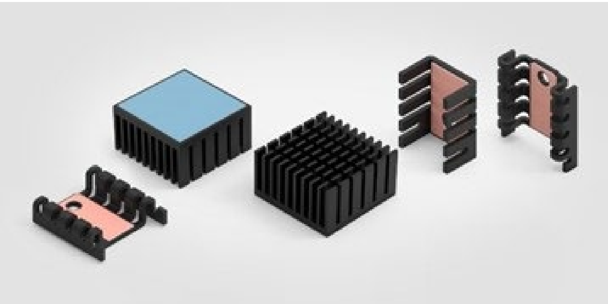


Figure 5: Examples of heatsinks pre-assembled with thermal interface materials

3.6 Heatsink Design

The main goal of any heatsink design is to maximize heat transfer from a hot component to the surrounding air; this is mainly governed by the following formula:

$$Q = h_{conv} \cdot A \cdot (T_{source} - T_{ambient}) \qquad (1)$$

Where:

- Q = dissipated heat in Watts;
- h_{conv} = convective heat transfer coefficient (10 W/m^{2}K for natural convection, 15-50 W/m^{2}K for forced convection); [1]
- A = total surface area in contact with the ambient;
- T_{source}-$T_{ambient}$ = temperature difference between heatsink and ambient.

To increase the amount of power dissipated, we can increase the area, but this is limited by how much heat the base of the heatsink can spread. The convective heat transfer coefficient can also be increased from natural to forced convection.

As shown in Figure 6, from the design point of view, there are three additional characteristics that influence how a heatsink will perform.

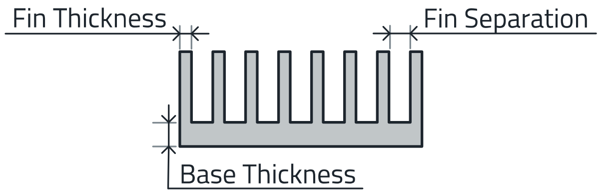


Figure 6: Heatsink characteristics.

- Base Thickness: The base helps to spread the heat from the source to all the fins of the heatsink. Thicker bases help spread the heat. This has cost and weight implications. An optimal value for most general-purpose applications is 3 mm; lower power applications can reduce thickness down to 1-2 mm.
- Fin Thickness: Thick fins (> 1 mm) help to transfer the heat from the base to the ambient when fins are tall, but they reduce the number of fins and surface area in each volume. They are optimal for natural convection environments. Thin fins (< 0.5 mm) maximize surface area but may vibrate or bend under mechanical stress or high airflows.
- Fin Separation: Fin spacing determines how air flows through the heatsink. In natural convection environments, wider gaps (> 5 mm) allow air to rise freely between fins. Tighter spacings (2-4 mm) maximize surface area but require higher airflow.

3.7 Design-In Examples

As a design-in example on how to select the right heatsink for our application, let's assume that our goal is to provide enough cooling for an IC that stabilizes at around 85 °C. Considering that there will be a thermal interface material between the source and the heatsink, we can define 80 °C as the target surface temperature and a working environment of 40 °C maximum ambient temperature. We will first find what minimum rate of heat transfer (W/K) the heatsink needs to bring into the system to achieve our design goals and second, what area it should have, considering other mechanical constraints.

Parameter	Value
Dissipated power (P_S)	10 W
Target surface temperature (T_S)	80 °C
IC surface area (A_{IC})	250 mm^2

Table 6: Parameter example.

We can rearrange the convection formula, separating the parameters that are fixed by the design and the ones that we can modify to achieve our goals:

$$h_{conv} \cdot A \geq \frac{Q}{T_S - T_A} = \frac{10\ \text{W}}{80\ °\text{C} - 40\ °\text{C}} = 0.25\ \frac{\text{W}}{\text{K}} \qquad (2)$$

0.25 W/K is the minimum rate of heat transfer to the ambience. To determine the required heatsink surface area, we consider two scenarios:

- Natural Convection: h_{conv} ~10 W/m^{2}K:

$$A \geq \frac{0.25\ \frac{\text{W}}{\text{K}}}{h_{conv}} = \frac{0.25\ \frac{\text{W}}{\text{K}}}{10\ \frac{\text{W}}{\text{m}^2\text{K}}} = 0.025\ \text{m}^2 \qquad (3)$$

- Forced Convection: h_{conv} ~25 W/m^{2}K:

$$A \geq \frac{0.25\ \frac{\text{W}}{\text{K}}}{h_{conv}} = \frac{0.25\ \frac{\text{W}}{\text{K}}}{25\ \frac{\text{W}}{\text{m}^2\text{K}}} = 0.01\ \text{m}^2 \qquad (4)$$

For a heatsink that operates in natural convection environments, a large spacing between fins is required. Let's consider a heatsink that has 10 fins, each 25 mm tall, 50 mm long, 1 mm thick and spaced 5 mm apart.

$$A = 10\ \text{fins} \cdot 2\ \text{sides} \cdot 2.5\ \text{cm height} \cdot 5\ \text{cm length}$$
$$A = 0.025\ \text{m}^2 \qquad (5)$$

If our design could operate in a forced convection environment, we could achieve a larger area in the same footprint by making the fins thinner and bringing them closer together. 16 fins, 25 mm tall, 50 mm long and 0.5 mm thick and spaced 3 mm.

$$A = 16\ \text{fins} \cdot 2\ \text{sides} \cdot 2.5\ \text{cm height} \cdot 5\ \text{cm length}$$
$$A = 0.04\ \text{m}^2 \qquad (6)$$

Both heatsinks would provide the necessary transfer rate to achieve our design goal. Depending on where the final design will operate, we can choose between natural or forced convection.

With the area, we can estimate the thermal resistance of a heatsink of the calculated area as:

$$R_{HS} = \frac{1}{10\ \frac{\text{W}}{\text{m}^2\text{K}} \cdot 0.025\ \text{m}^2} = 4\ \frac{\text{K}}{\text{W}} \qquad (7)$$

Now we would have everything we need to evaluate our thermal system and see if we can reach our initial design goals. For this purpose, we can use a resistance thermal model:

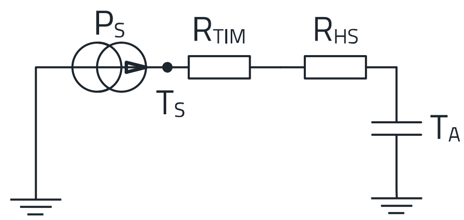


Figure 7: Model for calculating the thermal resistance of the heat sink.

$$T_S = P_S \cdot (R_{TIM} + R_{HS}) + T_A \qquad (8)$$

Since 10 W is a large amount of power the selection of thermal interface plays a critical role. For this scenario we will evaluate a silicone pad like the WE-TGF series with a thermal performance of 3 W/mK and a thickness of 0.5 mm to keep the thermal resistance value low.

$$R_{TIM} = \frac{\text{Thickness}}{\text{Thermal Conductivity} \cdot \text{Area}}$$
$$R_{TIM} = \frac{0.0005\ \text{m}}{3\ \frac{\text{W}}{\text{mK}} \cdot 0.00025\ \text{m}^2} = 0.66\ \frac{\text{K}}{\text{W}} \qquad (9)$$

Finally, we can evaluate if our system meets the goal of T_S = 80 °C:

$$T_S = 10\ \text{W} \cdot \left(0.66\ \frac{\text{K}}{\text{W}} + 4\ \frac{\text{K}}{\text{W}}\right) + 40\ °\text{C} \approx 86\ °\text{C} \qquad (10)$$

Considering this is a simplified thermal model that assumes that all heat flows from the component to the heatsink and is dissipated to the ambient through natural convection without any radiation, we can assume our design is consistent for a first approximation. If we wanted to evaluate it more comprehensively, we would require thermal simulation software like Ansys' Icepak.

4. THERMAL CHARACTERISATION

Providing application-like measurement data is critical in our goal to help developers efficiently design-in heatsinks. For that purpose, we have developed a measurement setup capable of generating different power outputs and evaluating the thermal resistance of any heatsink in both natural and forced convection environments (Figure 8).

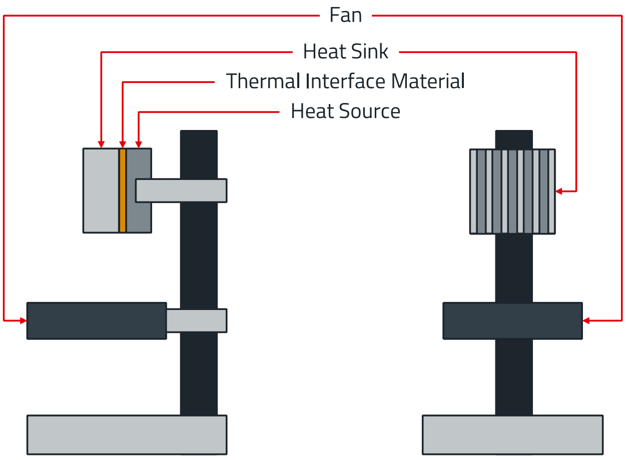


Figure 8: Test setup for measuring the thermal properties of heatsinks.

During the measurement we monitor the power output of the heat source as well as the temperature of the source and the ambience (Figure 9).

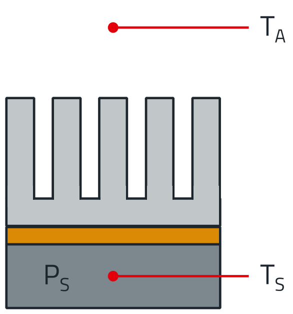


Figure 9: Temperature monitoring example.

To calculate the thermal resistance of the heatsink, we can thermally model the measurement setup as a series of thermal resistances:

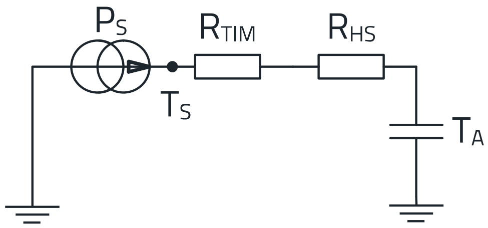


Figure 10: Model for calculating the thermal resistance of the heatsink.

Since the thermal interface material used in the setup is known, we can determine the thermal resistance of the heatsink as:

$$R_{HS} = \frac{T_S - T_A}{P_S} - R_{TIM} \qquad (11)$$

Where,

- R_{HS} = Resistance Heatsink
- T_S = Temperature source
- T_A = Temperature ambience
- P_S = Power Source
- R_{TIM} = Resistance Thermal Interface Material

This is the setup used to obtain the thermal resistance value that appears in the datasheets. It should be taken as a reference and bear in mind that the value may differ from that obtained in your specific application, as it will be a completely different scenario.

5. INSTALLATION, HANDLING AND ATTACHMENT METHODS

Proper installation of a heatsink is critical to ensure efficient heat transfer, mechanical stability, and long-term reliability. For this purpose, the following steps are recommended:

1. Clean the component and heatsink base surface to ensure no dust or grease is present in the interface. Use a lint-free cloth with isopropyl alcohol.
2. Apply the appropriate thermal interface material, suited for the gap and contact surfaces, to the heat source.
3. Place the heatsink with a rolling motion to ensure no large air bubbles remain on the thermal interface.
4. Fix the heatsink in place with the attachment method that best suits the application.

6. ANODIZATION PROCESS

Anodizing is an electrochemical process used to improve the surface properties of aluminum heatsinks. During the process, the heatsink is first cleaned to remove oils and oxides, then immersed in a sulfuric acid electrolyte. When a direct current is applied, the aluminum acts as the anode, and oxygen from the electrolyte reacts with its surface to form a thin, hard layer of aluminum oxide.

This oxide layer is porous at first, which allows it to be dyed in different colors to increase its ability to radiate heat. After coloring, the pores are sealed to improve corrosion resistance and lock in the color.

The resulting surface is much harder, more corrosion-resistant, and has higher surface resistance compared to bare aluminum. This process greatly increases emissivity, which enhances the heatsinks ability to dissipate heat through radiation. This combination of protection, durability, and improved thermal performance is why most aluminum heatsinks are black anodized.

During the anodization process, the aluminum parts must be electrically connected to the power supply so that current can flow through them. To achieve this, each part is physically clamped, hooked, or hung from an aluminium or titanium fixture that serves as the electrical contact to the anode . This connection point allows the anodizing current to enter the part and drive the electrochemical reaction that forms the oxide layer.

Figure 11: Anodization attachment example for stamped parts.

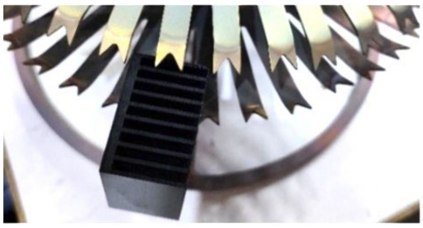


Figure 12: Anodization attachment example for extruded parts.

However, wherever the part is in direct contact with the fixture, the current cannot flow evenly across the surface. The tight mechanical contact prevents electrolytes from reaching that small area, and since no oxidation occurs there, the surface at those contact points remains bare metal — not anodized. These uncoated regions are often called “rack marks”, “contact points”, or “hanging spots”. Figure 11 and Figure 12 show examples of how heatsinks can be attached during the anodization process:

The hanging spot marks may affect the aesthetics but do not affect the performance of the heatsink. If any customer requires an aesthetic result without these marks, the heatsinks can be post-processed by painting over these marks upon request.

A APPENDIX

A.1 Attachment Methods

Attachment Method	When to use	When to avoid	Heatsink Types	Assembly information
Screw Mounting	▪ High power (> 20 W) ▪ High vibration	▪ Limited PCB space ▪ Plastic packages ▪ Non-reworkable designs	▪ Extruded ▪ Thick-base stamped ▪ Bonded fin	▪ 0.5 to 1.2 Nm torque ▪ Lock washers for vibration resistance
Spring Clips	▪ Medium power (5 – 10 W) ▪ Rapid assembly ▪ Cost-sensitive design	▪ Tall components (> 25 mm) ▪ Extreme vibrations ▪ Uneven surfaces.	▪ Extruded ▪ Thin stamped	▪ 3.4 to 6.9 N/cm^2 hand pressure ▪ Steel springs
Thermal Adhesive Tape	▪ Low power (< 5 W); ▪ Space-constrained.	▪ High temperatures ▪ High reliability ▪ Frequent rework	▪ Stamped ▪ Thin profile extruded	▪ 3.4 to 10.3 N/cm^2 during bonding
Thermal Epoxy	▪ Permanent bonding ▪ Harsh environments ▪ Irregular surfaces	▪ Need for rework ▪ Need for high performing interface	▪ Any	▪ Room temperature or oven curing
Push Pins	▪ Medium-high power (10 to 30 W) ▪ Plastic packages	▪ High mechanical stress ▪ Metal packages	▪ Stamped ▪ Some extruded	▪ 20 to 30 N insertion force ▪ Single use

Table 7: Attachment Methods.

A.2 Overview of Thermal Interface Materials – Choosing the Right TIM

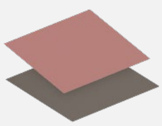
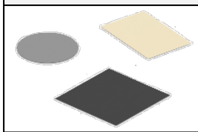
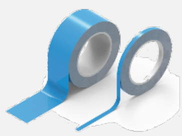
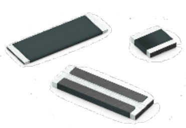
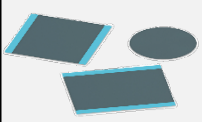
	Material	Match-Code	Best For	Avoid When	Key Specs
	Silicone Elastomer Pads	WE-TGF	Uneven surface, high compressibility	Thin gaps [< 0.5 mm]	1-6 W/mK, 10-30 % Compression
	Silicone Rubber Pads	WE-TINS	Moderate vibration, withstand high compression	Uneven surfaces	1.6-3.5 W/mK, 0.2 mm thickness
	Phase Change Material	WE-PCM	High performance, thin bond lines	Applications that require disassembly or maintenance	1.6-5 W/mK, melting ~55 °C
	Thermal Tape	WE-TTT	Thin bonded interfaces [no clamp]	High heat flux	1 W/mK, 0.2 mm thickness
	Graphite Gasket	WE-TGFG	Large gaps, interface with single flat surfaces	Interfacing multiple components	400 W/mK [graphite in-plane]
	Graphite Sheets	WE-TGS	In-plane heat spreading	High mechanical stress or vibrations	1800 W/mK [in-plane]

Table 8: Overview of Thermal Interface Materials – Choosing the Right TIM.

A.3 Literature

[1] Çengel, Yunis. A (2003). Heat Transfer: A Practical Approach. McGraw-Hill, 2nd edition, web chapter 15, page 68

IMPORTANT NOTICE

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