THERMAL DESIGN FOR CONDUCTION COOLED LOADS

Understanding Conduction Cooled Loads

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Application Note

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Application Note: Understanding Conduction Cooled Loads

When considering a termination with conduction cooling, there are certain factors that must be considered:

- *What is the impact on other components in the system?*
- *Will the heat from the load and the heat sink (or cold plate as the heat sink is sometimes referred to) impact other com ponents in the system?*
- *Will the air-flow required for the heat sink impact any com ponents that also require air-flow? Is there enough air flow for the dissipation through the heat sink?*
- *What changes might I see in the system due to the additional heating effect; such as overheating of components or wiring?*

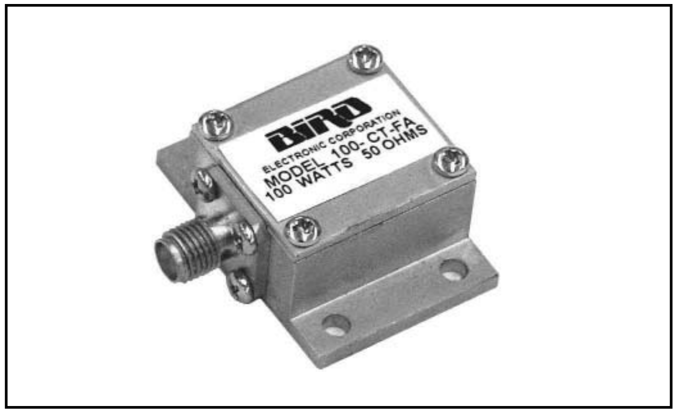
Conduction is heat transfer by means of molecular agitation within a material without any motion of the material as a whole. It is heat transfer by mass motion of a fluid such as air or water and when the heated fluid is caused to move away from the source of heat, carrying energy with it.

Heat transfer will use the lowest energy mode available. Typically this lowest energy method is a flow of heat in a direction opposite to the thermal gradient. In other words, the heat will flow from the highest temperature region to the lowest temperature region until the lower temperature region attains the same temperature as the host.
Although a conductive load is considered a passive-cooling device, by using a fan along with the heat sink, it becomes an active-cooling device which allows more cooling with less space.

When there is little space available but a heat dissipating device (Load) is required, the answer could easily be a conductive cooled load, or dependent on the application, could be convection. The conductive load is small and has a metal enclosure and is typically used where metal is readily available and/or space is limited. The convective load is larger than the conductive load and has fins designed to meet heat flow requirements and therefore, needs no outside source for heat dissipation.

What parameters do I need to know before using a conductive load?
Important considerations are ambient temperature, and how much free air-flow is available. One would also need to know the amount of heat needed to dissipate, i.e. A transmitter with a 100 watt output would require a 100 watt load with the appropriate size heat sink. The heat sink can be constructed by the user or there are companies that specialize in heat sink manufacturing.

It is possible to purchase a heat sink from one of the heat-sink manufacturers. Typically the manufacturer will ask the °C/W ratio. This calculation is simply 100 (this is the maximum power rating of unit) minus the ambient room temperature divided by the power.



If the room temperature is assumed to be 25 degrees C, the load can increase its temperature by the maximum flange temperature minus the ambient room temperature (100-25 = 75 degrees C) or 75 degrees. If the load is dissipating 100 watts, the °C/ W = 0.75 (See example in chart table 1). The heat sink will need to be rated at 0.75°C/W. Typically, these are the characteristics used by heat sink suppliers.used by heat sink suppliers.

Conductive Load Power	100 minus Temperature (assumed to be 25° C)	Temperature Divided by Load Power	°C/W
25	25	0.0	0.0
100	25	0.75	0.75
150	25	1.25	1.25
300	25	2.75	2.75
500	25	4.75	4.75

Tabel 1

The next consideration is how large and what thickness of a heat sink do I need? The size is dependent on the amount of power that needs to be dissipated. For a small load, such as a 25 Watt, the heat sink is small, only 67 square inches and 1/8th inch thick, but for 500 watts the heat sink is very large, 1,333 square inches and ½ inch thick. The large heat sink for the 500 watt unit could be a transmitter enclosure, dependent on the size of the enclosure, for proper dissipation.

Typically, the medium for heat transfer is some type of metal already available in the application. For example, if you need to have a reject load inside a transmitter, a conductive load can be used along with the transmitter housing as your heat sink. Typically the transmitter is large enough that the heat being dissipated through the entire housing should not affect the outer temperature of the transmitter for loads 100 watts and below. If the power required is 300 Watts or more, the temperature of the outside housing of the transmitter should be measured, as an additional internal heat sink or cooling fan may be required to keep the transmitter cool to the touch.

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Using a conduction-cooled termination requires more than just connecting it to a transmitter output. These loads have very little heat dissipation when used alone. For example, 150 watt conduction load with an N connector will only dissipate 15 watts when used as a stand alone unit and the majority of that heat is through the N connector.

When using a conductive load (such as the Bird model 100-CT-FA shown below) it is imperative to keep the flange temperature at 100 degrees C or less. If this rating is exceeded, the film on the resistors inside the load may melt changing the overall resistance of the load. It is always a good idea to use a thermocouple with the unit to assure that the flange temperature of the conductive load does not rise above 10°C when in operation.

Once you exceed the 100°C flange temperature, the power of the load de-rates quickly at a linear rate. Table 2 shows an example of the de-rating of a 20 watt load. For any power rating, use the full rated power de-rated linearly to 0 watts at 150°C.

Flange Temp. °C	De-Rated Power
100	20 watts
120	15 watts
130	10 watts
140	5 watts
150	0 watts

Tabel 2

Table 3 shows approximate sizes for the heat sink. This is *only an approximation.* Remember that the free air flow and ambient temperature are also important characteristics to consider when using a conduction load.

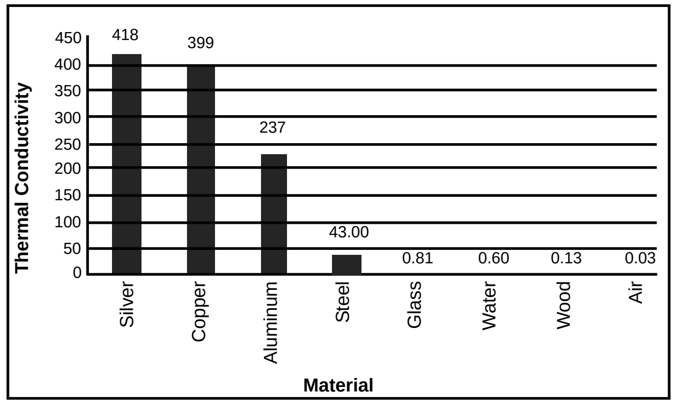
Approximation of sizes for cold plates.

Model	Ambient Temp. °C	Length (Inches)	Width (Inches)	Square In.	Thickness (Inches)	Material
25-CT-XX	25	8.2	8.2	67	1/8	Aluminum
50-CT-XX	25	11.6	11.6	133	1/8	Aluminum
100-CT-XX	25	16	16	267	1/8	Aluminum
150-CT-XX	25	20	20	400	1/8	Aluminum
250-CT-XX	25	26	26	667	1/2	Aluminum
300-CT-XX	25	28.5	28.5	800	1/2	Aluminum
500-CT-XX	25	36.5	36.5	1333	1/2	Aluminum

Tabel 3

Aluminum is the most commonly used medium as it is typically cost effective and provides good thermal performance, but there are other metals that can be used as well. (See Table 4)

Thermal Conductivity of Material



Tabel 4

By looking at the table 4, you can see that Silver has the most thermal conductivity. Silver is also very expensive. Looking across the chart, glass, water, wood and air have very little thermal conductivity, but can be good insulators. Therefore, these are almost never used for heat sinks.
Silver would be used in a system where the conductivity was very critical. Typically due to the price and availability of Aluminum, it is the most commonly used metal for heat sinks.

Understanding your application and criteria for the heat sink when using a conductive load can eliminate problems down the road. Understanding the importance of the heat sink parameters required for proper operation will assure your needs are met in thermal performance, and will help eliminate any unwanted effects in the entire system.

References:

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