

Magnetics operating temperature defined



Operating temperature rating of inductors and transformers (Magnetics) is an often misunderstood and confusing topic. This technical note provides detail information, definitions and how Eaton defines the operating temperature for magnetics products on the data sheets.

Definition

Ambient temperature

The temperature of still air immediately surrounding a component.

Operating Temperature (Basic)

A minimum and maximum range of ambient temperatures that a component can be safely operated.

Operating Temperature (Magnetics)

A minimum and maximum range of ambient temperatures that a component can be safely operated.

The maximum operating temperature is defined as the magnetics device internal self-temperature rise plus the maximum application ambient temperature exposed to the magnetics.

The minimum operating temperature is defined as the absolute minimum application ambient temperature exposed to the magnetics.

Application temperature references

Operating temperature ranges differ throughout different application grades. The following table contains a list of typical operating temperatures for a variety of application grades.

Grade type	Operating temperature range	Notes
Commercial grade	0°C to +70°C	
Industrial grade	-40°C to +85°C -25°C to +100°C	
High grade	-40°C to +105°C	
Automotive grade 3	-40°C to +85°C	Reference AEC-Q200
Automotive grade 2	-40°C to +105°C	Reference AEC-Q200
Automotive grade 1	-40°C to +125°C	Reference AEC-Q200
Automotive grade 0	-40°C to +150°C	Reference AEC-Q200
Military/Aviation grade	-55°C to +125°C -65°C to +175°C	

Understanding the magnetics temperature specification

As stated previously Eaton defines the maximum operating temperature rating of magnetics as the ambient temperature the magnetics will be exposed to plus internal self-temperature rise of the magnetics.

Example:

The magnetics of interest has a maximum operating specification temperature rating of 125°C and will be used at full rated current (e.g. Irms rating with proper derating for AC currents) to achieve a self-temperature rise of 40°C.

The maximum operating temperature of the magnetics per the definition is 125°C-40°C= 85°C. So, based on the 85°C calculation and referencing Table 1 above, the selected magnetics could be used in Commercial, Automotive Grade 3 (if AEC-Q200 qualified), and most Industrial grade applications based on operating temperature.

If the self-temperature rise of the magnetics is reduced by using a lower rated current (e.g. operating the magnetics at a lower current than the specified Irms rating with proper derating for AC currents) to achieve a self-temperature rise of 20°C; the new maximum operating temperature would be 125°C-20°C= 105°C. The new operating condition now expands the usable operating temperature range and allows the magnetics to be used in additional application grades depending on qualified temperature.

Frequently asked question

I noticed that the magnetics selected is AEC-Q200 Grade 3 qualified yet it has an operating range of -55°C to +125°C. Why is that?

The operating temperature of magnetics is -55°C to 125°C (ambient temperature + self-temperature rise). The temperature rise at full rated current (e.g. Irms rating with proper derating for AC currents) is 40°C. By the definitions provided earlier the maximum operating temperature of the magnetics is 125°C-40°C= 85°C.

If the self-temperature rise of the magnetics is reduced to 20°C by derating (e.g. operating the magnetics at a lower current than the specified Irms rating with proper derating for AC currents) then the magnetics could be used at 105°C operating temperature.

AEC-Q200 only requires a minimum operating temperature of -40°C. However, qualifying the magnetics at -55°C allows the opportunity of expanding the magnetics to additional application grades that require a lower minimum operating temperature if qualified.

My understanding is that AEC-Q200 grade 3 operating temperature range is only -40°C to +85°C, is that correct?

Correct. Operating temperature is an ambient temperature. In order for magnetics to meet an operating temperature of -40°C to +85°C the magnetics operating temperature must be able to meet the application ambient temperature range + self-temperature rise of the magnetics.

The magnetics selected is rated for a minimum operating temperature of -40°C. I will have a self-temperature rise of 40°C. Can I use the magnetics at -80°C or below the -40°C rating based on the definition of ambient temperature plus self-temperature rise?

No. The minimum operating temperature rating of the magnetics cannot be exceeded. The ambient temperature plus self-temperature rise definition applies only to the maximum operating temperature rating of the magnetics and that rating must be above the magnetics minimum operating temperature rating.

What is the Junction temperature of the magnetics?

Theta JA, Theta JC, Rja and Rjb are terms applicable only to active devices, such as integrated circuits. Inductors and transformers do not contain semiconductor material junctions so do not have the same potential failure modes. Theta JA and Theta JC are therefore not applicable to inductors or transformers.

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