Curie Temperature of Isolators and Circulators

Introduction

This application note describes the relationship between the Curie temperature of components used in isolators and circulators and the reflow solder profile used in the surface mounting of these isolators and circulators.

Definitions

Magnetic materials can be classified as diamagnetic, paramagnetic or ferromagnetic. A materials magnetic classification is determined by its bulk magnetic susceptibility (the ratio of of the magnetization of a material to the magnetic field strength)

A diamagnetic material will have a susceptibility which is small and negative (c = -0.000001). Their magnetic response opposes the applied magnetic field. Examples of diamagnets are copper, silver and gold)

A paramagnetic material will have a susceptibility which is small and positive (c = +0.0001). The magnetization of paramagnets is weak but aligned parallel with the direction of the applied magnetic field. Examples of paramagnets are aluminium, platinum and manganese. Paramagnets do not retain any magnetization in the absence of an externally applied magnetic field

A ferromagnetic material will have a susceptibility which is positive and much greater than 1 (c = 100). Examples of ferromagnets are iron, cobalt, nickel and ceramic magnets.

Ferrimagnetism is a type of magnetism that occurs in solids, in which the magnetic fields associated with individual atoms spontaneously align themselves, some parallel (as in ferromagnetism), and others antiparallel. The materials are less magnetic than ferromagnets, as the antiparallel atoms dilute the magnetic effect of the parallel alignment. Examples of ferrimagnets are spinels and garnets.

The Curie point of a ferromagnetic material is the temperature above which it loses its characteristic ferromagnetic ability (768°C for iron). At temperatures below the Curie point the magnetic moments are partially aligned within magnetic domains in ferromagnetic materials. As the temperature is increased towards the Curie point, the alignment (magnetization) within each domain decreases. Above the Curie point, the material is purely paramagnetic and there are no magnetized domains of aligned moments.

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Material used in isolators and circulators

The permanent magnets used in M/A-Com isolators and circulators are ceramic magnets (typically barium ferrite or strontium ferrite). These magnets are ferromagnetic and have a Curie temperature in the region of 460°C. As this temperature is far greater than the peak temperature of the recommended reflow profiles below, the permanent magnets performance will be unaffected by the solder reflow process.

The ferrite discs used in M/A-Com isolators and circulator are ferrimagnetic, with Curie temperatures varying between 227°C to 280°C. Above the Curie temperature, the spontaneous alignment of atom is disrupted and ferrimagnetism is destroyed, but it is restored upon cooling below the Curie temperature. Therefore, even though the ferrite discs magnetic properties are disrupted by the solder reflow process, these properties are restored upon cooling below the Curie temperature.

Conclusion

The magnetic materials used in the construction of M/A-Com isolators and circulators do not suffer any degradation in performance when undergoing a solder reflow operation.

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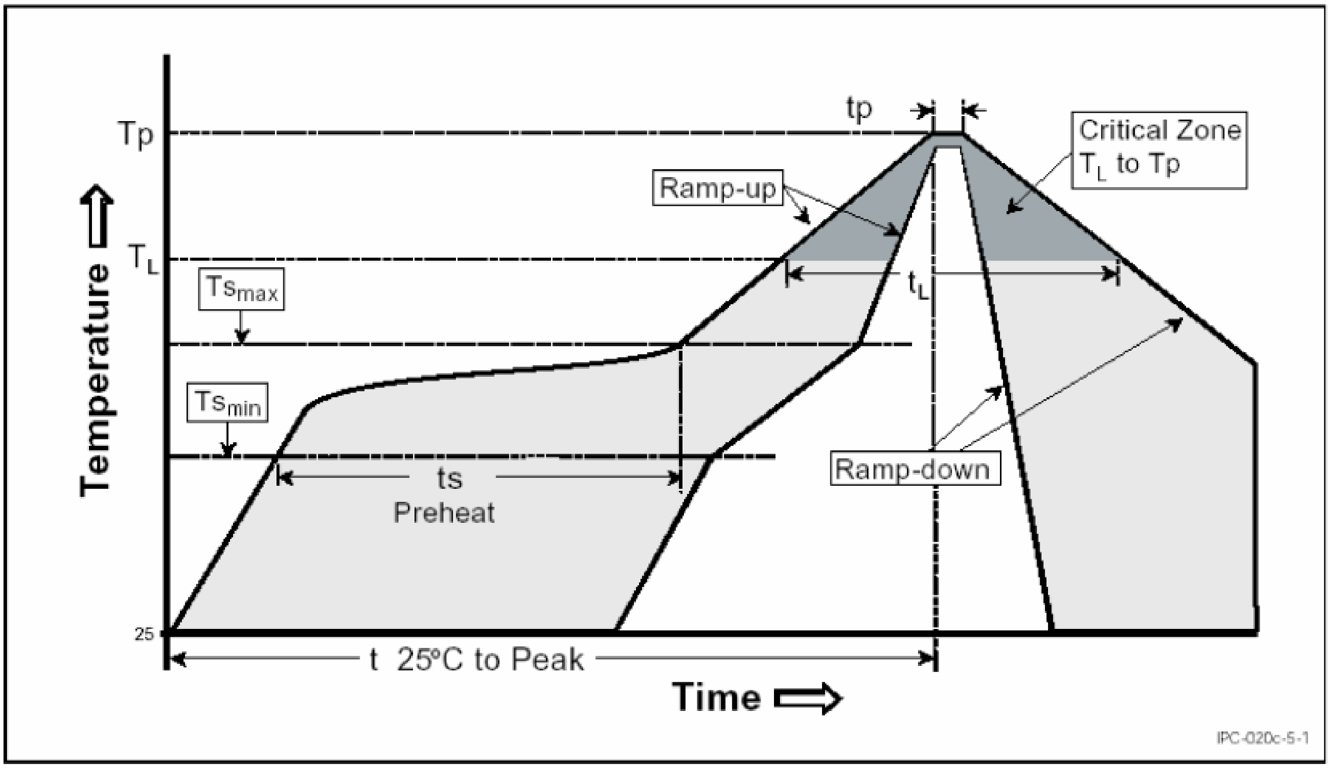
Typical Reflow Profile



Typical Reflow Parameters

Parameter	Symbol	Profile A	Profile B
Solder Composition		88Sn / 3.5Ag / 8.0In / 0.5Bi	96.5Sn / 3.0Ag / 0.5Cu
Average Ramp up rate	T_s	0.6º—1.5º per second	0.6º—1.25º per second
Minimum ramp up temperature	$T_{s\,MIN}$	160º	180º
Maximum ramp up temperature	$T_{s\,MAX}$	210º	210º
Time from $T_{s\,MIN}$ to $T_{s\,MAX}$		90 to 120 seconds	60 to 180 seconds
Liquid Temperature	T_L	210º	215º
Time above T_L	t_L	60 to 150 seconds	60 to 150 seconds
Peak Temperature	T_P	235º	250º
Time at Peak Temperature (±5º)	t_P	20 to 40 seconds	20 to 40 seconds
Ramp Down Rate		3.0º—3.25º per second	3.0º—3.25º per second
Total Time from 25º to T_P		5.0 to 5.5 minutes	5.0 to 5.5 minutes

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