**APPLICATION NOTE**

**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 isolators and circulators.

**Definitions**

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

A diamagnetic material has a susceptibility that is small and negative ($\chi = -0.000001$). The magnetic response of these materials opposes the applied magnetic field. Examples of diamagnets are copper, silver, and gold.

A paramagnetic material has a susceptibility that is small and positive ($\chi = +0.0001$). The magnetization of paramagnets is weak but aligned parallel with the direction of the applied magnetic field. Examples of paramagnets are aluminum, platinum, and manganese. Paramagnets do not retain any magnetization in the absence of an externally applied magnetic field.

A ferromagnetic material has a susceptibility that is positive and much greater than 1 ($\chi = 100$). 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 ferromagnetic materials) and others anti-parallel. Ferrimagnets are less magnetic than ferromagnets, since the anti-parallel 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, magnetic moments are partially aligned within magnetic domains in ferromagnetic materials. As the temperature increases toward the Curie point, the alignment (i.e., magnetization) within each domain decreases. Above the Curie point, the material is purely paramagnetic and there are no magnetized domains of aligned moments.

**Materials Used in Isolators and Circulators**

The permanent magnets used in Skyworks 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. Since this temperature is far greater than the peak temperature that a circulator or isolator is subjected to during the solder reflow process, the performance of the permanent magnet is not affected by the solder reflow process.

The ferrite discs used in Skyworks isolators and circulators are ferrimagnetic with Curie temperatures varying between 227 °C and 280 °C. Above the Curie temperature, the spontaneous alignment of atoms is disrupted and ferrimagnetism is destroyed. However, these properties are restored once the discs are cooled below the Curie temperature.

**Conclusion**

The magnetic materials used in the production of Skyworks isolators and circulators do not suffer any degradation in performance during a solder reflow operation.