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Which Thermal Sensor to Choose?

Introduction:

Thermal sensor is used in various applications and plays very important role in electronics to maintain stable operation by monitoring temperature, detecting abnormal temperature etc. KEMET offers thermal sensor TRS series and OHD series. KEMET thermal sensor is based on thermo ferrite and reed switch using KEMET original Thermolite® material, and it can be used as low cost thermal switch solution. In this application note, different types of thermal sensor technology are described. In addition, KEMET thermal sensor construction, operation principal and suitable applications are explained.

Different types of thermal sensors:

There are three thermal sensor types. (1) Thermo ferrite + Reed switch type (KEMET sensors), (2) Bi-metal type thermal sensors, (3) Thermistors. Table 1 shows operation principles and functions of each sensor. KEMET offers TRS series and OHD series thermal sensor (Table 2).

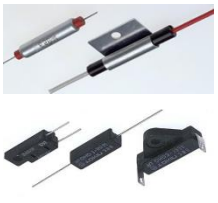
Sensors	Thermo ferrite+Reed switch	Bi-metal	Thermistors
Appearance			
Type	Contact type- Mechanical	Contact type- Mechanical	Contact type- Electric
Operation Principal	Switching reed switch ON or OFF at a trigger temperature by using curie temperature of the thermo-ferrite	Switch ON or OFF at a trigger temperature By using two metals that have different thermal expansion coefficients which deform by temperature	Semiconductor (NTC) or ceramic (PTC). Monitor temperature by resistance change due to temperature

Table 1

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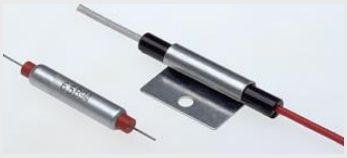
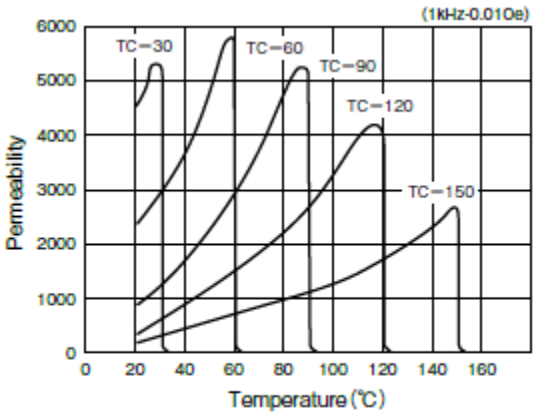
	TRS series (Thermal reed switch)	OHD Series (Thermal Guard)
Appearance		
Product type	Metal case, Lead wired type	Molded type
Operating temp. accuracy	±2.5◦C	±5◦C
Rated power	Maximum 72 Watt	6 Watt (1 watt only 5R type)
Safety Standard	**UL, CSA Acquisition (some products)**	**UL, CSA, TUV Acquisition**

Table 2

What is Thermolite® ?:

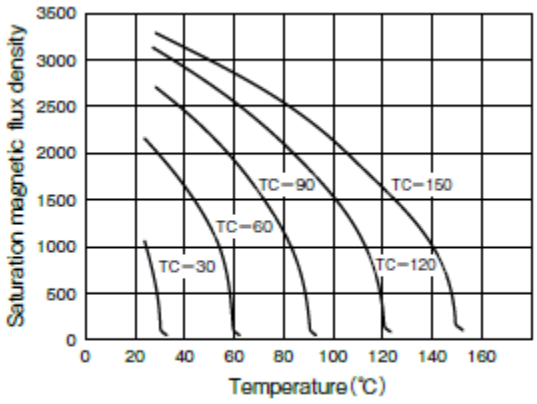
Temperature sensitive ferrite, Thermolite®, is a ferromagnetic material that has soft magnetic characteristic under curie temperature. Material's saturated magnetic flux density decreases as material temperature goes up, and it becomes paramagnetic (ferrite lose its magnetic property) rapidly when the temperature of the material reaches at curie temperature. Graph 1 and Graph 2 below show thermal property of Thermolite®. Graph 1 shows that Thermolite® rapidly lose its permeability at its curie temperature (TC), and Graph 2 shows that saturated magnetic flux density becomes close to zero at its curie temperature (TC). Curie temperature does not vary with time because it depends on compounding ratio of the material.

Graph 1: Permeability vs. Temperature



TC=Curie temperature

Graph2: Saturation Magnetic Flux Density vs. Temperature



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KEMET Thermal Sensor Construction & Operation Principle:

KEMET Thermal Sensor has two types, “Break type” (Figure 1) and “Make type” (Figure 4). Sensors consist with Thermolite®, Reed switch, Permanent magnet and Gap/Space (for “Make” type sensor only). Reed switch opens or closes by temperature dependent Thermolite® that converts thermal energy to magnetic field energy.

Break type is a normal close type sensor and consists with Thermolite®, Reed switch and Permanent magnet as shown in Figure 1. The switch is ON (closed) when the operating temperature is lower than a trigger temperature and switch becomes OFF (switch is open) when the operating temperature reaches equal or higher than the trigger temperature.

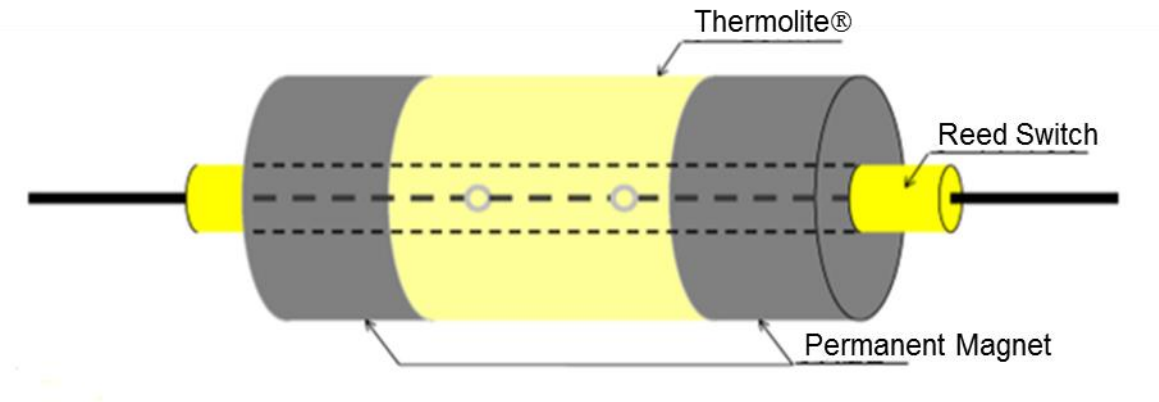

Figure 1: Construction of Break Type Sensor

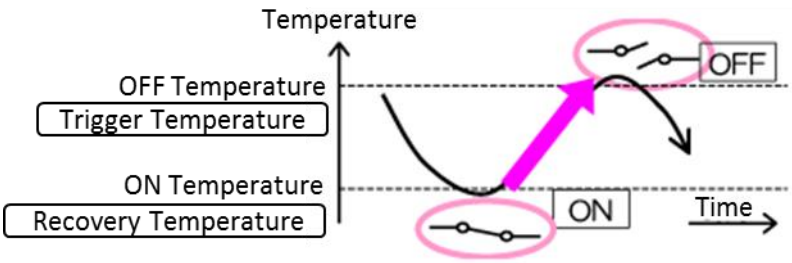

Figure 2: Definition of Break Type Sensor

Thermolite® is magnetic when the temperature is lower than the trigger temperature, and it generates annular magnetic field as in Figure 3. Reed switch is induced to N polarity and S polarity due to magnetic field, tips of the reed switch touch due to magnetic attraction force and the reed switch becomes ON. When temperature of Thermolite® reaches to a trigger temperature (=Curie temperature), Thermolite® loses magnetic flux and becomes non-magnetic. Tips of the reed switch become apart (OFF, open) due to non-magnetic state in Thermolite®.

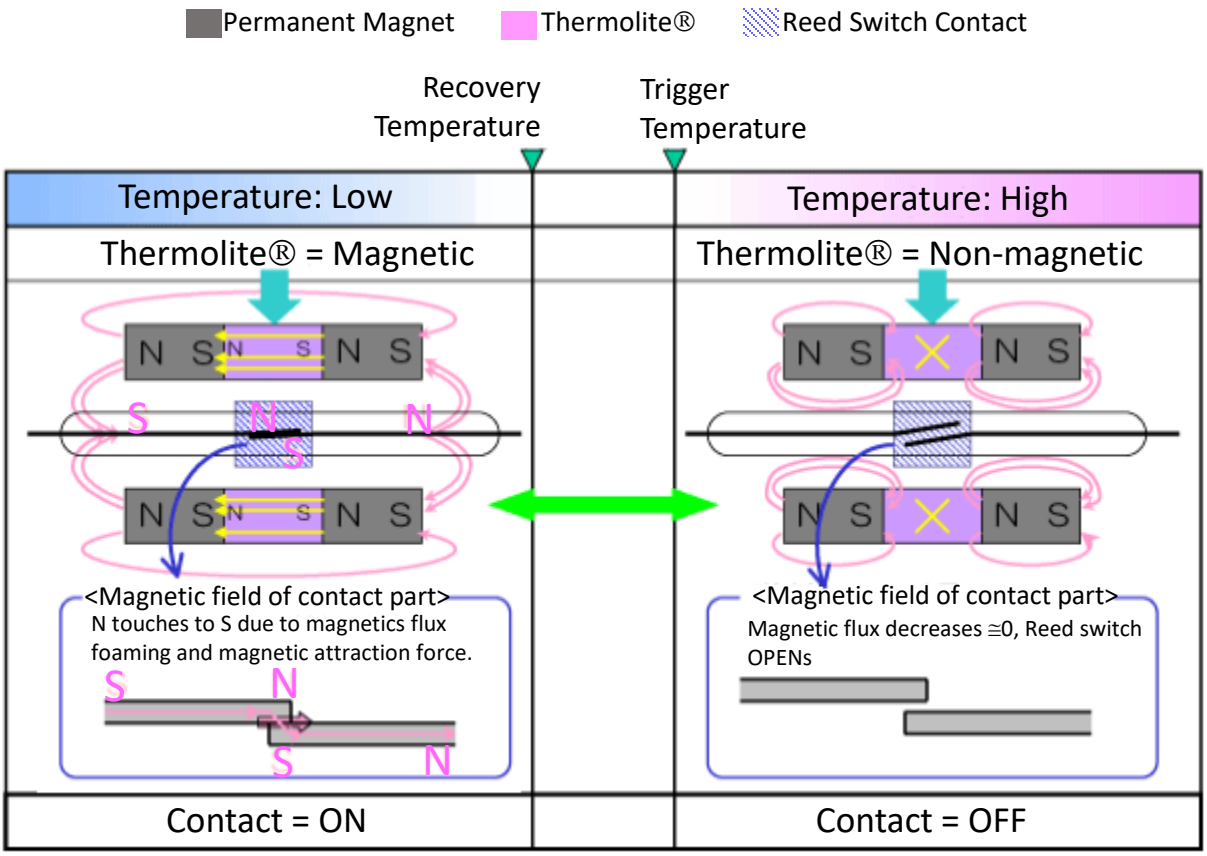

Figure 3: Break Type Sensor Operation Principal Detail

Make type is a normal open type and consists with Thermolite®, Reed switch, Gap/Space and Permanent magnet as shown in Figure 4. It operates as OFF (switch is open) when the operating temperature is lower than a Trigger temperature, and the switch closes (switch is ON) when the operating temperature becomes higher than the Trigger temperature.

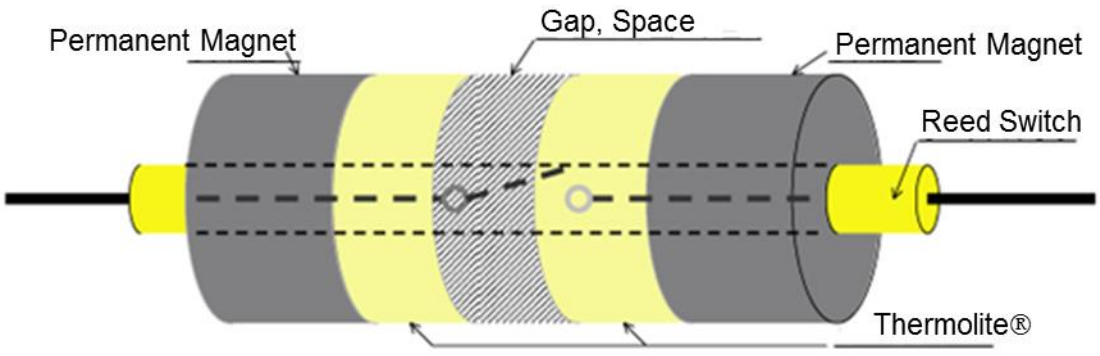

Figure 4: Construction of Make Type Sensor

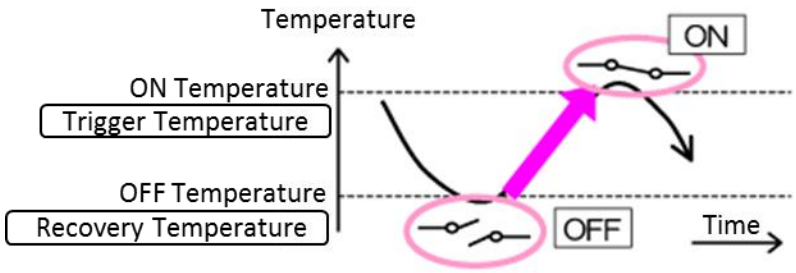

Figure 5: Definition of Make Type Sensor

Make type sensor has a gap spacer in between Thermolite® material as shown in Figure 6. When the temperature is below a trigger temperature, permanent magnet and Thermolite® creates annular magnetic field and tips of the reed switch become apart (OFF). When Thermolite® reaches its curie temperature (trigger temperature), Thermolite® loses magnetic flux and becomes non-magnetic. Tips of the reed switch are induced to N polarity and S polarity. Tips of the reed switch touch due to magnetic attraction force, and the reed switch closes (ON).

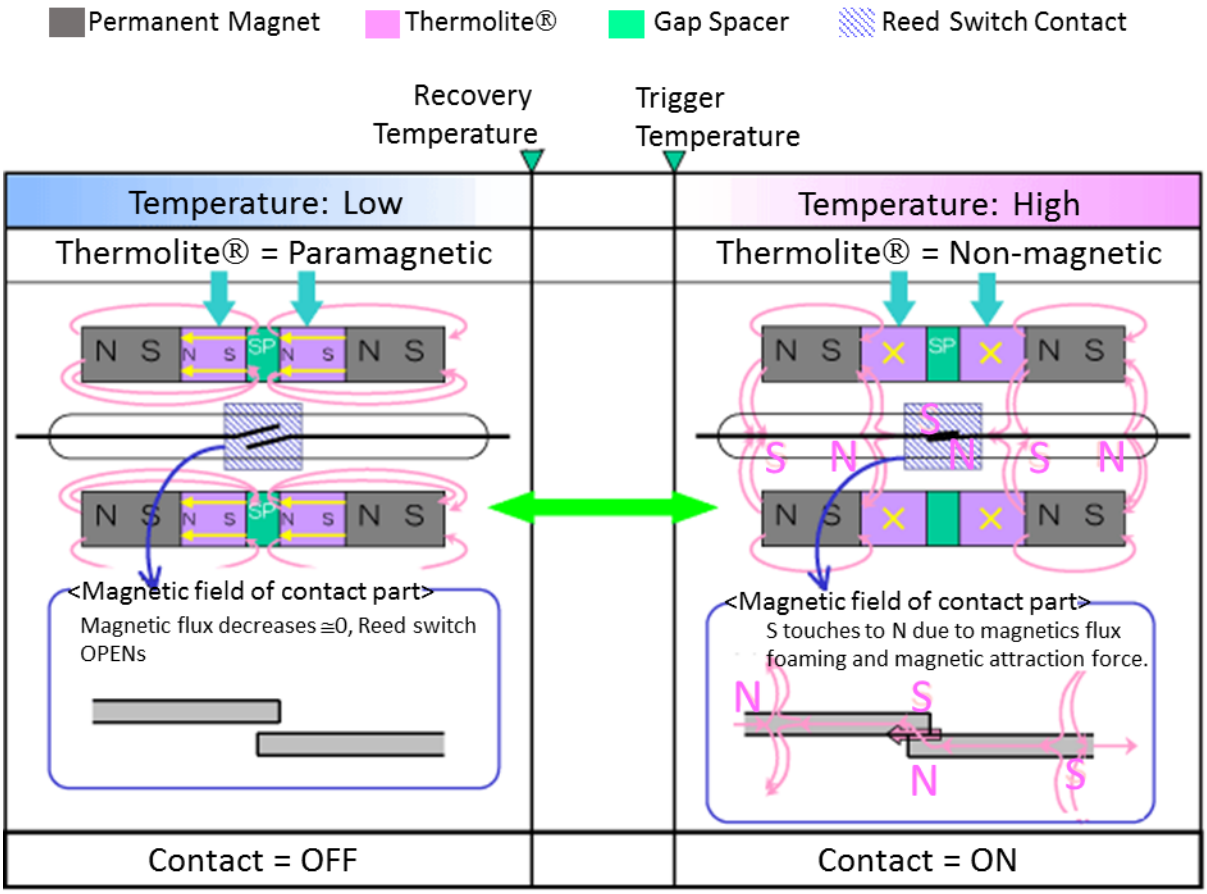

Figure 6: Make Type Sensor Operation Principal Detail

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Reed Switch Structure:

Reed switch is a magnetic reaction type switch and consists with two Fe-Ni alloy small plates. It is placed into a glass tube with inactive gas inside. This allows the reed switch to reduce metal fatigue risk and to provide long life (500K times compared with 100k times on bimetal type sensor). This structure also allows dust resistance and moisture resistance.

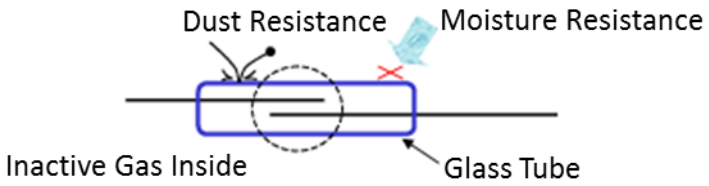

Figure 7: Reed Switch Structure

Advantages of the KEMET Temperature Sensor:

KEMET thermal sensor is an excellent simple switch to monitor threshold temperature such as overheating situation. There is no external control circuitry needed unlike thermistors, providing cost effective solution. It can provide high reliability because of how reed switch is enclosed reducing metal fatigue risk. Temperature accuracy compared with similar technology such as bimetal temperature sensor is excellent (±1~±5 degree C vs. ±5 degree C). Table 3 below show comparisons in between three technologies.

	KEMET Temperature Sensor (Magnetic contact type)	Bi-metallic strip Temperature sensor	Semiconductor base Thermistor
Operating temp. accuracy	±1.0~2.5℃(TRS series) ±5.0℃(OHD series)	±5.0℃	±1.2~2.5℃
Min. operation current	10uA	50mA	---
Rated Power	Max 72 Watt (TRS series) Max 6 Watt (OHD series)		
Life time	500K times *	100K times	---
Thermal response (Relative value)	50 * = fast thermal response	100	<50
Control Circuitry	No	No	Control circuitry and physical switch are needed to provide ON or OFF function

Table 3

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Application Example:

KEMET TRS and OHD series are used in many applications such as home appliance, OA equipment, power supply and other systems where monitoring critical temperature is required and where simple ON or OFF operation by a trigger temperature is needed. We will list several examples.

Figure 8 is an example of using a break type TRS series to control heater in a rice cooker or a crock pot application. The reed switch of the TRS sensor is normally closed below a trigger temperature providing power to the system to keep heater warm and ON. When the temperature of the system reaches at a trigger temperature, the TRS sensor lose its magnetic property and the reed switch OPENs to avoid excessive heating in the system. Similar concept is used for preheating of the drum in OA equipment to keep preheating temperature at 20C~30C.

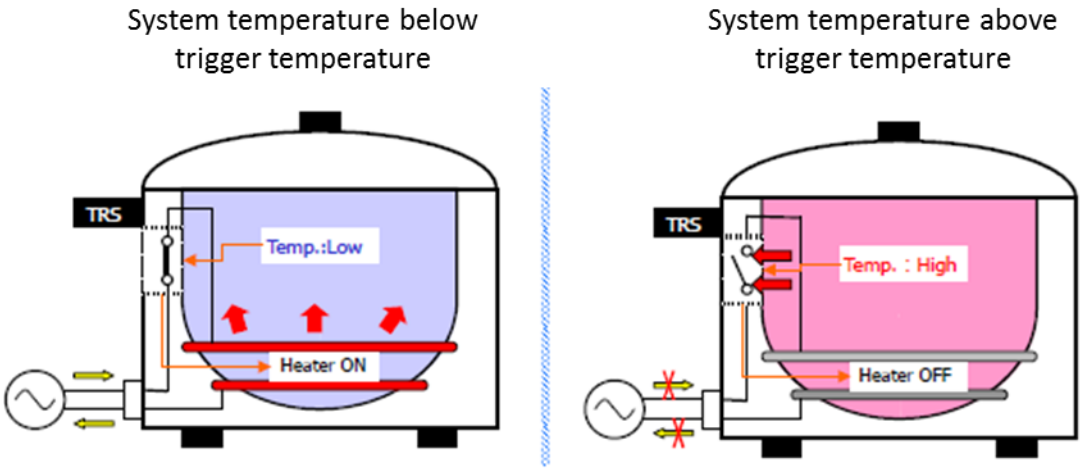

Figure 8: Example of using a break type TRS sensor

Another example is using a make type OHD series in power supply application for overheat monitoring. There are several international safety standards for power supplies, and they require to monitor hot temperature in between 60 degree C~100 degree C to avoid overheating of the system. In Figure 9, two make type OHD series are placed close to heatsink in a power supply. Under normal operation (under a trigger temperature), the OHD is open. When the power supply is overheated, the first sensor (OHD3-40M) detects that the temperature reaches 40 degree C and it sets off an alarm function in the power supply. When the second sensor (OHD3-60M) detects that the temperature reaches 60 degree C, the reed switch turns ON so that the voltage can be applied to OVP pin of the control IC and the power supply shuts down.

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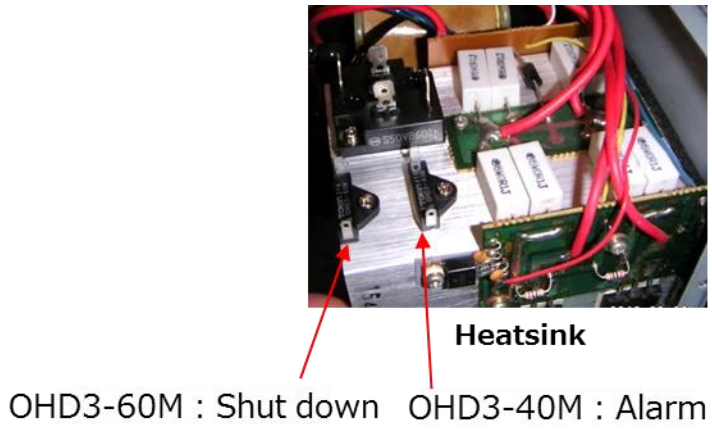

TRS and OHD series are also used in applications such as monitoring efficiency loss by monitoring temperature of the power IC (IGBT or Transistor), monitoring abnormal heat generation of the battery etc.

Summary:

TRS series and OHD series are simple and reliable solutions to monitor critical temperature and they are cost effective thermal switches. They can be simply incorporated into the customer circuit without any external circuitry, operates ON and OFF at trigger temperature, providing output and letting the system know abnormal temperature is detected.