Data Sheet

Thermal sensors

RS stock numbers 307-929, 307-935

Two solid state thermal sensors, having very sensitive active areas of metal oxide material produced by thin film techniques. They exhibit a high negative temperature coefficient of resistance within a narrow temperature band called the transition temperature region and a relatively small resistance change outside the region. Each sensor, encapsulated in a T018 metal case with an isolated mounting tab, will quickly change resistance from approximately 100kΩ down to approximately 100Ω when heated through its specified transition temperature region. A similar characteristic is followed when cooling, but with a rapidly increasing resistance. Suitably applied, these devices are ideal for many temperature and power control applications.

Absolute maximum ratings

Working temperature range ____ 0°C to 120°C

Continuous current ____ See below† (Junction temperature)

Power dissipation (T_{case} = 25°C) ____ 310mW*

Voltage proof lead to tab ____ 600Vdc

* Derate linearly to zero power at 120°C.

† Maximum continuous operating current is limited by several factors defined in the basic formula:

$T_{junction} = (P_D \times 180) + T_{case}$

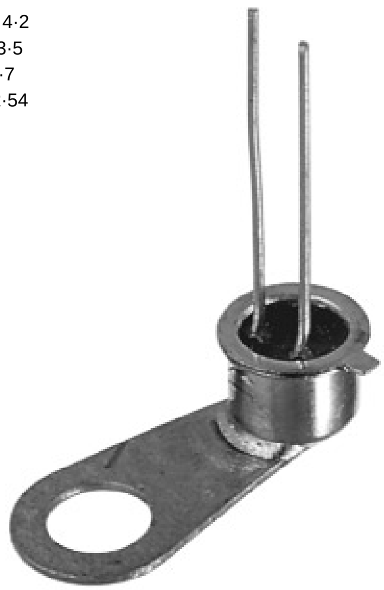
where $T_{junction}$ n is the junction temperature
P_D is the I^2R power dissipated by the device
T_{case} is the device case temperature

Note: $T_{junction}$ must NOT exceed 120°C.

Features

- High sensitivity
- High off/on impedance ratio
- Low noise (no mechanical contacts)
- Low shunt capacitance
- Small physical size
- Excellent reliability.

L. 25·4 W. 6 H. 4·2
Hole diameter 3·5
Lead length 12·7
Lead spacing 2·54



Thermal characteristics

		T57 (**RS** stock no. 307-929)	T75 (**RS** stock no. 307-935)
Transition temperature		57°C	75°C
Typical temperature coefficient (% per °C).	pre-transition	-2	-3.5
	transition	-100	-70
	post-transition	-0.25	-1

General characteristics

Type	Parameter	Temp °C	Min.	Typ.	Max.	Units
	Resistance	35	35	85	230	kΩ
T57	Resistance	57		1.0		kΩ
(307-929)	Resistance	75	15	45	100	Ω
	Latching current*		0.6	1.8	3.2	mA
	Sensitivity	57	40	100		%/°C
	Resistance	55	40	80	300	kΩ
T75	Resistance	75		3.0		kΩ
(307-935)	Resistance	95	20	115	200	Ω
	Latching current*		0.7	1.9	3.1	mA
	Sensitivity	75	50	70		%/°C
	Thermal Resistance					
	Die to tab			170		C/W
	Tab to air			150		C/W
T57 AND T75	Time Constant					
	Air to tab			35		s
	Tab to die			0.5		s
	Shunt Capacitance					
	Lead to lead			0.2		pF
	Lead to tab			0.8		pF

* See circuit considerations

Figure 1 **Resistance - temperature characteristics**

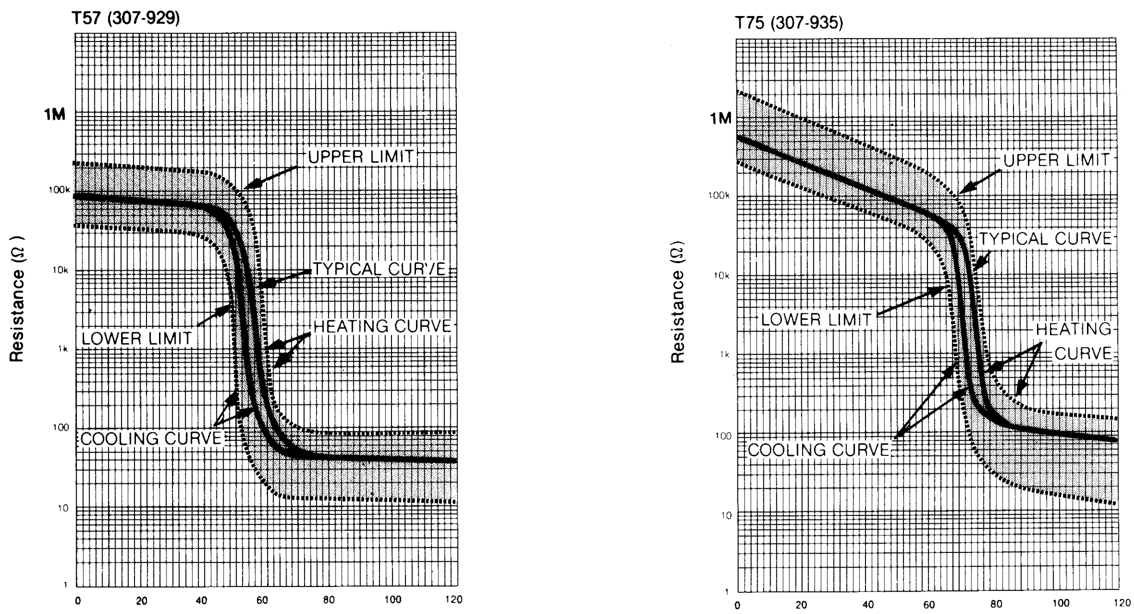
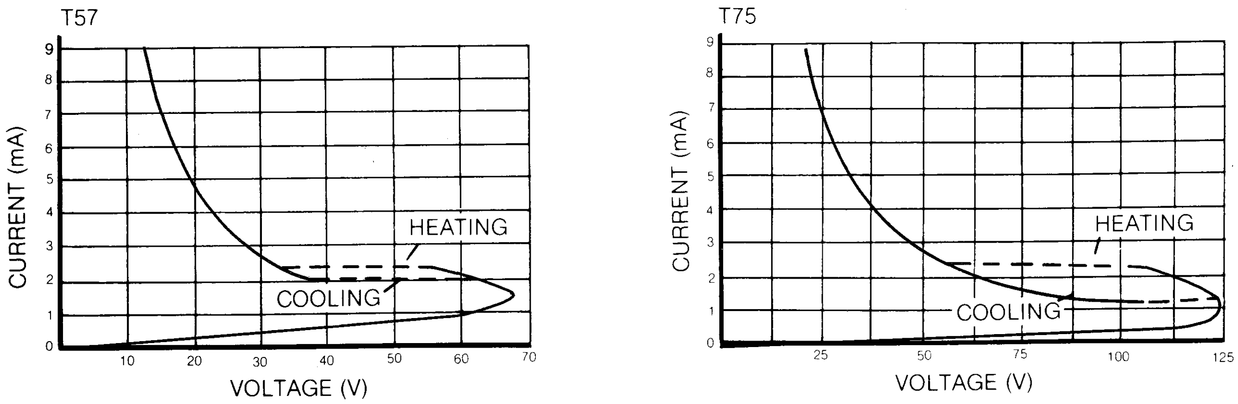


Figure 2 **Typical voltage - current characteristics**



Design considerations

The four most important factors in a design using these sensors are: (not necessarily in order of importance).

1. Temperature of operation
2. Physical mounting procedure
3. Circuit considerations
4. Mode of operation.

Temperature of operation

Below its transition temperature a sensor has very little effect on normal circuit operation owing to its high impedance, and being purely resistive in nature it exhibits negligible reactive effects. As the device approaches the temperature at which it becomes active it begins to respond with increasing sensitivity. Resistance changes rapidly with temperature when either heating or cooling. There is an inherent hysteresis, which means that the device will require a slightly higher temperature (4-6°C depending on type) to reach a given resistance level on heating than when it is cooled. This is seen on the response characteristics shown on Page 2 which demonstrates the resistance level for a variety of heating and cooling cycles. Calibration is not required because the transition temperature is an inherent material characteristic. A rearrangement of the crystal structure in the material always occurs at the same temperature for any given piece of material.

Physical mounting procedure

In order to provide reliable and predictable temperature sensing a low thermal resistance path between sensor and sensing point is essential. The use of silicone based compound (RS stock no. 554-311 is recommended).

Circuit considerations

Since the sensor is a solid state active device whose characteristics change dramatically with temperature it is important to consider and determine the current flow through the device under all conditions. The most critical is the magnitude of voltage across the device and current through it after it passes through transition. Care should be taken not to exceed maximum power dissipation, or minimum latching current under normal operation as specified in general characteristics. The minimum latching current is the smallest current that will cause the sensor to make step changes in resistance when following the normal cooling characteristic.

The device may also latch or stay in its low resistance state due to self heating caused by high current and will switch to its high resistance state only after significant cooling has occurred. However, latching may be a desirable feature in certain applications, such as the shutting down of equipment until it has cooled to a safe operating temperature.

Latching must be considered in conjunction with the basic formula for junction temperature Page 1.

A further factor to be considered is that since these are low current devices, they may be damaged by fast surge current pulses. A small capacitance across the device represented by long lead lengths could be discharged into the device in its low resistance state resulting in device failure. It is recommended therefore that a series resistance of between 300 and 500 ohms be fitted, should long lead lengths be necessary.

Mode of operation

There are two common modes of operation:

1. Normal mode in which a sensor will follow its resistance temperature characteristics (see Page 2) unaffected by circuit operation.
2. Latching mode in which a circuit is designed to pass a current through a sensor in its low resistance state such that the power dissipation in the sensor causes self heating sufficient to maintain the low resistance state.

Applications

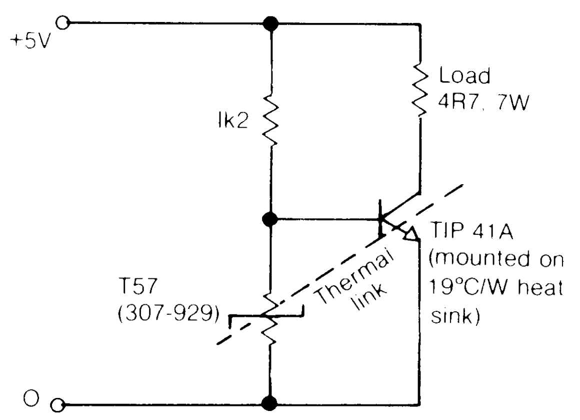
The most common method of using the sensors is in circuits designed to minimise the power applied to a service or load so that the high sensitivity of the sensor can be used to change circuit state at or below a critical temperature. The large resistance change in the transition region may be used to actuate other electronic circuitry, to sound an alarm, cut back power or heat generation, to control temperature etc. Some common applications are power transistor protection in amplifiers and power supplies, triac and SCR protection in power switching applications and temperature control in ovens.

The following circuits show how these sensors can be used and may be taken as a guide to typical applications.

Transistor protection

In Figure 3 the circuit is constructed so that the T57 sensor is mounted on the tab of a TIP41A transistor. Under normal conditions the temperature reached by the transistor will not exceed the switching temperature of the sensor and the load will remain fully energised. Should load current and/or transistor temperature increase, causing the sensor to reach 57°C, it will change to its low resistance state, turning the transistor off and limiting load current. Heat sink temperature will be limited to approximately 60°C and the transistor will be protected from thermal runaway and possible breakdown. The circuit has been arranged so that the sensor will work in its normal mode and will therefore return to its normal state when the transistor has cooled down.

Figure 3

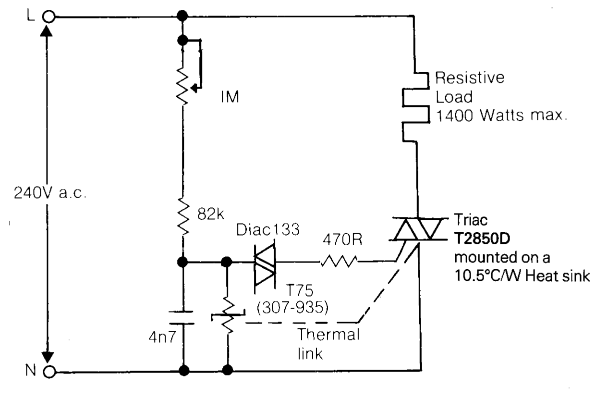


Triac protection

Figure 4 shows the T75 thermally linked to a triac T2850D.

Under normal conditions the sensor will remain in its high resistance state and the firing circuit will trigger the triac whilst the temperature is below 60°C. Should load current increase, a temperature rise on the triac will be detected by the sensor which changing to its low resistance state will cut out the firing circuit. The triac will therefore be protected from overheating and possible failure.

Figure 4



Overloading limitation and indication

Figure 5 shows a circuit where the sensor T57 is used in a latching mode. The sensor is thermally linked to the load resistor. With a 12 V d.c. supply a 33Ω, 7W load resistor will generate sufficient power to heat the sensor up to and beyond 60°C. At the switching temperature the sensor will change to its low resistance state and hold the transistor off, which in turn allows the LED to turn on indicating overload. The 220Ω variable resistor may be adjusted so that the current passing through the sensor in its low resistance state will self heat the sensor to maintain the low resistance state until the supply is removed. The continuous current through the sensor should not exceed the maximum value defined in the basic formula for junction temperature on Page 1.

Should the load resistance be increased thus reducing power to a point where the stabilised load temperature is below the switching temperature of the sensor, the circuit will not latch off and the indicator will remain off. A circuit designer may therefore select a margin of temperature rise between normal stabilised load temperature and sensor switching temperature. Should that margin be exceeded, the power in the load will be automatically limited and the indicator will record the overload.

Figure 5