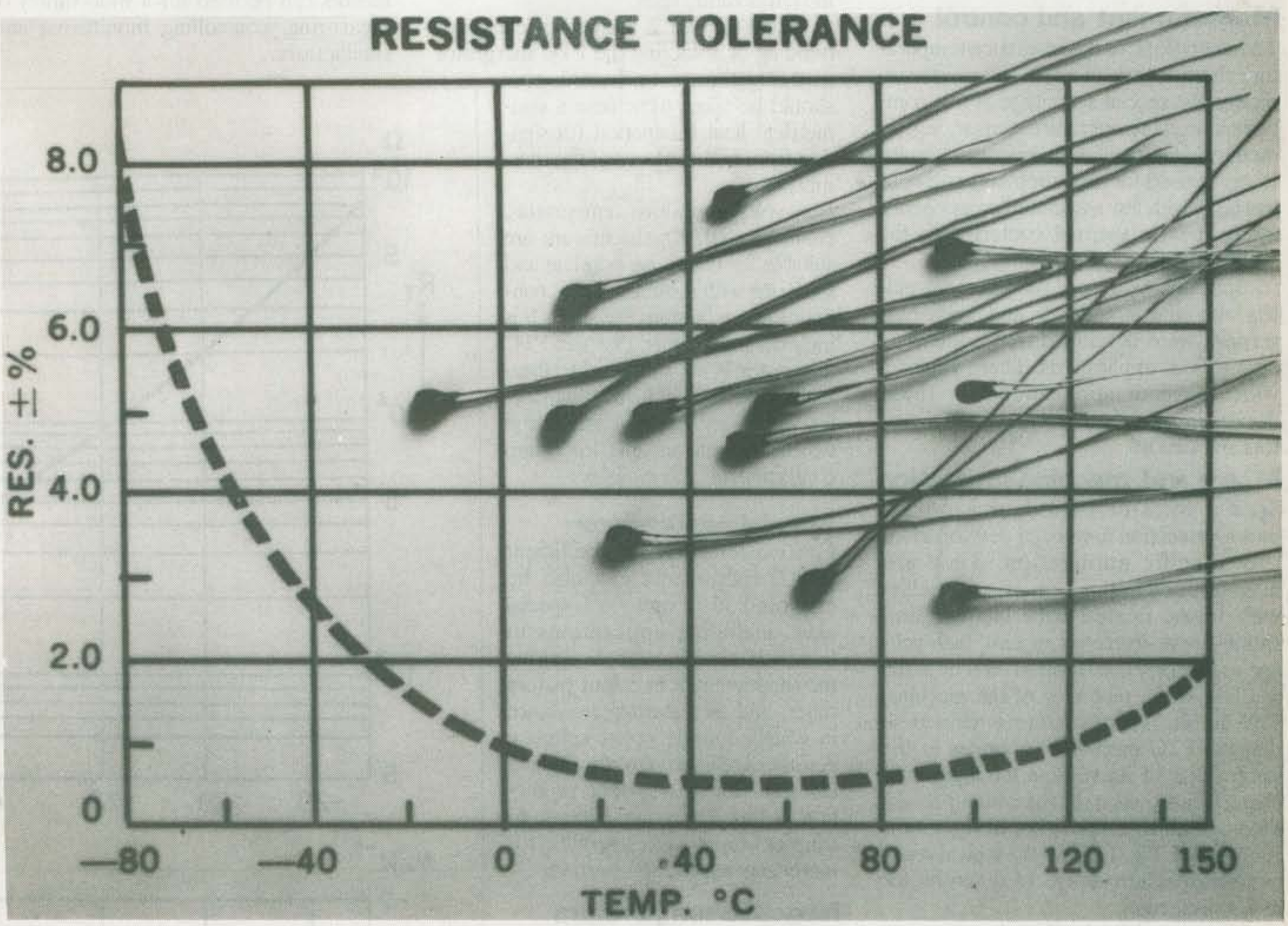
The Thermistor

Resistors that vary with temperature are versatile control devices for a wide variety of applications.

DR. H. VIRANI



Ceramic positive temperature coefficient thermistors are temperature-dependent resistors that can be used in a wide field of applications in electrical engineering and electronics. The characteristic of a positive temperature coefficient thermistor is that in the "cold" state it is a relatively good conductor of electric current and, at a particular temperature, it increases its resistance suddenly.

Depending on the design of the positive temperature coefficient thermistor, and with an appropriate shape, it is used for measuring temperature, compensating for temperature-dependence, as non-destructive fusing elements and for delayed switching and stabilization tasks. Further more, it is increasingly used as a heavy-duty self-limiting heating element. Applications include electronics, telecommunications, electrical engineering, motor vehicles, and household appliances.

Overload protections

In this application, the positive temperature coefficient thermistor is connected in series with the load to be protected. An operation of the load under rated conditions, the positive temperature coefficient thermistor remains at a low resistance, and a low voltage is then applied to the device. In event of an overcurrent during a fault conditions, the positive temperature coefficient (PTC) thermistor becomes heated to a level greater than its reference temperature and suddenly changes to a high resistance. The current flowing through the load is reduced simultaneously to an acceptable level, i.e. a few MA. When the supply voltage has been switched off, the positive temperature coefficient (PTC) thermistor cools and becomes operational once again.

When the equipment is started, it again assumes its protective function.

Delayed Switching

If the PTC thermistor is subjected to current or voltage in order to heat it beyond the reference temperature, the time taken to reach the reference temperature and the high-resistance state depends on the initial power. The "Switching time" (ts) can be varied within wide limits by selecting the voltage (current), series resistance, size of the PTC thermistor, reference temperature and thermal capacitance.

Measurement and control

The steep slope of the resistance/temperature characteristic of a PTC thermistor indicates the special advantage of this component as a temperature sensor, e.g. in monitoring - specified temperature limits. It can be used for measurements and control tasks with few associated components, where it is in thermal contact with the body or medium to be monitored.

Special design types such as disks, pellets with or without leads, and screw-type versions were developed to the following examples of applications. There is also a wide range of applications for these devices in combination with triacs, thyristors and LEDs.

Motor and machine protection

Special types of PTC thermistors for motor protection have been developed for this specific application. They are manufactured in the form of small pellets with leads, coated with lacquer and shrink-sleeve insulated against high-voltage so that they can be fitted directly in the winding of the motor or of the machine. The threshold temperature is chosen so that the PTC thermistor operates in the steep slope of its resistance/temperature characteristic, when the maximum permissible operating temperature of the motor is exceeded. Fig. 1 shows the typical resistance/temperature curve of a sensor for motor protection.

These specially developed sensors can be used to provide full protection of heavy-duty motors which are subject to severe thermal stress, for thermal monitoring of sleeve bearings, and for temperature monitoring of heat sinks in power semi conductors.

Heating elements and thermostats

Positive temperature coefficient (PTC) thermistors can be used in the design of self-regulating heating systems which require no additional auxiliary elements.

If a positive temperature coefficient (PTC) thermistor is subjected to a voltage, which is sufficient to heat the device to a temperature above the reference temperature, a sudden change of resistance takes place. This results in a balanced state in which the dissipated heat is equal to the electrical power applied. The stabilization temperature does not depend on the ambient temperature. As a result of the positive temperature coefficient of the PTC thermistor material, the power drawn rises as the temperature drops and decreases as the temperature rises.

Heat transfer is ensured by clamping, bonding or soldering the PTC thermistor to the system to be heated; care should be taken to achieve a symmetrical heat dissipation (dissipation from both surfaces of the thermistor).

Low-voltage positive temperature coefficient (PTC), thermistors are suitable for clamping, bonding and soldering with suitable solders consisting of a minimum 3% silver. It is important to ensure that the PTC thermistor is not subjected to thermal shock, and pre heating is therefore necessary. Low-voltage version which are only suitable for clamp contacting are also available.

Special applications

Positive temperature coefficient (PTC) thermistors can also be employed in a variety of special uses, including applications in television servicing for degaussing the shadow mask in colour picture tubes, and as a starting resistance in switched-mode power supplies. Another use is as delayed switching elements for overcurrent protection at high operating voltages, to suppress input peak currents, for motor starting and soft starting.

Negative temperature coefficient (NTC) thermistor

Negative temperature coefficient thermistors are temperature dependent semiconductor resistors with a negative temperature coefficient between 3% and 5% K and are produced from carefully selected and tested raw materials. The starting materials are different oxides of metals such as manganese, iron, cobalt, nickel, copper and zinc, to which in-part stabilizing oxides are added to achieve better reproducibility and stability for a thermistor's characteristics.

NTC thermistors have many advantages including: high sensitivity; good reproducibility thanks to mechanical thermal, and electrical influences; long life; compact design; and favorable price/performance ratio.

They have been used for many years in a broad range of applications in the field of electronic circuitry. Owing to their ease of handling and high reliability NTC thermistors can be used for a wide variety of measuring, controlling monitoring and similar tasks.

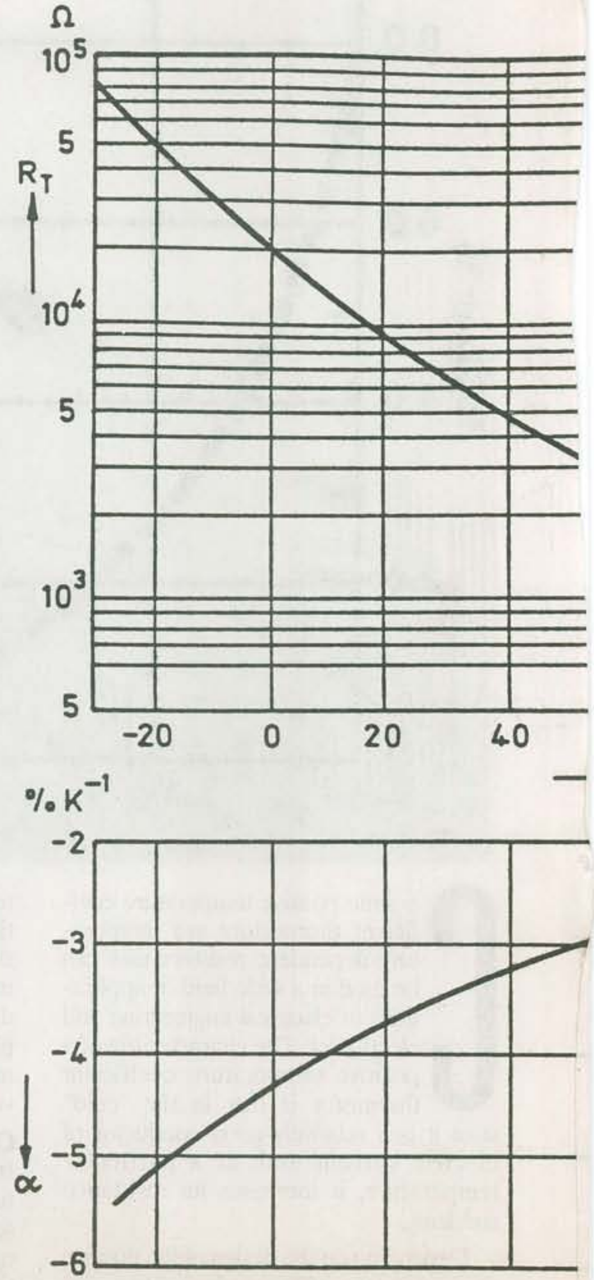
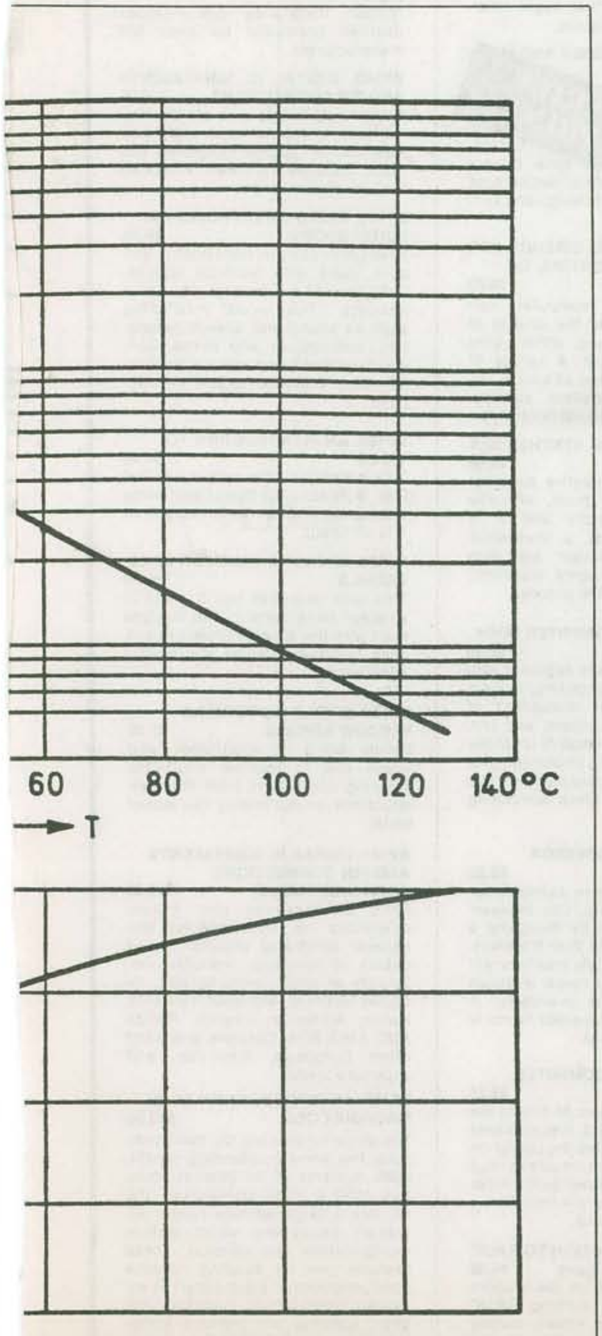


Fig. 1. The relationship between temperature and the resista

The interrelationship between resistance value and temperature is expressed by the R/T characteristic Curve or by the temperature coefficient, as shown in Fig. 1.

Temperature measurement

Compared to other temperature sensors, thermistors present considerable advantages in many applications. First, the high resistance makes the ohmic effect of leads negligible, and thus compensation of the lead resistances can be omitted.



:e (top graph), and the temperature coefficient (bottom).

Second, close resistance tolerances implying high accuracy in measuring temperature can be achieved with little effort.

Thirdly, the high temperature coefficient of 3% to 5% K makes it possible to reliably detect temperature difference of 10-4K with few additional components. Fourthly, the small dimensions enable temperature sensors with very small time constants to be designed, which can be used in the tightest measuring locations and respond very fast.

Because of the more attractive price, the greater ruggedness and the higher measurement accuracy that can be achieved, disk thermistors are preferred for temperature measurement. Thermistors used for temperature measurement should have a low electric load, so that no significant heating occurs and the resistance of the thermistor is determined only by the ambient temperature. Bread negative temperature coefficient (NTC) thermistors, are particularly suitable for applications requiring high temperature resistance (operating range up to 450°) and short response time. Equally suitable for high temperature are NTC thermistors in glass diode design, where the thermistor disk is sealed in a glass tube and thus protected from environmental influences. Such devices are suitable for host of temperature measurement applications in automobile vehicles, household appliances, heating, airconditioning and medicine.

Temperature compensation

Virtually all semiconductor and the circuits that are made up of them exhibit a temperature coefficient, just like the copper coils of measuring instrumentation or the focusing coils of TV sets. For the compensation of this generally-undesirable temperature response, thermistors are particularly suitable owing to their high temperature coefficient. By using series and parallel resistors and appropriate voltage-divider and bridge circuit, it is possible, with simple means, to produce temperature-dependent resistances and voltages that will compensate for any temperature response. It is important that the compensating thermistor should have the same temperature, as far as possible, as the device causing the temperature response. Among the thermistors that are suitable for temperature compensation there are, in addition to the conventional types with leads, thermistors in packages with a screw of attachment to cooling fins and heat sinks, and a chip form for surface mounting by automatic placement machinery.

Negative temperature coefficient (NTC) thermistors can be used for temperature compensation in entertainment and industrial electronics and household appliances.

Inrush current limiting and relay delay

Many kinds of equipment, like switched-made power supplies, electric motors or transformers, exhibit excessive current when they are switched on, meaning that other components can be damaged or fuses can be tripped. With thermistors it is possible to effectively limit these currents, at attractive cost, by connecting a thermistor in series with the unit concerned. The thermistors specially developed for this application limit the current at switch-on by their relatively high cold resistance. As a result of the current load, the thermistor ten reduces its resistance by a factor of 10 to 50 and the power that it draws reduces accordingly, thus continuous currents of up to 7.5A are possible.

What is important in selecting the appropriate thermistor is the continuous current that is required, the permissible continuous current determining the cold resistance of the thermistor.

It is not possible to connect two or more thermistors in parallel, because the thermistor with the smaller resistance receives the larger portion of the currents and heats to a greater degree and thus its resistance decreases further. Finally, this thermistor receives the entire current and parallel thermistor remains cold.

Certain thermistors are particularly suitable for relay delay. Such devices permit relay operation delay times of 0.1 s to several seconds. A series connection of thermistor and relay coil is used to delay relay operation, while a parallel connection or relay coil and thermistor is used to delay relay release.

Negative temperature coefficient (NTC) thermistors can be used in switched-mode power supplies for computer terminals, personal computers, TV sets, and as soft-start devices for vacuum cleaner motors. Other uses include the limiting of inrush currents in fluorescent, projection and halogen lamps. ■