PTC Thermistor

Product Guide

RTI Electronics, Inc.

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Commitment To Excellence

The Company - RTI Electronics, Inc. designs, manufactures and sells thermistor products to a diverse international marketplace. The company has developed lasting customer relationships by providing reliable, industry standard thermistor products, just-in-time service and competitive prices. As the recognized leader in the supply of NTC inrush current limiting devices, RTI Electronics, Inc. also produces a broad PTC product offering, including two mil-spec silicon PTC thermistor products. The company has earned a reputation for meeting the most exacting specifications as well as demanding global delivery schedules. The company is staffed by experienced, innovative professionals, uniquely qualified to assist design and production engineers in the application of thermistor products.

Quality - Quality principles are firmly established in the company's operating methodology. Our vision is to use TQM principles as the foundation of our business and have employees who are empowered to create and maintain an environment that fosters excellence...where creativity and teamwork combine to do the job right the first time, every time.

TEMPERATURE PROTECTION DEVICES
DISC STYLE

DISC STYLE

Features

- **Wide Ohmic Value Range**
- **Fast Thermal Response Time**
- **Range of Transition/ Switching Temperature**
- **High Sensitivity**

STANDARD PTC THERMISTORS

Positive Temperature Coefficient (PTC) thermistors are thermally sensitive semiconductor resistors which exhibit an increase in resistance at a specified temperature. Change in the resistance of a PTC thermistor can be brought about either by a change in the ambient temperature or internally by self heating resulting from current flowing through the device. Most of the practical applications of PTC thermistors are based on these material characteristics.

PTC DISC STYLE DEVICES

RTI Electronics manufactures and distributes disc style thermistors in resistance values ranging form 1.0 to 1500 ohms @25°C, and switching temperatures (T_S) of 40 to 120°C. The maximum operating voltage (V_{max}) available is 350V DC.

Thermistor Terminology for Temperature Measurement & Control Devices

- **D.C. -** The dissipation constant is the ratio, normally expressed in milliwatts per degree C (mw/ °C) at a specified ambient temperature, of a change in power dissipated in a thermistor to the resultant change in body temperature.

- **T.C. -** The thermal time constant is the time required for a thermistor to change 63.2% of the total difference between its initial and final body temperature when subjected to a step function change in temperature under zero-power conditions and is normally expressed in seconds (S).

APPLICATIONS

The applications of standard PTC thermistors can be classified in two main groups:

1. Applications where the temperature of the PTC is primarily determined by the temperature of the surrounding environment.

   The first group includes applications such as temperature measurement, temperature control, temperature compensation and over-temperature protection.

2. Applications where the temperature of the PTC is primarily determined by the electrical power dissipated by the device.

   The second group includes applications such as over-current protection, liquid level detection and time delay.

NOTE: Do not apply voltage exceeding Vmax to the PTC device. Doing so may destroy the thermistor. Although several PTC's may be connected in series for temperature sensing applications, ***do not connect PTC thermistors in series to obtain higher voltage ratings.*** Since no two devices are exactly the same, one would tend to heat faster than the others thereby limiting the current flow through the other devices and resulting in the entire voltage available being dropped across the single device.

PTC's may, however, be connected in parallel to increase the current ratings in current limiting applications. RTI Electronics' engineers specialize in the development of state-of-the-art devices for the most demanding applications. If you have a unique application which requires a part not listed in this catalog please feel free to contact our applications engineering department. RTI Electronics is capable of producing many custom PTC thermistor designs to meet your critical demands.

Some of the more popular applications of PTC Thermistors include:

- **Over-Temperature Protection**
- **Temperature Compensation**
- **Arc Suppression**
- **Time Delay**
- **Liquid Level Sensing**
- **Air Flow Sensing**
- **Automatic Color TV Degaussing**
- **Non-Destructive Fusing**
- **Self Regulating Heaters**
- **Single Phase Motor Starting**

Other Considerations:

- **Voltage**
- **Review thermal time constant**
- **Determine operating temperature range**

Selection Considerations for PTC Thermistor Disc Devices

The most important considerations necessary when selecting standard PTC thermistors are resistance at 25°C as well as the transition temperature.

- **Base Resistance (R@25°C) -** The first consideration in the selection of a standard PTC disc PTC disc thermistor is the nominal Base Resistance value at 25°C (R@25°C). The available values are tabulated in the Standard PTC Thermistor Specifications table located on page 4.

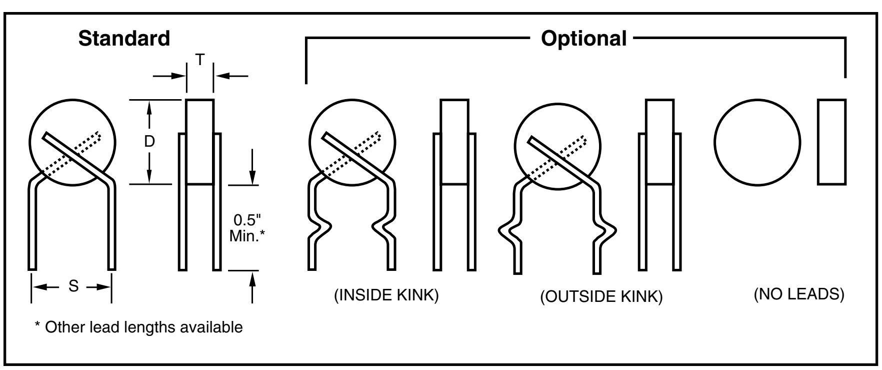
- **Switch Temperature (T_S) -** The second consideration is to determine the required Switch Temperature (T_S) (sometimes alternatively identified as the Transition Temperatures or Curie Point). RTI's standard PTC disc thermistors are available with Switch Temperatures ranging from 40°C to 120°C. The Switch Temperatures available for each Base Resistance value are show in the Standard PTC Thermistor Specifications table located on page 4.

- **Maximum Operating Voltage (V_{max}) -** Next calculate or estimate the voltage that will be across the tentatively selected thermistor when the device is switched into its high resistance mode (the thermistor's resistance in its high resistance mode will typically be greater by two to three orders of magnitude than its R@25°C value). If the voltage estimated is greater than the Vmax rating of the selected part then another selection with a higher V_{max} rating must be made.

  Note: Consult RTI's Application Engineering Department for technical assistance in selecting devices with requirements that cannot be found in the Standard PTC Thermistor Specification table on page 4.

Standard PTC Thermistor Specifications

Part Number	Base Resistance R_o @ 25 °C (Ω) ±30%	Switch Temp. Ts (°C) ±6°C	Maximum Operating Voltage V_{max}	Dissipation Constant Dc (mW/°C)	Time Constant (Sec.)	Heat Capacity Hc (Watt-Sec/ °C)	Reference Dimensions			
							D	T	S	Lead Dia. (in.)
SL5504D-1R0-120	1	120	15	15	50	0.48	0.55	0.04	0.30	0.032
SL5003D-1R8-120	1.8	120	20	12	50	0.29	0.50	0.03	0.30	0.025
SL5004D-2R0-120	2	120	25	14	50	0.39	0.50	0.04	0.30	0.032
SL4005D-5R0-110	5	110	25	10	45	0.31	0.40	0.05	0.30	0.025
SL3505D-7R5-120	7.5	120	50	9	40	0.24	0.35	0.05	0.25	0.020
SL5510D-100-110	10	110	132	16	90	1.19	0.55	0.10	0.30	0.025
SL3005D-100-120	10	120	50	7	35	0.18	0.30	0.05	0.25	0.020
SL5510D-100-120	10	120	132	16	90	1.19	0.55	0.10	0.30	0.025
SL2505D-200-120	20	120	50	7	30	0.12	0.25	0.05	0.20	0.020
SL5010D-250-065	25	65	132	15	80	0.98	0.50	0.10	0.30	0.025
SL3006D-250-120	25	120	50	7	35	0.21	0.30	0.06	0.25	0.020
SL3010D-400-110	40	110	132	8	45	0.35	0.30	0.10	0.25	0.020
SL5510D-500-065	50	65	265	16	90	1.19	0.55	0.10	0.30	0.032
SL4010D-500-110	50	110	132	12	60	0.63	0.40	0.10	0.30	0.025
SL2005D-101-040	100	40	50	6	30	0.08	0.20	0.05	0.20	0.020
SL2005D-101-050	100	50	50	6	30	0.08	0.20	0.05	0.20	0.020
SL2005D-101-060	100	60	50	6	30	0.08	0.20	0.05	0.20	0.020
SL2005D-101-070	100	70	50	6	30	0.08	0.20	0.05	0.20	0.020
SL2005D-101-080	100	80	50	6	30	0.08	0.20	0.05	0.20	0.020
SL2005D-101-090	100	90	50	6	30	0.08	0.20	0.05	0.20	0.020
SL2005D-101-100	100	100	50	6	30	0.08	0.20	0.05	0.20	0.020
SL2005D-101-110	100	110	50	6	30	0.08	0.20	0.05	0.20	0.020
SL2005D-101-120	100	120	50	6	30	0.08	0.20	0.05	0.20	0.020
SL3010D-101-110	100	110	132	8	45	0.35	0.30	0.10	0.25	0.020
SL5010D-101-120	100	120	265	15	80	0.98	0.50	0.10	0.30	0.025
SL2008D-251-120	250	120	150	6	30	0.13	0.20	0.08	0.20	0.020
SL2010D-501-120	500	120	250	6	30	0.16	0.20	0.10	0.20	0.020
SL2010D-102-110	1000	11	300	6	30	0.16	0.20	0.10	0.20	0.020
SL2012D-152-110	1500	110	350	6	30	0.19	0.20	0.12	0.20	0.020



The values for dissipation constant and time constant are for reference only. Mounting method and environmental conditions can affect these parameters.

Options:

Standard devices may be modified to best suit a particular application by specifying any of the following options.

- Non-standard resistance values and tolerances at 25°C or other temperatures
- Non-standard switch temperature
- Encapsulation (epoxy or silicone resin)
- Special lead material
- Special lead configuration

PTC OVER-TEMPERATURE PROTECTORS

RTI Electronics' solid state over–temperature protectors are designed to sense the temperature of power transistors, heat sinks, chassis, etc. Construction consists of a small 0.2" diameter positive temperature coefficient thermistor disc attached to an anodized aluminum mounting tab using thermally conductive epoxy.

The devices remain in their low resistance state at all temperatures below the switch temperature. When the switch temperature is reached or exceeded, they increase in resistance rapidly thereby limiting current to the drive circuitry to protect the critical components. Once the temperature decreases to a normal operating level, the device resets to its low resistance state.

Part Number*	Switch Temp. °C (±6°C)
SL20T-101 -40	40
SL20T-101 -50	50
SL20T-101 -60	60
SL20T-101 -70	70
SL20T-101 -80	80
SL20T-101 -90	90
SL20T-101 -100	100
SL20T-101 -110	110
SL20T-101 -120	120

* Add -1 to Part Number for variation with 0.140" dia. ±0.005 mounting hole.

Specifications:

Resistance @ 25°C: 100 Ohms ± 30%

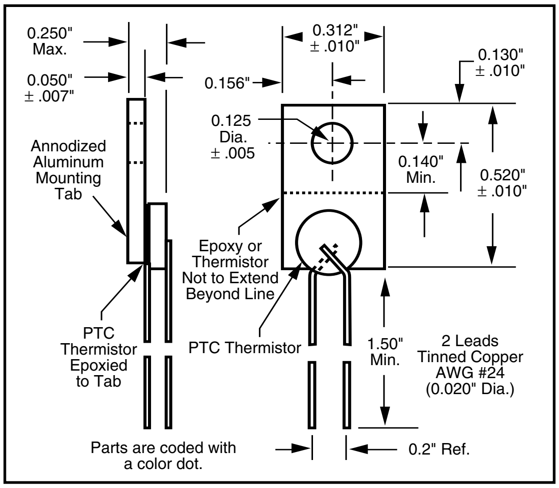
Maximum Voltage Rating: 50 Volts

Maximum Operating Temperature: 150°C

Switch Temperature: Temperature at which the resistance is two (2) times the resistance at 25°C.

Dielectric withstanding voltage: 50 VDC minimum between element and tab.

Note: Units with resistance values or switch temperatures not listed are available. Please consult RTI Electronics Applications Engineering Department.



PTC OVER-CURRENT PROTECTORS

PTC OVER–CURRENT PROTECTORS

PTC Over-current Protector Features

- **Fast Switching**
- **No Electrical Noise**
- **Virtually Unlimited Life**
- **Self Resetting**
- **No Contacts**
- **Automatic Operation**
- **Efficient**

Options

- **Encapsulation**
- **Special Lead Configuration**
- **Non-Standard Values**

The PTC over-current protector is connected in series with the load which is to be protected. During normal operating conditions, the PTC remains in its low resistance state resulting in negligible attenuation to current flow. When a short circuit or over current condition occurs, the PTC will switch into its high resistance state thereby limiting the current flow in the circuit to a point well below the normal operating level. When the fault condition is removed, the PTC will return to its low resistance state allowing the current flow to recover to its normal level. RTI Electronics produces over-current protectors for a wide range of load protection applications.

Typical Applications

Some of the most popular applications of over-current protectors include:

- Telephone Line Fault Protection
- Transformer Protection
- FHP Protection
- Transistor Protection
- Speaker Protection

- **Maximum Continuous Current (I_{cc}) –** One of the first considerations is the (I_{cc}), the maximum amount of current. The PTC must be capable of conducting without switching into its high resistance state. See the over–current protectors specification sheet located on page 7.

- **Minimum Switching Current (I_S) –** The second consideration is to determine the (I_S), the minimum amount of current required to switch the PTC into its high resistance state. See the over-current protectors specifications located on page 7.

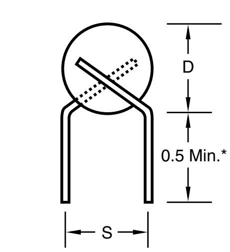
- **Maximum Operating Voltage (V_{max}) –** Next calculate or estimate the voltage that will be across the tentatively selected thermistor when the device is switched into its high resistance mode (the thermistor's resistance in its high resistance mode will typically be greater by two to three orders of magnitude than its R@25°C value). If the voltage estimated is greater than the Vmax rating of the selected part then another selection with a higher V_{max} rating must be made.

  Note: Consult RTI's Application engineering personnel for technical assistance for devices not found on the over–current protector specifications sheet. See page 7.

During normal operating conditions the PTC remains in its low resistance state resulting in negligible attenuation to current flow. When a fault such as short circuit or over–current condition occurs, the PTC will switch into its high resistance state which limits the current in the circuit to a point well below the normal operating level, therefore, protecting the load circuit components. When the fault condition is removed. The PTC will return to its low resistance state allowing the current flow to recover to its normal level.

PTC Over-Current Protector Specifications

Part Number	Base resistance		Maximum	Maximum*	Minimum**	Switch			Reference Dimensions		
	(ohm)	Tolerance (±)	Operating Voltage Vmax	Continuous Current (Amps)	Switching Current (Amps)	Temp. (Ref.) (°C)	Heat Capacity (Watt-Sec./°C)	Dissipation Constant (mW/°C)	D Max. Dia.(In.)	Lead Dia. (In.)	S Ref. (In.)
SP5504D-1R0-120	1	20%	15	0.600	1.300	120	0.48	13	0.60	0.032	0.3
SP5004D-2R0-120	2	20%	25	0.440	0.900	120	0.39	12	0.55	0.032	0.3
SP4004D-3R3-120	3.3	30%	25	0.300	0.690	120	0.25	10	0.45	0.025	0.3
SP6709D-4R7-110	4.7	20%	132	0.290	0.650	110	1.59	16	0.70	0.032	0.
SP4004D-5R0-110	5	20%	25	0.220	0.500	110	0.25	10	0.45	0.025	0.3
SP3505D-7R5-120	7.5	30%	50	0.180	0.400	120	0.24	8	0.40	0.020	0.2
SP5510D-100-110	10	30%	132	0.170	0.430	110	1.19	13	0.60	0.025	0.3
SP3505D-100-120	10	30%	50	0.150	0.350	120	0.24	8	0.40	0.020	0.2
SP2505D-200-120	20	30%	50	0.095	0.215	120	0.12	6	0.30	0.020	0.2
SP3510D-300-110	30	30%	132	0.075	0.190	110	0.48	8	0.40	0.020	0.2
SP3010D-500-110	50	30%	132	0.055	0.140	110	0.35	7	0.35	0.020	0.2
SP3010D-101-110	100	30%	132	0.04	0.100	110	0.35	7	0.35	0.020	0.2
SP2008D-251-120	250	30%	150	0.028	0.070	120	0.13	7	0.25	0.020	0.2
SP2010D-501-120	500	30%	250	0.020	0.050	120	0.16	7	0.25	0.020	0.2
SP2010D-102-110	1000	30%	300	0.012	0.032	110	0.16	7	0.25	0.020	0.2
SP2012D-152-110	1500	30%	350	0.010	0.026	110	0.19	7	0.25	0.020	0.2



* Other lead lengths available

*Maximum Continuous Current (Icc) – The maximum amount of current, expressed in AMPS, the PTC must be capable of conducting without switching into its high resistance state.

**Minimum Switching Current (Is) – The minimum amount of current, expressed in AMPS, required to switch the PTC into its high resistance state.

Note – The values for minimum switching current and maximum continuous current are for reference only. Mounting method and environmental conditions can affect these parameters. Please contact RTI Electronics Inc. for specific applications engineering assistance.

SILICON PTC THERMISTORS

Features

- **High Temperature Coefficient**
- **Multiple Configurations**
- **High Reliability**

Options

- **DO7 Glass Encapsulation**
- **Molded Epoxy Encapsulation**
- **Radial Leads**
- **Axial Leads**
- **SMD**

Applications

- **Telemetry**
- **Thermometry**
- **Temperature Regulation**
- **Over temperature Protection**
- **Amplifiers**

Description

The positive temperature coefficient of resistance is very large: approximately 0.7%/°C, making these units ideal for use in temperature compensating and sensing applications. Applications include amplifiers, power supplies, transducers, telemetry, computers, magnetic amplifiers, thermometry, meteorology, temperature regulation and over-temperature protection.

Silicon PTC Specifications

Style	Wattage Rating @ 100°C (Watts)	Resistance Range (Ohms)	Thermal Time Constant (Sec. Max)	Operational Ambient Temperature Range (°C)	Temp. vs. Coefficient of Resistance Table
DS125	0.125	10 to 39,000	34.8	-65 to +150	A
DS200	0.250	10 to 39,000	34.8	-65 to +150	A
DS250	0.250	10 to 39,000	54.0	-65 to +150	A
DG125	0.125	10 to 10,000	60.0	-65 to +125	B
DC125	0.125	10 to 10,000	54.0	-65 to +125	B
DU100	0.125	10 to 10,000	9.0	-65 to +125	B
RTH22ES	0.250	10 to 10,000	34.8	-65 to +150	A
RTH42ES	0.125	10 to 10,000	60.0	-65 to +125	B

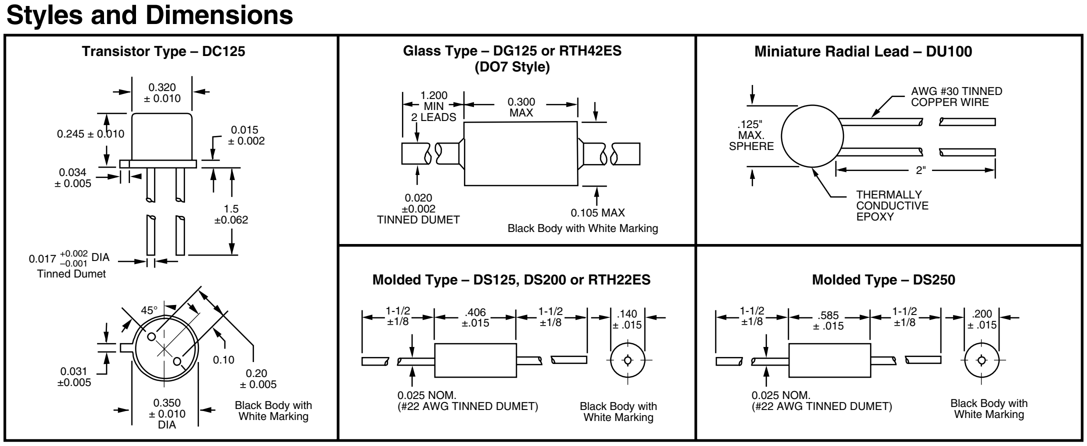
MIL-Approved Series

RTI Electronics' PTC thermistors are designed and built to withstand all environmental conditions required by the most stringent Mil specs. They meet or exceed all requirements of MIL-T-23648 for positive temperature coefficient thermistors.

RTH42ES - Per MIL-T-23648/19. Glass, hermetically sealed type, similar to DG125 series.

RTH22ES - Per MIL-T-23648/9. Molded style, similar to DS200 series.

Styles and Dimensions



Temperature vs Coefficient of Resistance Tables

Table A

TEMP. °C	Resistance Ranges @ 25 °C: 10 to 75	82 to 160	180 to 620	680 to 1800	2000 to 12,000	15,000 to 39,000
-55	0.615	0.582	0.560	0.550	0.515	0.481
-15	0.790	0.770	0.755	0.740	0.730	0.712
0	0.863	0.847	0.838	0.835	0.825	0.814
25	1.000	1.000	1.000	1.000	1.000	1.000
50	1.160	1.170	1.180	1.200	1.230	1.210
75	1.350	1.370	1.400	1.420	1.450	1.430
100	1.545	1.584	1.623	1.656	1.670	1.670
125	1.750	1.800	1.860	1.920	1.960	N/A

Table B

TEMP. °C	Resistance Ranges @ 25 °C (ohms): 10 to 75	82 to 160	180 to 510	560 to 1300	1500 to 6200	6800 to 10,000
-55	0.615	0.582	0.560	0.550	0.515	0.510
-15	0.790	0.770	0.755	0.740	0.730	0.730
0	0.863	0.847	0.838	0.835	0.825	0.825
25	1.000	1.000	1.000	1.000	1.000	1.000
50	1.160	1.170	1.180	1.200	1.230	1.190
75	1.350	1.370	1.400	1.420	1.450	1.400
100	1.545	1.584	1.623	1.656	1.670	1.610
125	1.750	1.800	1.860	1.920	1.960	1.830

Standard Resistance Values (Ohms)

10	56	390	2,200
12	68	470	2,700
15	82	500	3,300
18	100	560	3,900
22	120	680	4,700
27	150	820	5,000
33	180	1,000	5,600
39	220	1,200	6,800
47	270	1,500	8,200
50	330	1,800	10,000

Table C

Tolerance at Temperatures Other Than 25°C

Temp. (°C)	±5% (J)*	±10% (K)*
-55	± 20	± 25
-15	± 13	± 18
0	± 7	± 12
50	± 7	± 12
75	± 9	± 14
100	± 12	± 17
125	± 15	± 20

*Tolerance @ 25°C

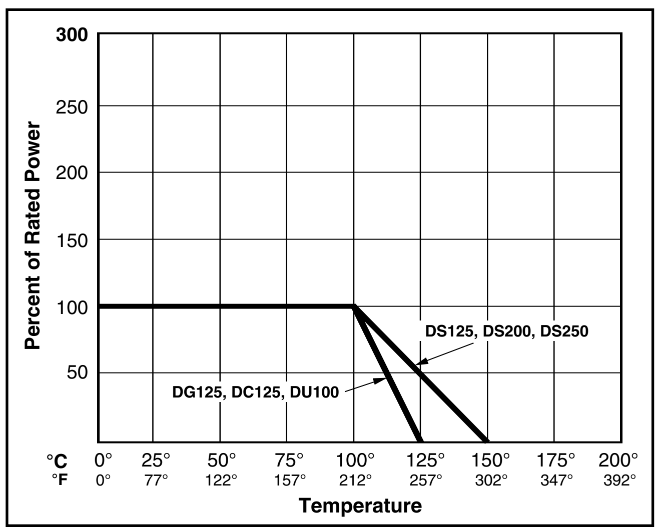
The tables above will give the resistance value of the thermistor for the listed temperatures (R_T). To determine the resistance value of the thermistor at temperature (R_T):

Find the temperature in the vertical column, "Temp. °C". Next find the resistance range of the thermistor at 25°C, (R_{25}°C), in the appropriate vertical column. The intersection of the two columns will give the "coefficient of resistance", (Rc), of the thermistor at the desired temperature. Compute as follows:

$$R_T = R_{25}°C \times Rc$$

Resistance tolerances for temperatures other than 25°C are shown in "Table C". For instance, the resistance tolerance at +50°C for a Silicon PTC Thermistor with a tolerance of ± 5% @ 25°C would be ± 7%.

Recommended Derating Curve



Ordering Information

RTI Electronics' part number consists of a multi-digit alphanumeric code. The example shown here: DG125 122K is the DG125 with a resistance value of 1200 ohms and a tolerance of ±10%.

Contact factory for more information.

DG125 12 2 K

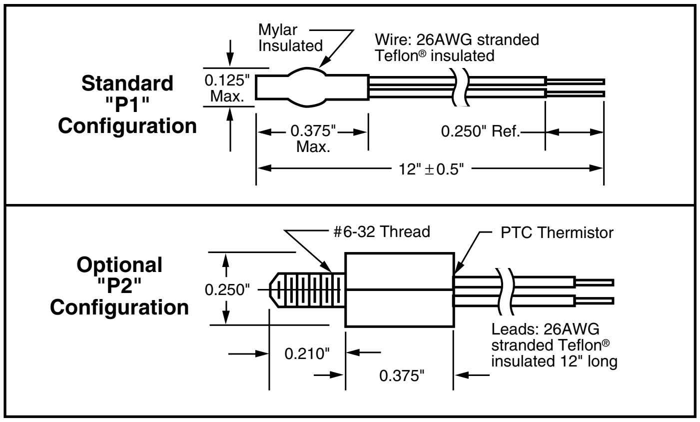
- Style designation — DG125
- First two resistance digits — 12
- Number of zeros — 2
- Tolerance: F = 1% • G = 2% • J = 5% • K = 10%
  10% is standard tolerance

PTC THERMISTOR PROBES

RTI Electronics produces a wide variety of PTC thermistor probes suitable for numerous applications including liquid level and air flow sensing as well as temperature sensing of electric motors, transformers, transistors, heat sinks, chassis, liquids and gases.

Options

- **Custom Lead Lengths**
- **Special Wire Types**
- **Special Probe Housings**
- **Non-Standard Resistance Values**
- **Non-Standard Switch Temperatures**



Part Numbers*	Resistance Rmax @ 25°C (Ohms)	Switch Temp. Ts (°C)	Rmax@ (Ts-6) (Ohms)	Rmin@ (Ts+6) (Ohms)	Rmin@ (Ts+15) (Ohms)	Maximum Voltage Rating**	Maximum Operating Temp. (°C)	Dissipation Constant (mW/°C)	Time Constant (Sec.)
SL0403C-251 -070P1	500	70	1000	2500	7500	35	160	4	10
SL0403C-251 -080P1	500	80	1000	2500	7500	35	160	4	10
SL0403C-251 -090P1	500	90	1000	2500	7500	35	160	4	10
SL0403C-251 -100P1	500	100	1000	2500	7500	35	160	4	10
SL0403C-251 -110P1	500	110	1000	2500	7500	35	160	4	10
SL0403C-251 -120P1	500	120	1000	2500	7500	35	160	4	10
SL0403C-251 -130P1	500	130	1000	2500	7500	20	200	4	10
SL0403C-251 -140P1	500	140	1000	2500	7500	20	200	4	10
SL0403C-251 -150P1	500	150	1000	2500	7500	20	200	4	10

*To specify optional configuration substitute P2 suffix for P1 in part number. Optional configuration not available with switch temp. above 130°C.
**Maximum voltage rating for P2 configuration is 20 volts.

Special Applications

Thermistor Probes & Assemblies

PROBES & ASSEMBLIES

RTI Electronics has extensive experience in designing thermistors to suit the specific needs of users for a wide range of applications. RTI Electronics has produced components from simple consumer sensors to hybrid substrates for critical satellite applications.

RTI Electronics application engineers are available to work with customers in order to provide custom designs with the proper resistance properties, response times, sizes and other application specific requirements.

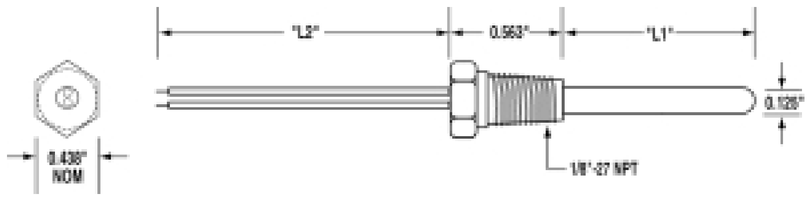
Customized thermistor products are subject to the same exacting quality controls as are standard products, assuring high reliability, stability and precision designed into each product.

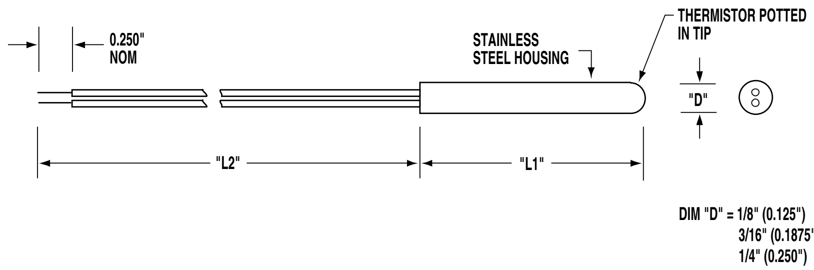
RTI Electronics thermistors can be supplied in networks of two or more units to accomplish specific application tasks. They can be connected in series or parallel, depending on the requirements of the specific application.

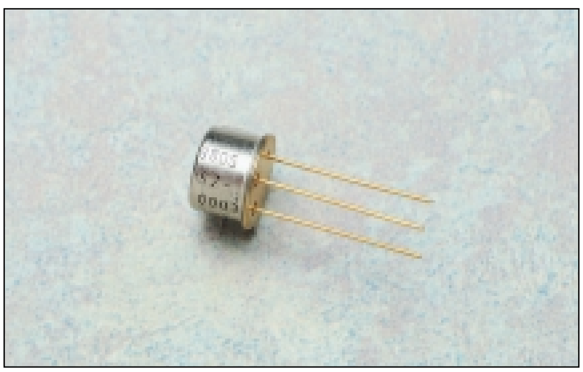
RTI Electronics has also designed and produced a variety of probes and assemblies for a broad range of temperature measurement and controls applications. These probes can be ultra miniature chip probes or large units with thermowells, special leads and cable assemblies or standard screw mount fixtures.

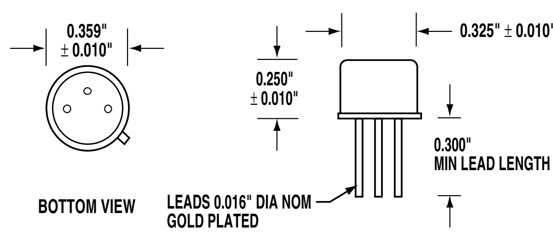
For difficult environments, such as liquid submersion, chemical media, et. al., consult RTI Electronics' engineering staff for recommendations on thermistor housings and critical physical properties.

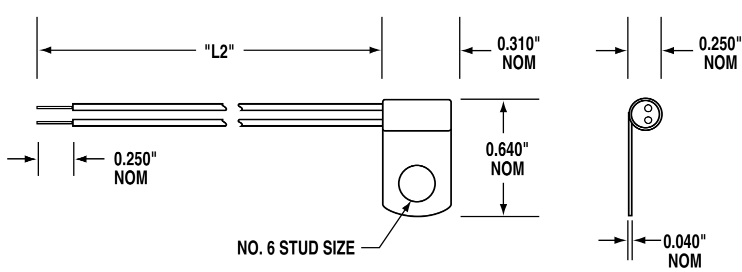
Probe Diagrams





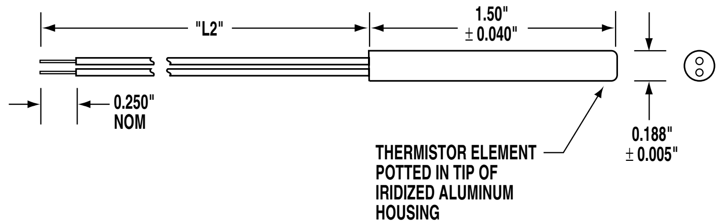


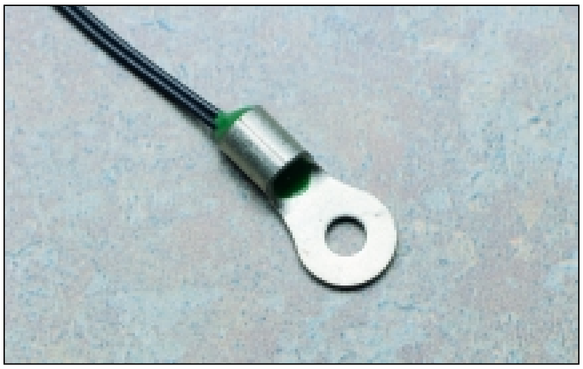


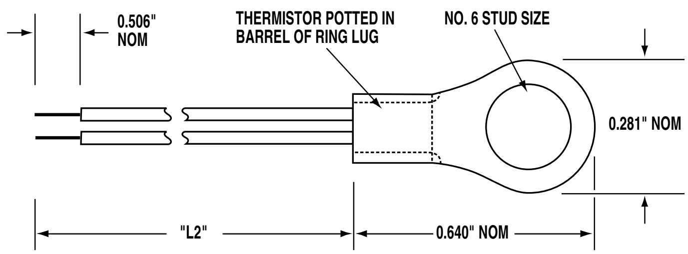


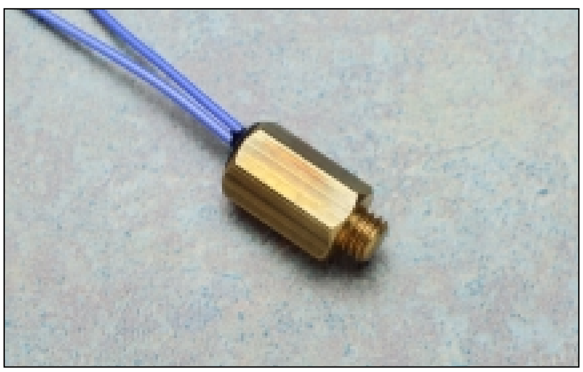
For the recommended dimension designators, "L1", "L2" and "D".
Please contact RTI Electronics applications engineering for assistance.

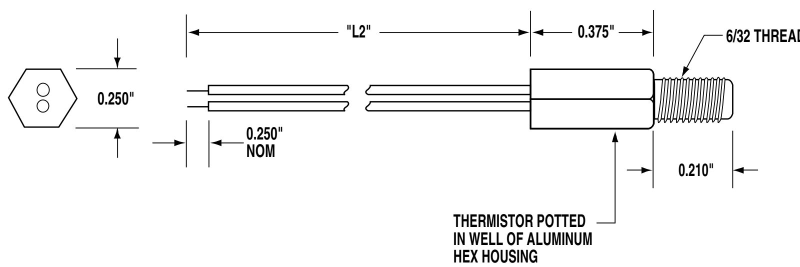
Probe Diagrams

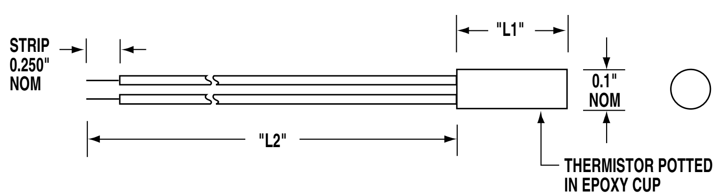












For the recommended dimension designators, "L1", "L2" and "D".
Please contact RTI Electronics applications engineering for assistance.

Thermistor Glossary

Accu-Curve™: Accu-Curve™ is the trademark name for RTI's NTC precision interchangeable thermistors.

Alpha (α): See Temperature coefficient of resistance (alpha, α).

Beta (β): See Material constant (Beta, β).

Curie point: See Switch temperature (Ts).

Current-time characteristic: The current-time characteristic is the relationship at a specified ambient temperature between the current through a thermistor and time, upon the application or interruption of voltage to it.

D.C.: See Dissipation constant (D.C. or delta, δ).

Delta (δ): See Dissipation constant (D.C.) or delta, δ).

Dissipation constant (D.C. or delta δ): The dissipation constant is the ratio, normally expressed in milliwatts per degree C (mw/°C), at a specified ambient temperature, of a change in power dissipation in a thermistor to the resultant body temperature change.

Heat capacity (H_c): The heat capacity of a thermistor is the amount of heat required to increase the body temperature of it by one degree centigrade (1°C). Heat capacity is a common rating of standard PTC thermistors and is expressed in watt-second per cubic inch per degree C (watt-sec/in^3/°C). The heat capacity per unit volume relationship of standard PTC thermistors is approximately 50 watt-sec/in^3/°C.

H_c: See Heat capacity (H_c)

I_{cc}: See Maximum continuous current (I_{cc}).

I_{max}: See Maximum steady-state current (I_{max}).

Inrush current: Inrush current is the initial surge of current that results when power is first applied to a load having a low starting impedance, such as a discharged capacitor, a cold lamp filament, or a stopped motor's winding.

Inrush current limiter: Specially designed and constructed NTC thermistors may be used as inrush current limiters. RTI Surge-Gard™ inrush current limiters are available in a wide range of current handling and zero-power resistance value combinations.

I_s: See Minimum switching current (I_s).

Material constant (Beta , β): The material constant of a NTC thermistor is a measure of its resistance at one temperature compared to its resistance at a different temperature. Its value may be calculated by the formula shown below and is expressed in degrees kelvin (°K). The reference temperatures used in this formula for determining material constant ratings of RTI thermistors are 298.15°K and 348.15°K.

$$\beta = \ln (R @ T2/R @ T1) / (T2^{-1} - T1^{-1})$$

Maximum continuous current (I_{cc}): The maximum continuous current is the amount of current, normally expressed in amperes (A), that a standard PTC thermistor must be capable of conducting without switching into its high resistance state.

Maximum operating temperature: The maximum operating temperature is the maximum body temperature at which a thermistor will operate for a extended period of time with acceptable stability of its characteristics. This temperature is the result of internal or external heating, or both, and should not exceed the maximum value specified.

Maximum power rating: The maximum power rating of a thermistor is the maximum power, expressed in watts or milliwatts (W or mW), which a thermistor will dissipate for an extended period of time with acceptable stability of its characteristics.

Maximum steady-state current (Imax): The maximum steady-state current is the rating of the maximum current, normally expressed in amperes (A), allowable to be conducted by an inrush limiting NTC thermistor for an extended period of time.

Maximum surge current: The maximum surge current is the maximum permissible surge current in a circuit and, in conjunction with the maximum peak voltage, determines the minimum required zero-power resistance of the Surge-Gard™ thermistor required to limit it adequately. See inrush current.

Maximum operating voltage (V_{max}): The maximum operating voltage is the maximum rated voltage, either direct current or 60 Hz RMS alternating current, expressed in volts (VDC or VAC), that a standard PTC thermistor will continuous withstand for an extended period without affecting its normal characteristics.

MIL-T-23648: MIL-T-23648 is the U.S. military's general specification for thermistors.

Minimum switching current (I_s): The minimum switching current is the minimum amount of current, normally expressed in amperes (A), that, when conducted by a standard PTC thermistor, is required to cause it to switch to its high resistance state.

Mini-Sensor™: Mini-Sensor™ is the trademark name for RTI miniature glass encapsulated thermistors.

Negative temperature coefficient (NTC): A NTC thermistor is one whose zero-power resistance decreases with an increase in temperature.

NTC: See Negative temperature coefficient (NTC).

Positive temperature coefficient (PTC): A PTC thermistor is one whose zero-power resistance increases with an increase in temperature.

PTC: See Positive temperature coefficient (PTC)

Recovery time: The recovery time of a thermistor is the approximate time required for it to cool sufficiently after power is removed and allow it to provide the characteristics required when power is reapplied.

Resistance at maximum current (RI_{max}) The resistance at maximum current is the approximate resistance of an inrush current limiting thermistor, expressed in ohms (Ω), when it is conducting its rated maximum steady-state current.

Resistance ratio characteristic: The resistance ratio characteristic identifies the ratio of the zero-power resistance of a thermistor measured at one temperature to that resistance measured at a different temperature. The resistance ratio characteristic specified in military specification MIL-T-23648 is the resistance measured at 25°C divided by the resistance measured at 125°C.

Resistance-temperature characteristic: The resistance temperature characteristic is the relationship between the zero-power resistance of a thermistor and its body temperature.

RI_{max}: See Resistance at maximum current (RI_{max}).

R_t: See Zero-power resistance (R_t or R_o).

R_o: See Zero-power resistance (R_t or R_o).

Silicon PTC thermistor: A silicon PTC thermistor is a type PTC thermistor that has an approximately linear resistance-temperature characteristic and a temperature coefficient of resistance of approximately +0.7%/°C. Silicon PTC thermistors are distinguished from standard PTC thermistors.

Stability: The stability of a thermistor is the ability of it to retain specified characteristics after being subjected to designated environmental or electrical test conditions.

Standard PTC thermistor: A standard PTC thermistor is a type of PTC thermistor that has a switch temperature. Standard PTC thermistors are distinguished from silicon PTC thermistors.

Standard reference temperature: The standard reference temperature is the thermistor body temperature at which nominal zero-power resistance is specified and is usually 25°C.

Static voltage-current curve: The static voltage-current (V/I) curve defines the relationship between voltage and current at any point of equilibrium for a standard PTC thermistor.

Surge-Gard™: Surge-Gard™ is the trademark name for RTI inrush current limiting thermistors.

Switch temperature (T_s): The switch temperature is the temperature of a standard PTC thermistor at which its resistance begins to increase very rapidly. The typical specification for RTI standard PTC thermistors rates their resistance at their switch temperature as two times their zero-power resistance at 25°C. Switch temperature is sometimes also identified as transition temperature or Curie point.

Tau (τ): See Thermal time constant (T.C. or tau, τ).

T.C.: See Thermal time constant (T.C. or tau, τ).

Temperature coefficient of resistance (alpha, α): The temperature coefficient of resistance is the ratio at a specified temperature, T, of the rate of change of zero-power resistance with temperature to the zero-power resistance of the thermistor. The temperature coefficient is commonly expressed in percent per degree C (%/°C).

$$\alpha T = \frac{(dR_T)}{(d_T)}$$

T_s: See Switch temperature (T_s).

Temperature-wattage characteristic: The temperature-wattage characteristic of a thermistor is the relationship at a specified ambient temperature between the thermistor temperature and the applied steady-state wattage.

Thermal time constant (T.C. or tau, τ): The thermal time constant is the time required for a thermistor to change 63.2 percent of the total difference between its initial and final body temperature when subjected to a step function change in temperature under zero-power conditions and is normally expressed in seconds.

Thermistor: A thermistor is a thermally sensitive resistor whose primary function is to exhibit a change in electrical resistance with a change in body temperature.

Transition temperature: See Switch temperature (T_s).

V_{max}: See Maximum operating voltage (V_{max}).

Zero-power resistance (R_t or R_o): The zero-power resistance is the direct current resistance value of a thermistor measured at a specified temperature, T, with a power dissipation by the thermistor low enough that any further decrease in power will result in not more than 0.1 percent (or 1/10 of the specified measurement tolerance, whichever is smaller) change in resistance.

Standard PTC Thermistor Applications

GENERAL NOTES

The applications of standard PTC thermistors can be classified in two main groups.

1. Applications where the temperature of the PTC is primarily determined by the temperature of the surrounding environment.

2. Applications where the temperature of the PTC is primarily determined by the electrical power dissipated by the device.

The first group includes applications such as temperature measurement, temperature control, temperature compensation and over-temperature protection.

The second group includes applications such as over-current protection, liquid level detection, air flow detection, time delay, constant current and constant temperature applications.

Do not apply voltage exceeding Vmax to the PTC device. Doing so may destroy the thermistor. Although several PTC's may be connected in series for temperature sensing applications, do not connect PTC thermistors in series in order to obtain higher voltage ratings. Since no two devices are exactly the same, one would tend to heat faster than the others thereby limiting the current flow through the other devices and resulting in the entire voltage available being dropped across the single device.

PTC's may, however, be connected in parallel to increase the current ratings in current limiting applications. RTI Electronics' engineers specialize in the development of state-of-the-art devices for the most demanding applications. If you have a unique application which requires a part not listed in this catalog, please contact our applications engineering staff.

APPLICATIONS

Over-Current Protection

The voltage-current characteristic curve of the PTC thermistor makes it an ideal candidate as a short circuit or over-current protective device. The PTC is connected in series with the load (Figure 8) which is to be protected.

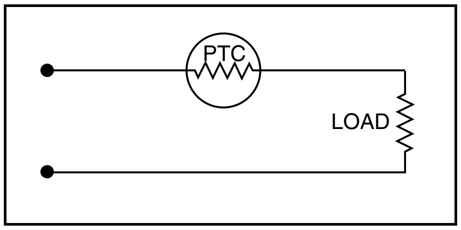


Figure 8

During normal operating conditions, the PTC remains in its low resistance state resulting in negligible attenuation to current flow. This is illustrated by the solid line in Figure 9. When a short circuit or over-current condition occurs, the PTC will switch into its high resistance state thereby limiting the current flow in the circuit to a point well below the normal operating level. This is illustrated by the dotted line in Figure 9. When the fault condition is removed, the PTC will return to its low resistance state allowing the current flow to recover to its normal level.

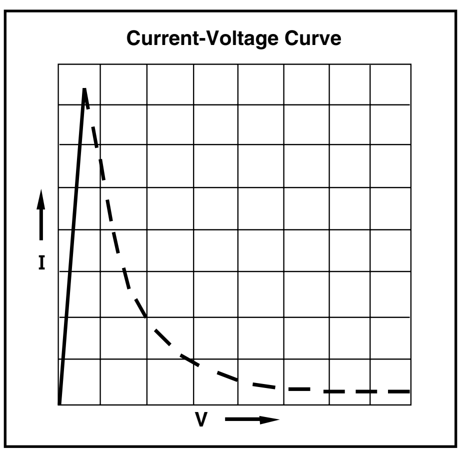
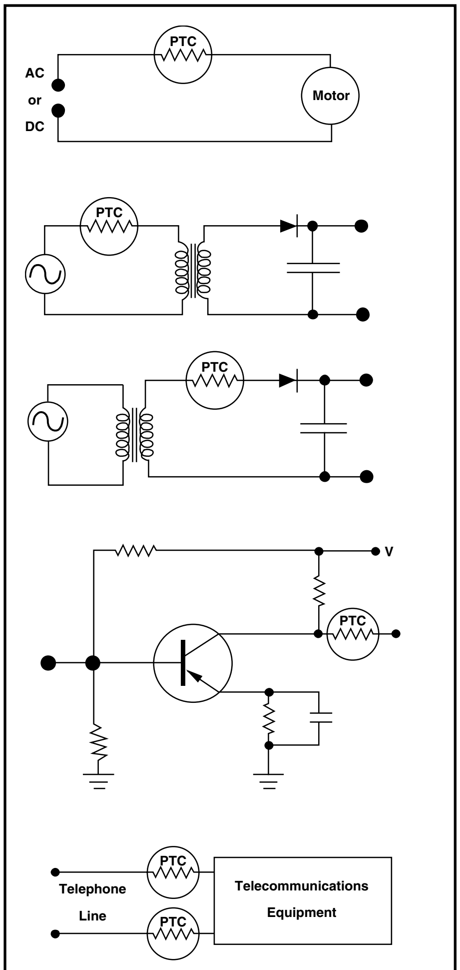


Figure 9

Figure 10 illustrates a few of the numerous applications for over-current protectors.



Over-Current Protection
PTC's sense over-current conditions in various applications.

Figure 10

Temperature Sensing

The typical standard PTC has an extremely high temperature coefficient of resistance at and above the switch temperature. This characteristic makes it ideal for various temperature sensing applications, especially over-temperature detection.

RTI Electronics manufactures units specifically designed for sensing the temperature of various devices including power transistors, heat sinks, motor windings, transformers, etc. Figure 11 illustrates some of the applications.

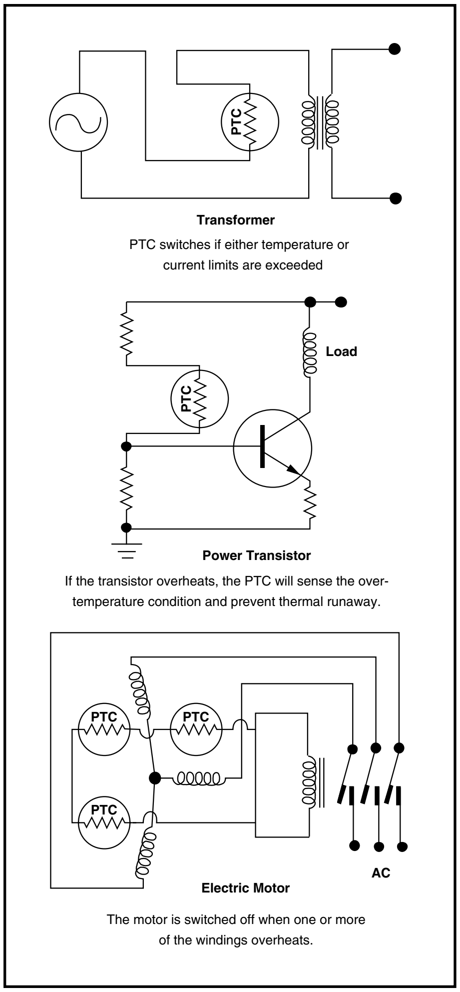


Figure 11

Self-Regulating Heating

A unique characteristic of PTC's is their ability, when self-heated above their switch temperature, to maintain a nearly constant temperature regardless of large fluctuations in ambient temperature or voltage applied. RTI Electronics produces devices specifically designed for self-regulating heater applications such as temperature control of crystals, oscillators and liquid crystal displays (LCD's).

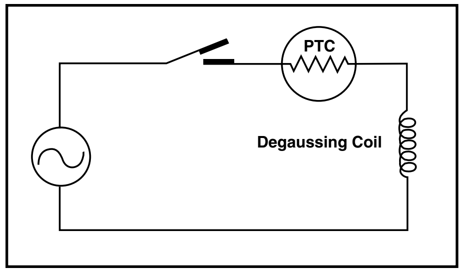


Figure 12

Automatic Degaussing

Figure 12 shows a PTC in series with a degaussing coil for a CRT in a color television or monitor. When the switch is closed, the low initial resistance of the PTC allows high inrush current to flow. After a short period of time, the PTC switches to its high resistance state thereby reducing the current to a negligible level as illustrated in Figure 13.

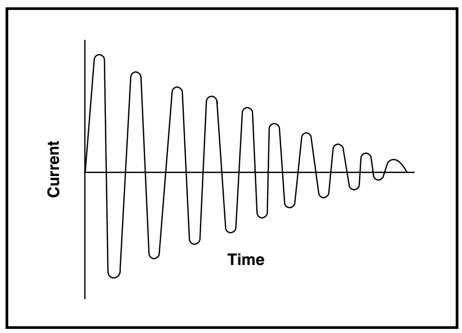


Figure 13

The amount of time required for the PTC to switch into its high resistance state is approximated by the following equation:

$$\text{Time (seconds)} = \frac{He\,(Ts - Ta)}{Po}$$

Where: He = Heat capacity wan-sec./°C
Ts = Switch temperature (°C)
Ta = Ambient temperature(°C)
Po = Initial power applied (watts)

EQUATION C

Motor Starting

Figure 14 shows a PTC in series with the starting winding in a single phase electric motor. The low initial resistance of the PTC allows sufficient current to flow through the starting winding until the motor starts. The PTC then switches to its high impedance state reducing current flow through the starting winding to near zero. The switch time can be approximated by equation C.

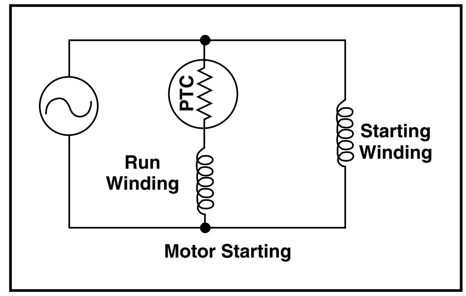


Figure 14

Time Delay

In Figure 1 5-A the PTC is in series with the relay coil. When the switch is closed, the relay will energize instantaneously and remain energized until the PTC switches to its high resistance state.

In Figure 15-B the PTC is in parallel with the relay coil.. When the switch is closed, the relay will not energize until the PTC switches to its high resistance state.

The time required for the PTC to switch to its high resistance state can be approximated by equation C.

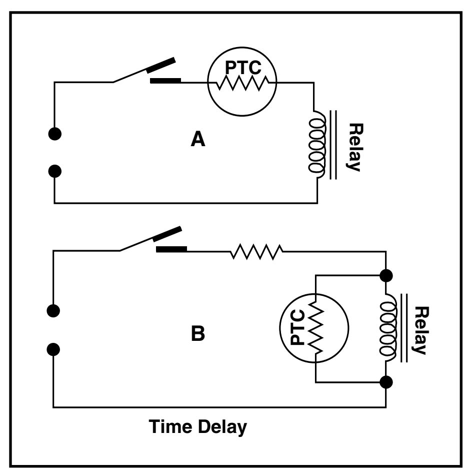


Figure 15

Liquid Level/Air Flow

The dissipation constant of PTC's vary proportionately to the thermal conductivity of their environment. Figure 16 shows the steady-state current-voltage curve of a RTI Electronics PTC subjected to various environmental conditions. This property makes them ideal devices for sensing liquid level or air flow. See Figure 17.

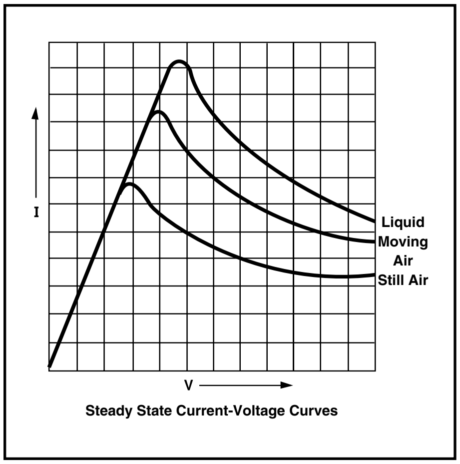


Figure 16

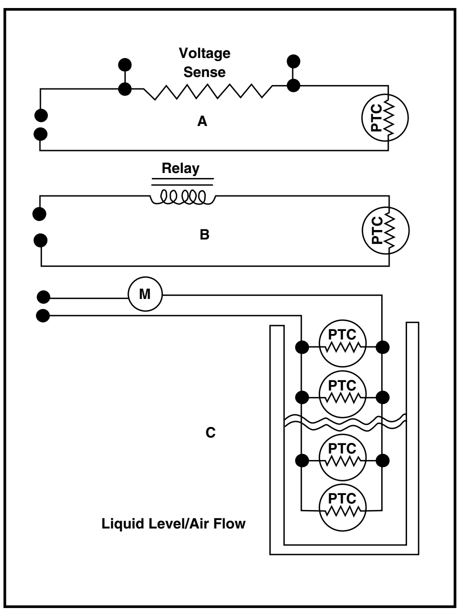


Figure 17

Constant Current

Figure 18 shows a standard PTC in a constant current circuit. If the applied voltage (Vapp) varies, the resistance of the PTC will change to compensate for this variation, resulting in nearly constant current through the load.

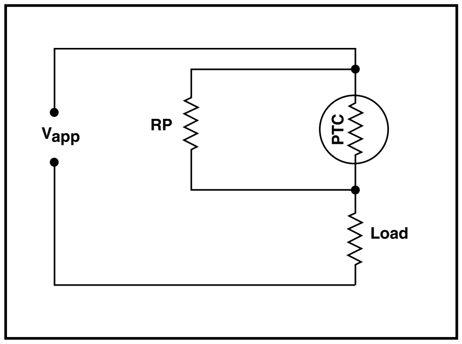


Figure 18

Temperature Compensation and Measurement

RTI Electronics PTC's are generally designed to exhibit sharp increases in resistance at and above the switch temperature. However, PTC's with nearly linear resistance-temperature characteristics are available for temperature compensation and temperature measurement applications. If your application requires such a device, please contact RTI Electronics' Applications Engineering Department. RTI Electronics engineers have many years of experience in solving complex temperature compensation and measurement problems.

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