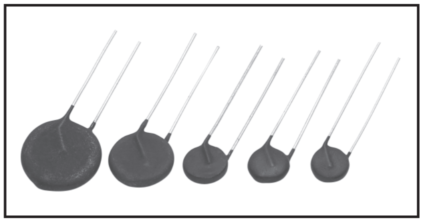
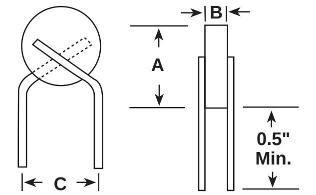
NTC Thermistors



TYPICAL APPLICATIONS

- Temperature measurement.
- Temperature control.
- Inrush current limiting.
- Temperature compensation.
- Sensing liquid level or air flow.



DIMENSIONAL CONFIGURATIONS

STANDARD ELECTRICAL SPECIFICATIONS

PART NUMBER	BASE RESISTANCE R_o @ 25°C (Ω) ± 10%	TCR @ 25°C (%/°C) (Curve)	DISSIPATION CONSTANT Dc (mW/°C)	TIME CONSTANT Tc (Sec)	BODY TYPE	REFERENCE DIMENSIONS (inches)			
						A	B	C	Lead AWG #
DN5004D2R5K	2.50		14.00	60.00	DISC	0.500	0.040	0.30	22.00
DN4005D5R0K	5.00		9.00	50.00	DISC	0.400	0.050	0.30	22.00
DN3003D5R0K	5.00		8.00	35.00	DISC	0.300	0.030	0.20	24.00
DN4008D7R5K	7.50		9.00	65.00	DISC	0.400	0.080	0.30	22.00
DN3005D7R5K	7.50		8.00	42.00	DISC	0.300	0.045	0.20	24.00
DN3508D100K	10.00		9.00	60.00	DISC	0.350	0.080	0.25	22.00
DN2304D100K	10.00		7.00	22.00	DISC	0.225	0.035	0.20	24.00
DN2707D150K	15.00		8.50	55.00	DISC	0.270	0.070	0.20	24.00
DN2004D150K	15.00		7.00	20.00	DISC	0.200	0.040	0.20	24.00
DN2508D200K	20.00		8.00	45.00	DISC	0.250	0.080	0.20	24.00
DN2005D200K	20.00	- 3.3 (D)	7.00	25.00	DISC	0.200	0.050	0.20	24.00
DN1705D250K	25.00		7.00	19.00	DISC	0.170	0.050	0.20	24.00
DN2008D300K	30.00		7.00	25.00	DISC	0.200	0.080	0.20	24.00
DN1708D400K	40.00		7.00	22.00	DISC	0.170	0.075	0.20	24.00
DN1104D400K	40.00		2.50	4.00	CHIP	0.110	0.040	—	28.00
DN1004D500K	50.00		2.50	4.00	CHIP	0.100	0.040	—	28.00
DN0804D400K	80.00		2.00	4.00	CHIP	0.080	0.040	—	28.00
DN0704D101K	100.00		2.00	4.00	CHIP	0.070	0.040	—	28.00
DN0503D151K	150.00		2.00	3.00	CHIP	0.050	0.040	—	28.00
DN0504D201K	200.00		2.00	3.00	CHIP	0.050	0.030	—	28.00
DN0404D301K	300.00		2.00	2.00	CHIP	0.040	0.040	—	28.00
DN0407D501K	500.00		2.00	2.00	CHIP	0.040	0.070	—	28.00
DN5004A250K	25.00		14.00	60.00	DISC	0.500	0.040	0.30	22.00
DN4005A500K	50.00		9.00	50.00	DISC	0.400	0.055	0.30	22.00
DN3003A500K	50.00		8.00	48.00	DISC	0.350	0.040	0.20	24.00
DN4008A750K	75.00		9.00	65.00	DISC	0.400	0.080	0.30	22.00
DN3005A750K	75.00		8.00	42.00	DISC	0.300	0.045	0.20	24.00
DN3508A101K	100.00		9.00	60.00	DISC	0.350	0.080	0.20	22.00
DN2304A101K	100.00		7.00	22.00	DISC	0.225	0.035	0.20	24.00
DN2707A151K	150.00	- 3.9 (A)	8.50	55.00	DISC	0.270	0.070	0.20	24.00
DN2004A151K	150.00		7.00	20.00	DISC	0.200	0.040	0.20	24.00
DN2508A201K	200.00		8.00	45.00	DISC	0.250	0.080	0.20	24.00
DN2005A201K	200.00		7.00	25.00	DISC	0.200	0.055	0.20	24.00
DN2008A301K	300.00		7.00	25.00	DISC	0.200	0.080	0.20	24.00
DN1104A401K	400.00		2.50	4.00	CHIP	0.110	0.040	—	28.00
DN1004A501K	500.00		2.50	4.00	CHIP	0.100	0.040	—	28.00
DN0904A601K	600.00		2.00	4.00	CHIP	0.090	0.040	—	28.00

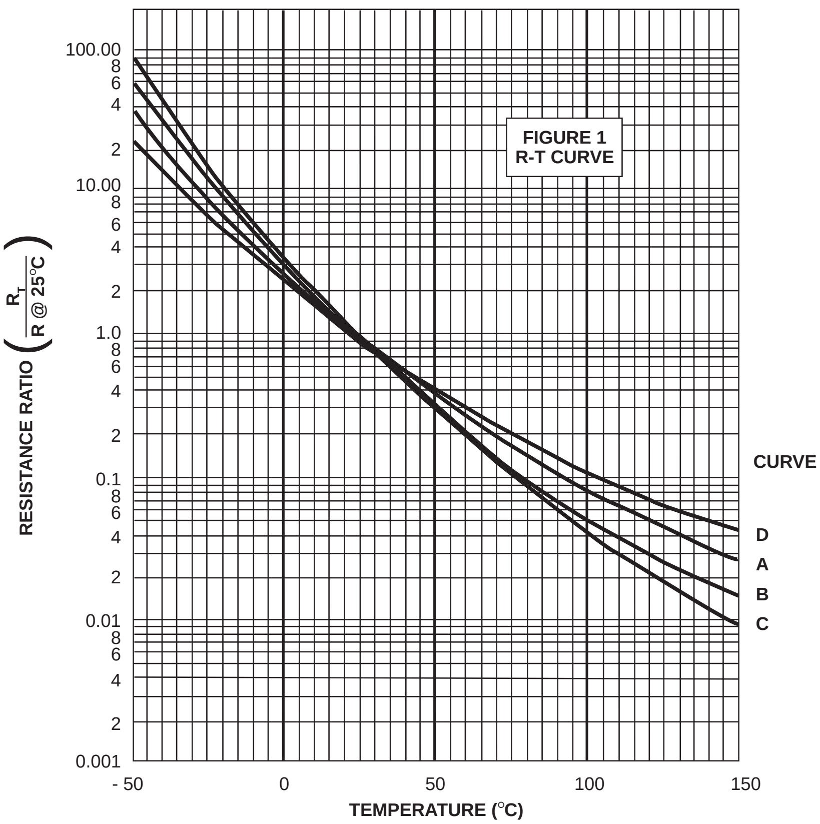
STANDARD ELECTRICAL SPECIFICATIONS

PART NUMBER	BASE RESISTANCE R_o @ 25°C (Ω) ± 10%	TCR @ 25°C (%/°C) (Curve)	DISSIPATION CONSTANT Dc (mW/°C)	TIME CONSTANT Tc (Sec)	BODY TYPE	REFERENCE DIMENSIONS (inches) A	B	C	Lead AWG #
DN0804A801K	800.00	- 3.9 (A)	2.00	4.00	CHIP	0.080	0.045	—	28.00
DN0704A102K	1000.00		2.00	4.00	CHIP	0.070	0.040	—	28.00
DN0503A152K	1500.00		2.00	3.00	CHIP	0.055	0.040	—	28.00
DN0504A202K	2000.00		2.00	3.00	CHIP	0.050	0.040	—	28.00
DN0404A302K	3000.00		2.00	2.00	CHIP	0.040	0.040	—	28.00
DN0406A402K	4000.00		2.00	2.00	CHIP	0.040	0.055	—	28.00
DN0407A502K	5000.00		2.00	2.00	CHIP	0.040	0.070	—	28.00
DN5005B201K	200.00	- 4.4 (B)	14.00	60.00	DISC	0.500	0.050	0.30	22.00
DN4004B251K	250.00		9.00	50.00	DISC	0.400	0.040	0.30	22.00
DN3506B501K	500.00		9.00	55.00	DISC	0.350	0.060	0.30	22.00
DN3004B501K	500.00		8.00	35.00	DISC	0.300	0.040	0.20	24.00
DN3308B751K	750.00		8.00	52.00	DISC	0.330	0.080	0.25	22.00
DN2701B751K	750.00		8.00	33.00	DISC	0.270	0.050	0.20	24.00
DN2707B102K	1000.00		8.00	38.00	DISC	0.270	0.070	0.20	24.00
DN2004B102K	1000.00		7.00	22.00	DISC	0.200	0.040	0.20	24.00
DN1704B152K	1500.00		7.00	20.00	DISC	0.170	0.040	0.20	24.00
DN2008B202K	2000.00		7.00	26.00	DISC	0.200	0.080	0.20	24.00
DN1204B202K	2000.00		3.00	6.00	CHIP	0.120	0.035	—	28.00
DN1004B302K	3000.00		3.00	5.00	CHIP	0.100	0.035	—	28.00
DN0804B502K	5000.00		3.00	5.00	CHIP	0.080	0.040	—	28.00
DN0804B602K	6000.00		2.00	4.00	CHIP	0.075	0.040	—	30.00
DN0704B802K	8000.00		2.00	3.00	CHIP	0.065	0.040	—	30.00
DN0605B103K	10,000.00		2.00	3.00	CHIP	0.060	0.045	—	30.00
DN0607B153K	15,000.00		2.00	4.00	CHIP	0.060	0.065	—	30.00
DN0607B203K	20,000.00		2.00	4.00	CHIP	0.055	0.070	—	30.00
DN5005C202K	2000.00	- 4.9 (C)	14.00	60.00	DISC	0.500	0.050	0.30	22.00
DN4004C252K	2500.00		9.00	50.00	DISC	0.400	0.040	0.30	22.00
DN3004C502K	5000.00		8.00	35.00	DISC	0.300	0.040	0.20	24.00
DN3308C752K	7500.00		8.00	52.00	DISC	0.330	0.080	0.25	22.00
DN2705C752K	7550.00		8.50	33.00	DISC	0.270	0.050	0.20	24.00
DN2707C103K	10,000.00		8.00	38.00	DISC	0.270	0.070	0.20	24.00
DN2004C103K	10,000.00		7.00	22.00	DISC	0.200	0.040	0.20	24.00
DN2008C203K	20,000.00		7.00	26.00	DISC	0.200	0.080	0.20	24.00
DN1204C203K	20,000.00		3.00	6.00	CHIP	0.120	0.035	—	28.00
DN1104C253K	25,000.00		3.00	6.00	CHIP	0.110	0.035	—	28.00
DN1004C303K	30,000.00		3.00	5.00	CHIP	0.100	0.035	—	28.00
DN0804C503K	50,000.00		3.00	5.00	CHIP	0.080	0.040	—	28.00
DN0804C603K	60,000.00		2.00	4.00	CHIP	0.075	0.040	—	30.00
DN0704C803K	80,000.00		2.00	3.00	CHIP	0.065	0.040	—	30.00
DN0605C104K	100,000.00		2.00	3.00	CHIP	0.060	0.045	—	30.00
DN0607C154K	150,000.00		2.00	4.00	CHIP	0.060	0.065	—	30.00
DN0607C204K	200,000.00		2.00	4.00	CHIP	0.055	0.070	—	30.00
DN0507C304K	300,000.00		2.00	4.00	CHIP	0.045	0.070	—	30.00
DN0408C404K	400,000.00		2.00	4.00	CHIP	0.040	0.075	—	30.00
DN0410C504K	500,000.00		2.00	5.00	CHIP	0.040	0.095	—	30.00

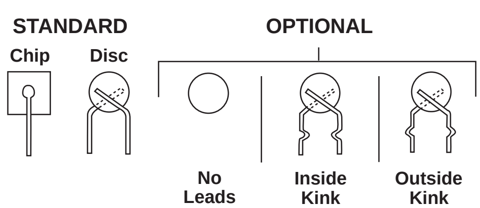
STANDARD NTC CURVE CHARACTERISTICS

CURVE		D		A		B		C	
BETA IN K 25/75 (°C)		2925 ± 225		3545 ± 150		3965 ± 125		4500 ± 200	
RESIS. RATIO 0/50°C		5.15 ± 8%		7.04 ± 5%		9.1 ± 5%		11.8 ± 6%	
RESIS. RATIO 25/125°C		11.8 ± 15%		19.80 ± 10%		29.4 ± 10%		48.7 ± 10%	
TCR @ 25°C (%/°C)		- 3.3		- 3.9		- 4.4		- 4.9	
TEMPERATURE		R-T CURVE	TCR (%/°C)	R-T CURVE	TCR (%/°C)	R-T CURVE	TCR (%/°C)	R-T CURVE	TCR (%/°C)
°F	°C								
- 58.00	- 50.00	23.62	5.400	40.06	6.100	67.06	7.20	98.20	7.40
- 49.00	- 45.00	18.13		29.62		47.81		67.83	
- 40.00	- 40.00	14.05	5.050	22.06	5.900	34.01	6.70	47.34	7.00
- 31.00	- 35.00	10.94		16.59		24.49		33.37	
- 22.00	- 30.00	8.623	4.700	12.51	5.500	17.84	6.20	23.76	6.60
- 13.00	- 25.00	6.849		9.633		13.12		17.06	
- 4.00	- 20.00	5.461	4.400	7.431	5.100	9.766	5.80	12.39	6.30
5.00	- 15.00	4.410		5.780		7.331		9.072	
14.00	- 10.00	3.588	4.10	4.534	4.80	5.552	5.50	6.700	5.90
23.00	- 5.00	2.932		3.879		4.246		4.989	
32.00	0.00	2.417	3.80	2.848	4.50	3.269	5.10	3.746	5.60
41.00	5.00	2.002		2.281		2.539		2.835	
50.00	10.00	1.674	3.60	1.844	4.30	1.988	4.80	2.161	5.30
59.00	15.00	1.397		1.494		1.567		1.661	
68.00	20.00	1.194	3.40	1.216	4.00	1.245	4.50	1.284	5.10
77.00	25.00	1.000	3.30	1.000	3.90	1.000	4.40	1.000	4.90
86.00	30.00	0.8575	3.20	0.8260	3.80	0.9052	4.30	0.7844	4.80
95.00	35.00	0.7340		0.6858		0.6526		0.6190	
104.00	40.00	0.6311	3.00	0.5726	3.60	0.5320	4.00	0.4915	4.50
113.00	45.00	0.5419		0.4804		0.4361		0.3926	
122.00	50.00	0.4673	2.85	0.4051	3.40	0.3596	3.80	0.3174	4.30
131.00	55.00	0.4015		0.3425		0.2983		0.2547	
140.00	60.00	0.3512	2.65	0.2915	3.20	0.2485	3.60	0.2069	4.10
149.00	65.00	0.3066		0.2489		0.2076		0.1689	
158.00	70.00	0.2686	2.50	0.2137	3.00	0.1745	3.40	0.1385	3.90
167.00	75.00	0.2365		0.1837		0.1478		0.1142	
176.00	80.00	0.2090	2.35	0.1592	2.90	0.1257	3.30	0.09453	3.70
185.00	85.00	0.1860		0.1385		0.1070		0.07863	
194.00	90.00	0.1660	2.25	0.1206	2.70	0.09146	3.10	0.06568	3.50
203.00	95.00	0.1485		0.1055		0.07856		0.05509	
212.00	100.00	0.1335	2.10	0.09242	2.60	0.06778	2.90	0.04640	3.40
221.00	105.00	0.1210		0.08137		0.05867		0.03923	
230.00	110.00	0.1100	2.00	0.07182	2.50	0.05094	2.80	0.03329	3.30
239.00	115.00	0.1002		0.06367		0.04443		0.02836	
248.00	120.00	0.09211	1.95	0.05653	2.30	0.03884	2.70	0.02424	3.10
257.00	125.00	0.08472	1.90	0.05033	2.30	0.03407	2.60	0.02059	3.00
266.00	130.00	0.07830	1.90	0.04488	2.20	0.02998	2.50	0.01789	3.00
275.00	135.00	0.07246		0.04022		0.02645		0.01545	
284.00	140.00	0.06767	1.80	0.03622	2.10	0.02340	2.40	0.01338	2.90
293.00	145.00	0.06323		0.03267		0.02079		0.01162	
302.00	150.00	0.05912	1.75	0.02679	2.00	0.01847	2.30	0.010110	2.70

STANDARD RESISTANCE RATIO - TEMPERATURE CURVE



CONFIGURATIONS



PACKAGING

— Bulk

HOW TO ORDER

DP2005D200K	- 06
MODEL	MODIFICATION

- 01 No Leads .... Disc/Chip
- 02 Inside Kink .... Disc Only
- 03 Outside Kink .... Disc Only
- 04 Epoxy Coating (150°C Max. Temp.) .... Disc/Chip
- 05 Silicone Coating .... Disc/Chip (200°C Max. Temp.)
- 06 Epoxy/Inside Kink .... Disc Only
- 07 Epoxy/Outside Kink .... Disc Only
- 08 Silicone/Inside Kink .... Disc Only
- 09 Silicone/Outside Kink .... Disc Only

Example: DP2005D200K-06 (standard part with epoxy coating and inside kink leads).

NOTE: If one of the modifications is required, add the dash number listed to the part number (see example). Other options are available including non-standard base resistance values and tolerances.

NTC Thermistors

TYPICAL APPLICATIONS

1. TELECOMMUNICATIONS APPLICATIONS
- Temperature Compensation of Crystal Oscillators (TCXO)
- Gain Stabilization
- Transistor Temperature Compensation
- Ambient Temperature Compensation

2. INDUSTRIAL APPLICATIONS
- Heat Pump Sensors
- Chiller Sensors
- Bearing Overtemp Protection
- Photographic Processing
- Copy Machines
- Gas Analyzers
- pH Monitors
- Compressor Controls
- Differential Temperature Control
- Industrial Process Controls
- Crystal Ovens
- Refrigeration
- Fan Motor Speed Control
- Commercial Vending Machines

3. CONSUMER APPLIANCES
- Thermostats
- Refrigerators
- Air Conditioners
- Dishwashers
- Microwave Meat Probes
- Small Appliances
- Coffee Makers
- Electronic Thermometers
- Energy Efficient Monitors
- Solar Collectors
- Smoke Detectors
- Portable Refrigerators/Food Warmers

4. MEDICAL
- Kidney Dialysis
- Blood Oxygenator
- Blood Analysis Equipment
- Respirators
- Blood Gases Monitors
- Infant Incubators

5. INSTRUMENTATION, COMPUTERS PERIPHERALS
- Oscillator Stabilization
- LCD Compensation
- Thermal Printer Head Control
- Hard Disc Drive Control and Compensation
- Laboratory Grade Temperature Probes
- Compensation of Solid State Circuit Drift
- Solid State Circuit Overtemp Protection
- Thermocouple Cold-Junction Compensation

6. AUTOMOTIVE AND TRANSPORTATION
- Emission Controls
- Coolant Sensors
- Air Temperature Sensors
- Climate Control
- Windshield/Mirror Defroster
- Altimeter
- Oil Temperature Sensor
- Automatic Transmission Temperature Sensor

HOW TO SELECT AN NTC THERMISTOR

1. Dissipation Constant (D.C.)

The dissipation constant is the amount of power (expressed in milliwatts) required to self-heat the thermistor suspended by its two inch leads in still air 1°C above its environment. The dissipation constant of NTC thermistor/NTC thermistor sensor assembly is typically defined as the ratio (at a specified ambient temperature) of the power dissipated in the thermistor to the resultant change in the temperature of the thermistor.

This constant (expressed as the power in milliwatts required to self-heat the thermistor 1°C above ambient temperature) increases slightly with increasing temperature. The lead length and type of lead, the type of encapsulating material (epoxy, Durez, stainless steel probe, thermoplastic probe, etc.) the mounting of the NTC thermistor/assembly, the medium of the surrounding environment (flowing gas, still air, water, oil, etc.) and other factors generally determine the dissipation constant of an NTC thermistor/NTC thermistor sensor assembly.

Given the variables that affect D.C., it is recommended that a prototype should be tested under actual operating conditions to determine the maximum allowable input current. The current through the thermistor must be small enough to produce negligible self-heating error in the thermistor at the maximum measuring or controlling temperature. At the same time, the current should be as large as possible to maximize system sensitivity.

If the rate of heat loss under actual operating conditions could be fixed and was constant from system to system, the D.C. would only be a consideration for determining the maximum power dissipated and an offset allowance could be made. For example, if the D.C. of a thermistor assembly had been determined as 3mW/°C in a stirred oil bath (the medium to be measured) and it was desired to measure the oil bath to an absolute temperature accuracy of ± 0.1°C, the maximum power that should be developed in the thermistor by the measuring current is 0.15mW. This is to keep the self-heat factor to 50% or less of the measurement accuracy.

The formula for this is:

3mW/°C x 0.1°C x 50% = 0.15mW

The D.C. of an NTC thermistor/NTC thermistor assembly can be determined by first measuring the zero-power resistance of the NTC thermistor at two temperature points 10°C to 25°C apart. The thermistor is then placed in series with a variable voltage supply, a current meter, and a sufficiently large enough resistor to prevent too much current flowing through the circuit and allowing the thermistor to "run-away." A high-resistance voltmeter is connected across the thermistor. The power supply is then gradually increased until the voltage across the thermistor and the current through it indicate a resistance equal to the measured resistance at the upper temperature. This is determined by using Ohm's Law E ÷ I = R (E = volts, I = current, R = resistance). The D.C. is then calculated by dividing the power dissipated in the NTC thermistor by the temperature difference between the two measured temperatures. Power is calculated by using Ohm's Law, P = E x I.

2. Time Constant (T.C.)

The time constant is the time in seconds required for the thermistor to change through 63.2% of the difference between its initial and final body temperatures, when subjected to a step change in temperature under zero-power conditions. Since the NTC thermistor's T.C. is determined by the same factors as D.C. (i.e., encapsulation, mounting, lead length, etc.), a prototype should be built if T.C. is important.

The time constant is determined by measuring the resistance of the thermistor at three temperature points, the middle point being 63.2% of the difference between the upper one and the lower one. A precision bridge is set for the middle temperature resistance with the bridge voltage supply set so as not to produce the self-heat error. An auxiliary bridge voltage is set for the higher temperature resistance. The thermistor is placed in the operating medium at the lower temperature and is connected to the auxiliary bridge. The auxiliary bridge is adjusted to balance the bridge, which in effect, will self-heat the thermistor to the upper temperature. The thermistor is then immediately switched to the precision bridge.

The time required for the precision bridge to balance is the time constant of the NTC thermistor/NTC thermistor sensor assembly in the operating medium.

3. Selection Of Resistance Value

Typically, NTC thermistors are specified and/or referenced to + 25°C. However, it is equally important to consider the minimum and maximum resistance values at the extremes of the operating temperature range.

The minimum resistance at the maximum temperature point must not be too low to meet the input requirements of the measuring circuit. If the resistance is too low, errors due to contact resistance, line resistance and self-heating increase.

It is recommended to have at least 500 ohm - 1000 ohm at the high end of the temperature range.

Conversely, the maximum resistance at the minimum temperature point must not be too high for the measurement circuit input. Range switching with two or more probes should be considered if the minimum/maximum resistance values cannot be met with one thermistor.

Sensitivity also is an important consideration in the selection of the correct resistance value. Usually, the minimum and maximum allowable resistance values typically limit this selection. It then must be determined which resistance values maximizes the output of the measuring system over the entire range, taking into consideration the maximum input current as determined by the dissipation constant and allowable self-heat error.

4. R-T Curve Selection

At present, eleven R-T curves are available from Vishay Dale. Each material has a different R-T characteristic. Given the different resistivities of the different R-T materials and the desirability of maintaining uniformity in size, not all resistance values (R25) are available in all R-T curves.

Once the minimum resistance at the maximum temperature is determined, divide this resistance value by a given R-T/R25 ratio from one of any of the R-T curves to determine an approximate R25 value. (**NOTE:** R-T ratio tables in 1°C increments are included on pages 18 - 23.) If the R25 value is not available in one R-T curve, select another until an appropriate R-T curve is determined. Then select a standard R25 value that is closest to the approximate value. Calculate the maximum resistance at the minimum temperature by multiplying the selected R25 by the given R-T/R25 ratio. If the selected R-T curve and R25 value meet the pre-determined minimum resistance, maximum resistance and sensitivity of the measurement system, then tolerance is the next consideration.

5. Tolerance

Most temperature measurement or control applications express their limitations or accuracy in temperature units (i.e. ± 1.0°C). When designing a system, it is important to consider the overall measurement accuracy of all components. A ± 1.0°C thermistor, coupled with a ± 1.0°C system, will insure measurement accuracy to ± 2.0°C.

Thermistors may be specified with either a temperature tolerance or a resistance tolerance at either a single temperature point or over a temperature range. If the required temperature measurement accuracy is over a temperature range, it is more practical to specify a temperature tolerance in lieu of a resistance tolerance. This is because a resistance tolerance specification over a range will not necessarily guarantee that the required system accuracy will be met unless the non-linear NTC (negative temperature coefficient) is taken into consideration.

NTC is expressed in % resistance change per degree C. Since one NTC resistance change is approximately equivalent to a 1° temperature change, NTC is useful in specifying temperature tolerances. NTC's are given on the Vishay Dale Specification Sheet in ten degree increments; however, the NTC may be calculated at any temperature point using a 1°C R-T table.

$$\left(\text{NTC} = \frac{1}{R} \bullet \frac{dR}{dT}\, 100\right)$$

Example: What is the NTC of 10,000 ohm (R25) of a Curve 1 thermistor at + 44°C?

$$100 \left(\frac{1}{4543\Omega \text{ @ } 44°C} \times \frac{4368\Omega \text{ @ } +45°C - 4725\Omega \text{ @ } +43°C}{2} \right) = 3.9\%$$

To determine the resistance tolerance at any given temperature point, simply multiply the specified temperature tolerance by the NTC at the given temperature.

Example: What are the resistance tolerances at 0°C, + 25°C and + 70°C for a Curve 1 thermistor with a ± 0.5°C temperature tolerance over the range of 0°C to + 70°C?

R0 = ± 0.5°C x - 5.1% = ± 2.55% resistance tolerance
R25 = ± 0.5°C x - 4.4% = ± 2.2% resistance tolerance
R70 = ± 0.5°C x - 3.4% = ± 1.7% resistance tolerance

It may now be clear why a single resistance tolerance over a temperature range may not be practical for a particular temperature measurement application.

If a single temperature point is the only design specification, NTC and Manufacturing Tolerances are useful in determining temperature tolerances at other temperature points. Manufacturing Tolerance is given on the Vishay Dale Specification Sheet in a ± % resistance tolerance. Point-matched specifications must have the difference in deviation between the specified temperature point and any other temperature point of interest added to the resistance tolerance at the specified temperature.

Example: What are the resistance tolerances at 0°C and + 50°C for a standard 1M1002?

R0 = ± 10% + ± 1.1% = ± 11.1% resistance tolerance.
R25 = ± 10% + ± 0.0% = ± 10% resistance tolerance.
R50 = ± 10% + ± 1.1% = ± 11.1% resistance tolerance.

To determine the temperature tolerance at any temperature point, divide the resistance tolerance by the NTC at that point.

Example: What is the temperature tolerance at 0°C for a 1M1002?

± 11.1% ÷ - 5.1% = ± 2.2°C temperature tolerances.

It should be noted that the Manufacturing Tolerances listed on the Vishay Dale Specification Sheet are all referenced at + 25°C. If the thermistor is referenced at a temperature other than + 25°C, then the total difference in deviation between the two points, if the + 25°C is between them, is the sum of the maximum deviations listed at each point.

Example: What is the maximum resistance tolerance of a Curve 1 thermistor at 0°C if the specified tolerance is ± 5% at + 70°C?

(± 5% resistance tolerance at + 70°C) + (MT ± 1.8% at + 70°C) + (MT ± 1.1% at 0°C) = ± 7.9% resistance tolerance at 0°C.

6. Tolerance Availability vs R-T Curve

Not all temperature/resistance tolerances are available in all R-T curves. If a temperature tolerance over an extended temperature range is required, then at present, Curves 1, 2, 4, 8 or 9 may be selected. All other curves may be specified to a resistance or temperature tolerance at a single temperature point. Curves 12 and 13 may only have ± 5% or ± 10% resistance tolerances specified. Contact the factory for further information.

7. Tolerance Availability vs Configuration

Not all temperature/resistance tolerances are available in all configurations. Basically, Hybrids, uncoated NTC thermistors without leads and uncoated NTC thermistors with leads are only available in ± 5% or ± 10% point-matched resistance tolerances.

8. Measurement Accuracy

Thermistor resistance measurements must be made at precisely controlled temperature while applying essentially zero-power to assure measurement accuracy.

RESISTANCE-TEMPERATURE RELATIONSHIP

Many empirical equations have been developed over the years in an attempt to accurately describe the non-linear resistance-temperature dependence of NTC thermistors.

An early equation called the “Beta” formula proved to be useful over narrow temperature ranges for broad tolerances. The Beta formula may be written using a single material dependent constant B as:

$$R(T) = R(To)\exp\left[B\left(\frac{1}{T} - \frac{1}{To}\right)\right]$$

where R (T) is the resistance at the temperature T in Kelvin and R (To) is a reference point at temperature To. The Beta formula requires a two-point calibration, but under the best of conditions is not accurate to ± 1°C over the range of 0°C to + 100°C and typically not to ± 5°C over our published temperature ranges.

The best empirical expression published to date is the Steinhart-Hart equation written explicitly in temperature T as:

$$\frac{1}{T} = A + B(\ln R) + C(\ln R)^3$$

where In R is the natural logarithm of the resistance R at temperature T and the A, B and C’s are derived coefficients from actual measurement. This form of the Steinhart-Hart equation requires a minimum of three calibration points to determine the derived coefficients. Typical accuracies would be less than ± 0.15°C over the range of - 50°C to + 150°C.

If the temperature points selected from the R-T tables to calculate A, B and C lie within a + 100°C range, the accuracy is better than ± 0.01°C, assuming measurement accuracy to at least four significant figures and preferably five.

The Steinhart-Hart equation is an approximation. If a tighter tolerance than guaranteed is desired, then each thermistor must be individually calibrated.

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