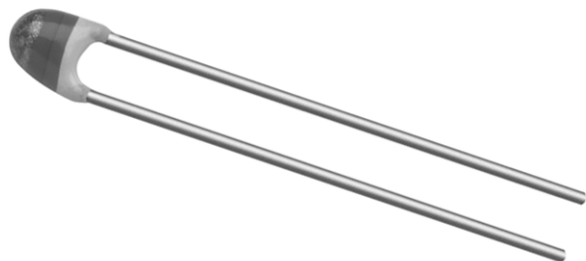


NTC Thermistors, Accuracy Line



QUICK REFERENCE DATA

PARAMETER	VALUE
Resistance value at 25 °C	3.3 Ω to 470 k Ω
Tolerance on R ₂₅ -value	$\pm 2\%$; $\pm 3\%$; $\pm 5\%$; $\pm 10\%$
Tolerance on B _{25/85} -value	$\pm 0.5\%$ to $\pm 3\%$
Maximum dissipation	500 mW
Dissipation factor δ (for information only)	7 mW/K 8.5 mW/K (for 640..338 to 689)
Response time	1.2 s
Thermal time constant τ (for information only)	15 s
Operating temperature range: at zero dissipation; continuously at zero dissipation; for short periods at maximum dissipation (500 mW)	-40 to +125 °C ≤ 150 °C 0 to 55 °C
Climatic category	40/125/56
Mass	≈ 0.3 g

FEATURES

- Accuracy over a wide temperature range
- High stability over a long life
- Excellent price/performance ratio

APPLICATIONS

- Temperature sensing and control

These thermistors have a negative temperature coefficient. The device consists of a chip with two tinned solid copper-plated leads. It is grey lacquered and colour coded, but not insulated.

PACKAGING

The thermistors are packed in bulk or tape on reel; see code numbers and relevant packaging quantities.

ELECTRICAL DATA AND ORDERING INFORMATION

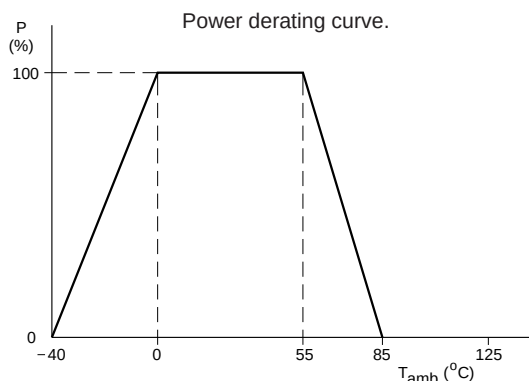
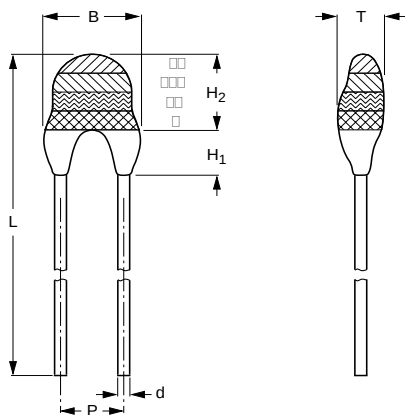
R ₂₅ (Ω)	B _{25/85} -VALUE	CATALOG NUMBER 2322 640 6....				COLOR CODE (see dimensions drawing and note 1)		
		R ₂₅ $\pm 2\%$	R ₂₅ $\pm 3\%$	R ₂₅ $\pm 5\%$	R ₂₅ $\pm 10\%$	I	II	III
3.3	2880 K $\pm 3\%$	4338	6338	3338	2338	orange	orange	gold
4.7	2880 K $\pm 3\%$	4478	6478	3478	2478	yellow	violet	gold
6.8	2880 K $\pm 3\%$	4688	6688	3688	2688	blue	grey	gold
10	2990 K $\pm 3\%$	4109	6109	3109	2109	brown	black	black
15	3041 K $\pm 3\%$	4159	6159	3159	2159	brown	green	black
22	3136 K $\pm 3\%$	4229	6229	3229	2229	red	red	black
33	3390 K $\pm 3\%$	4339	6339	3339	2339	orange	orange	black
47	3390 K $\pm 3\%$	4479	6479	3479	2479	yellow	violet	black
68	3390 K $\pm 3\%$	4689	6689	3689	2689	blue	grey	black
100	3560 K $\pm 0.75\%$	4101	6101	3101	2101	brown	black	brown
150	3560 K $\pm 0.75\%$	4151	6151	3151	2151	brown	green	brown
220	3560 K $\pm 0.75\%$	4221	6221	3221	2221	red	red	brown
330	3560 K $\pm 0.75\%$	4331	6331	3331	2331	orange	orange	brown
470	3560 K $\pm 0.5\%$	4471	6471	3471	2471	yellow	violet	brown
680	3560 K $\pm 0.5\%$	4681	6681	3681	2681	blue	grey	brown
1000	3528 K $\pm 0.5\%$	4102	6102	3102	2102	brown	black	red
1500	3528 K $\pm 0.5\%$	4152	6152	3152	2152	brown	green	red

R ₂₅ (Ω)	B _{25/85} -VALUE	CATALOG NUMBER 2322 640 6....				COLOR CODE (see dimensions drawing and note 1)		
		R ₂₅ ±2%	R ₂₅ ±3%	R ₂₅ ±5%	R ₂₅ ±10%	I	II	III
2000	3528 K ±0.5%	4202	6202	3202	2202	red	black	red
2200	3977 K ±0.75%	4222	6222	3222	2222	red	red	red
2700	3977 K ±0.75%	4272	6272	3272	2272	red	violet	red
3300	3977 K ±0.75%	4332	6332	3332	2332	orange	orange	red
4700	3977 K ±0.75%	4472	6472	3472	2472	yellow	violet	red
6800	3977 K ±0.75%	4682	6682	3682	2682	blue	grey	red
10000	3977 K ±0.75%	4103	6103	3103	2103	brown	black	orange
12000	3740 K ±2%	4123	6123	3123	2123	brown	red	orange
15000	3740 K ±2%	4153	6153	3153	2153	brown	green	orange
22000	3740 K ±2%	4223	6223	3223	2223	red	red	orange
33000	4090 K ±1.5%	4333	6333	3333	2333	orange	orange	orange
47000	4090 K ±1.5%	4473	6473	3473	2473	yellow	violet	orange
68000	4190 K ±1.5%	4683	6683	3683	2683	blue	grey	orange
100000	4190 K ±1.5%	4104	6104	3104	2104	brown	black	yellow
150000	4370 K ±2.5%	4154	6154	3154	2154	brown	green	yellow
220000	4370 K ±2.5%	4224	6224	3224	2224	red	red	yellow
330000	4570 K ±1.5%	4334	6334	3334	2334	orange	orange	yellow
470000	4570 K ±1.5%	4474	6474	3474	2474	yellow	violet	yellow

Notes

1. Dependent upon R₂₅-tolerance, the band IV is coloured as follows:

- for R₂₅ ±2%, band IV is coloured red
- for R₂₅ ±3%, band IV is coloured orange
- for R₂₅ ±5%, band IV is coloured gold
- for R₂₅ ±10%, band IV is coloured silver.

DERATING AND TEMPERATURE TOLERANCES

DIMENSIONS in millimeters


2322 640 6.338 to 6.474.

PHYSICAL DIMENSIONS FOR RELEVANT TYPE

CODE NUMBER 2322 640	B _{max}	d	H ₁		H ₂ max	L	P	T _{max}
			MIN.	MAX.				
6.338 to 6.221	5.0	0.6 ±0.06	1.0	4.0	6.0	24 ±1.5	2.54	4.0
6.331 to 6.474	3.3 ±0.5	0.6 ±0.06	—	2.0 ±1.0	6.0	24 ±1.5	2.54	3.0

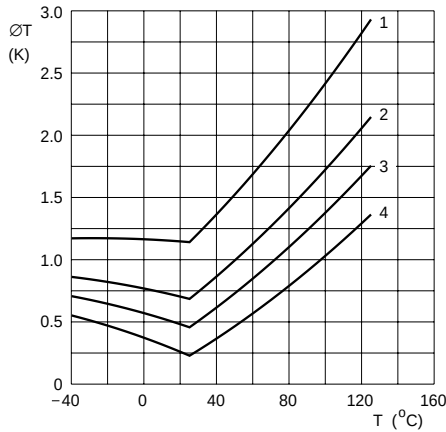
MARKING

The thermistors are marked with coloured bands; see dimensions drawing and "Electrical data and ordering information".

MOUNTING

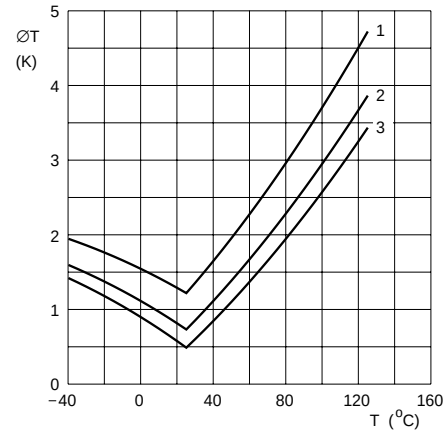
By soldering in any position.

TEMPERATURE DEVIATION AS A FUNCTION OF THE AMBIENT TEMPERATURE.



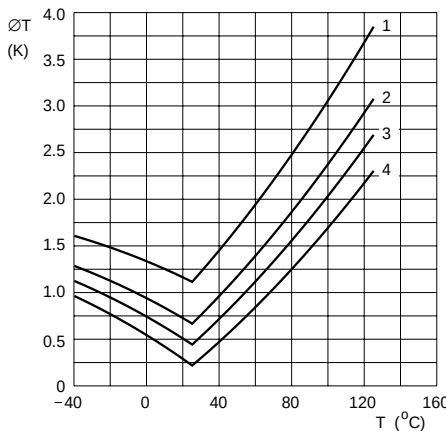
Curves valid for 2.2 to 10 kΩ.
 Curve 1: $\Delta R_{25}/R_{25} = 5\%$.
 Curve 2: $\Delta R_{25}/R_{25} = 3\%$.
 Curve 3: $\Delta R_{25}/R_{25} = 2\%$.
 Curve 4: $\Delta R_{25}/R_{25} = 1\%$
 (for 2322 640 5.... series only).

TEMPERATURE DEVIATION AS A FUNCTION OF THE AMBIENT TEMPERATURE.



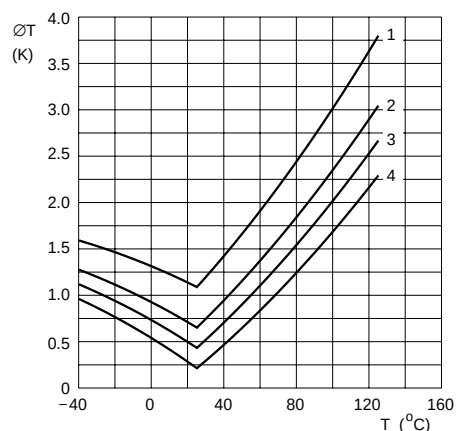
Curves valid for 12 to 22 kΩ.
 Curve 1: $\Delta R_{25}/R_{25} = 5\%$.
 Curve 2: $\Delta R_{25}/R_{25} = 3\%$.
 Curve 3: $\Delta R_{25}/R_{25} = 2\%$.

TEMPERATURE DEVIATION AS A FUNCTION OF THE AMBIENT TEMPERATURE.



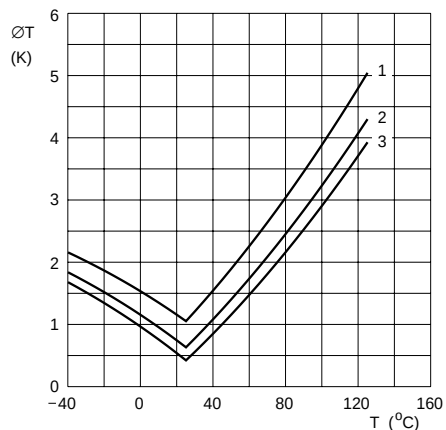
Curves valid for 33 to 47 kΩ.
 Curve 1: $\Delta R_{25}/R_{25} = 5\%$.
 Curve 2: $\Delta R_{25}/R_{25} = 3\%$.
 Curve 3: $\Delta R_{25}/R_{25} = 2\%$.
 Curve 4: $\Delta R_{25}/R_{25} = 1\%$
 (for 2322 640 5.... series only).

TEMPERATURE DEVIATION AS A FUNCTION OF THE AMBIENT TEMPERATURE.



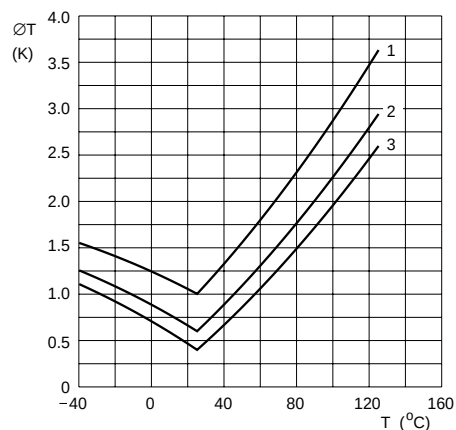
Curves valid for 68 to 100 kΩ.
 Curve 1: $\Delta R_{25}/R_{25} = 5\%$.
 Curve 2: $\Delta R_{25}/R_{25} = 3\%$.
 Curve 3: $\Delta R_{25}/R_{25} = 2\%$.
 Curve 4: $\Delta R_{25}/R_{25} = 1\%$
 (for 2322 640 5.... series only).

TEMPERATURE DEVIATION AS A FUNCTION OF THE AMBIENT TEMPERATURE.



Curves valid for 150 to 220 kΩ.
 Curve 1: $\Delta R_{25}/R_{25} = 5\%$.
 Curve 2: $\Delta R_{25}/R_{25} = 3\%$.
 Curve 3: $\Delta R_{25}/R_{25} = 2\%$.

TEMPERATURE DEVIATION AS A FUNCTION OF THE AMBIENT TEMPERATURE.



Curves valid for 330 to 470 kΩ.
 Curve 1: $\Delta R_{25}/R_{25} = 5\%$.
 Curve 2: $\Delta R_{25}/R_{25} = 3\%$.
 Curve 3: $\Delta R_{25}/R_{25} = 2\%$.

R_T VALUE AND TOLERANCE

These thermistors have a narrow tolerance on the B-value, the result of which provides a very small tolerance on the nominal resistance value over a wide temperature range. For this reason the usual graphs of $R = f(T)$ are replaced by Resistance Values at Intermediate Temperatures Tables, together with a formula to calculate the characteristics with a high precision.

FORMULAE TO DETERMINE NOMINAL RESISTANCE VALUES

The resistance values at intermediate temperatures, or the operating temperature values, can be calculated using the following interpolation laws (extended "Steinhart and Hart"):

$$R(T) = R_{ref} \times e^{(A + B/T + C/T^2 + D/T^3)} \quad (1)$$

$$T(R) = \left(A_1 + B_1 \ln \frac{R}{R_{ref}} + C_1 \ln^2 \frac{R}{R_{ref}} + D_1 \ln^3 \frac{R}{R_{ref}} \right)^{-1} \quad (2)$$

where:

A, B, C, D, A₁, B₁, C₁ and D₁ are constant values depending on the material concerned; see table below.

R_{ref} is the resistance value at a reference temperature (in this event 25 °C).

T is the temperature in K.

Formulae numbered (1) and (2) are interchangeable with an error of max. 0.005 °C in the range 25 °C to 125 °C and max. 0.015 °C in the range -40 °C to +25 °C.

DETERMINATION OF THE RESISTANCE/TEMPERATURE DEVIATION FROM NOMINAL VALUE

The total resistance deviation is obtained by combining the 'R₂₅-tolerance' and the 'resistance deviation due to B-tolerance'.

When:

X = R₂₅-tolerance

Y = resistance deviation due to B-tolerance

Z = complete resistance deviation,

$$\text{then: } Z = \left[\left(1 + \frac{X}{100} \right) \times \left(1 + \frac{Y}{100} \right) - 1 \right] \times 100\% \text{ or } Z \approx X + Y.$$

When:

TC = temperature coefficient

ΔT = temperature deviation,

$$\text{then: } \Delta T = \frac{Z}{TC}$$

The temperature tolerances are plotted in the graphs on the previous page.

Example: at 0 °C, assume X = 5%, Y = 0.89% and TC = 5.08%/K (see Table), then:

$$Z = \left\{ \left[1 + \frac{5}{100} \right] \times \left[1 + \frac{0.89}{100} \right] - 1 \right\} \times 100\%$$

$$= \{ 1.05 \times 1.0089 - 1 \} \times 100\% = 5.9345\% (\approx 5.93\%)$$

$$\Delta T = \frac{Z}{TC} = \frac{5.93}{5.08} = 1.167 \text{ °C } (\approx 1.17 \text{ °C})$$

A NTC with a R₂₅-value of 10 kΩ has a value of 32.56 kΩ between -1.17 and +1.17 °C.

PARAMETERS FOR DETERMINING NOMINAL RESISTANCE VALUES

B _{25/85} -VALUE (K)	A	B (K)	C (10 ⁵ K ²)	D (10 ⁶ K ³)	A ₁ (10 ⁻³)	B ₁ (10 ⁻⁴ K ⁻¹)	C ₁ (10 ⁻⁶ K ⁻²)	D ₁ (10 ⁻⁷ K ⁻³)
2880	-9.094	2251.74	229098	-27.4482	3.354016	3.495020	2.095959	4.260615
2990	-10.2296	2887.62	132336	-25.0251	3.354016	3.415560	4.955455	4.364236
3041	-11.1334	3658.73	-102895	0.516652	3.354016	3.349290	3.683843	7.050455
3136	-12.4493	4702.74	-402687	31.96830	3.354016	3.243880	2.658012	-2.70156
3390	-12.6814	4391.97	-232807	15.09643	3.354016	2.993410	2.135133	-8.05672
3528 ⁽¹⁾	-12.0596	3687.667	-7617.13	-5914730	3.354016	2.909670	1.632136	0.719220
3528 ⁽²⁾	-21.0704	11903.95	-2504699	247033800	3.354016	2.933908	3.494314	-7.71269
3560	-13.0723	4190.574	-47158.4	-11992560.91	3.354016	2.884193	4.118032	1.786790
3740	-13.8973	4557.725	-98275	-7522357	3.354016	2.744032	3.666944	1.375492
3977	-14.6337	4791.842	-115334	-3730535	3.354016	2.569355	2.626311	0.675278
4090	-15.5322	5229.973	-160451	-5414091	3.354016	2.519107	3.510939	1.105179
4190	-16.0349	5459.339	-191141	-3328322	3.354016	2.460382	3.405377	1.034240
4370	-16.8717	5759.15	-194267	-6869149	3.354016	2.367720	3.585140	1.255349
4570	-17.6439	6022.726	-203157	-7183526	3.354016	2.264097	3.278184	1.097628

Notes

1. Temperature < 25 °C.
2. Temperature ≥ 25 °C.



T _{oper} (°C)	R _T /R ₂₅	ΔR DUE TO B-TOLERANCE (%)	TC (%/K)	R ₂₅ (kΩ)					
				2322 640; see note 1 at end of tables					
				6.222	6.272	6.332	6.472	6.682	6.103
-5	4.216	1.08	5.24	9.275	11.38	13.91	19.81	28.67	42.16
0	3.255	0.89	5.08	7.162	8.790	10.74	15.30	22.14	32.56
5	2.534	0.70	4.92	5.575	6.842	8.362	11.91	17.23	25.34
10	1.987	0.52	4.78	4.372	5.366	6.558	9.340	13.51	19.87
15	1.570	0.34	4.64	3.454	4.239	5.181	7.378	10.67	15.70
20	1.249	0.17	4.50	2.747	3.372	4.121	5.869	8.492	12.49
25	1.000	0.00	4.37	2.200	2.700	3.300	4.700	6.800	10.00
30	0.8059	0.16	4.25	1.773	2.176	2.660	3.788	5.480	8.059
35	0.6535	0.32	4.13	1.438	1.764	2.156	3.072	4.444	6.535
40	0.5330	0.47	4.02	1.173	1.439	1.759	2.505	3.624	5.330
45	0.4372	0.62	3.91	0.9618	1.180	1.443	2.055	2.972	4.372
50	0.3605	0.77	3.80	0.7932	0.973	1.190	1.694	2.451	3.606
55	0.2989	0.91	3.70	0.6575	0.807	0.9863	1.405	2.032	2.989
60	0.2490	1.05	3.60	0.5478	0.672	0.8217	1.170	1.693	2.490
65	0.2084	1.18	3.51	0.4586	0.562	0.6879	0.9797	1.417	2.084
70	0.1753	1.31	3.42	0.3857	0.473	0.5785	0.8239	1.192	1.753
75	0.1481	1.44	3.33	0.3258	0.399	0.4887	0.6960	1.007	1.481
80	0.1256	1.57	3.25	0.2764	0.339	0.4146	0.5905	0.8544	1.256
85	0.1070	1.69	3.16	0.2355	0.289	0.3532	0.5031	0.7278	1.070
90	0.09154	1.81	3.09	0.2014	0.247	0.3021	0.4303	0.6225	0.9154
95	0.07860	1.93	3.01	0.1729	0.212	0.2594	0.3694	0.5345	0.7860
100	0.06773	2.04	2.94	0.1490	0.182	0.2235	0.3183	0.4607	0.6773
105	0.05858	2.15	2.87	0.1289	0.158	0.1933	0.2753	0.3983	0.5858
110	0.05083	2.26	2.80	0.1118	0.137	0.1677	0.2389	0.3457	0.5083
115	0.04426	2.37	2.73	0.0974	0.1195	0.1461	0.2080	0.3010	0.4426
120	0.03866	2.47	2.67	0.0851	0.1044	0.1276	0.1817	0.2629	0.3866
125	0.03387	2.57	2.61	0.0745	0.0915	0.1118	0.1592	0.2303	0.3387
130	0.02977	2.67	2.55	0.0655	0.0804	0.0982	0.1399	0.2024	0.2977
135	0.02624	2.77	2.49	0.0577	0.0709	0.0866	0.1233	0.1784	0.2624
140	0.02319	2.86	2.43	0.0510	0.0626	0.0765	0.1090	0.1577	0.2319
145	0.02055	2.96	2.38	0.0452	0.0555	0.0678	0.0966	0.1398	0.2055
150	0.01826	3.05	2.33	0.0402	0.0493	0.0603	0.0858	0.1242	0.1826

RESISTANCE VALUES AT INTERMEDIATE TEMPERATURES

T _{oper} (°C)	R _T /R ₂₅	ΔR DUE TO B-TOLERANCE (%)	TC (%/K)	R ₂₅ (kΩ)		
				2322 640; see note 1 at end of tables		
				6.123	6.153	6.223
-40	25.78	6.81	6.09	309.4	386.8	567.2
-35	19.13	6.16	5.89	229.5	286.9	420.8
-30	14.32	5.53	5.70	171.8	214.8	315.0
-25	10.82	4.93	5.52	129.8	162.3	238.0
-20	8.245	4.35	5.35	98.93	123.7	181.4
-15	6.335	3.80	5.19	76.02	95.03	139.4
-10	4.907	3.26	5.03	58.88	73.60	107.9
-5	3.830	2.74	4.88	45.95	57.44	84.25
0	3.011	2.24	4.73	36.13	45.16	66.24
5	2.384	1.76	4.60	28.60	35.76	52.45
10	1.900	1.30	4.46	22.80	28.50	41.81
15	1.525	0.85	4.34	18.30	22.87	33.55
20	1.231	0.42	4.21	14.77	18.47	27.09
25	1.000	0.00	4.10	12.00	15.00	22.00
30	0.8170	0.41	3.98	9.804	12.26	17.97