NTC thermistors, accuracy line 2322 640 6....

FEATURES

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

APPLICATION

- Temperature sensing and control.

DESCRIPTION

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.

MECHANICAL DATA

Marking

The thermistors are marked with colour bands in accordance with Fig.1 and Table 1.

Mounting

By soldering in any position.

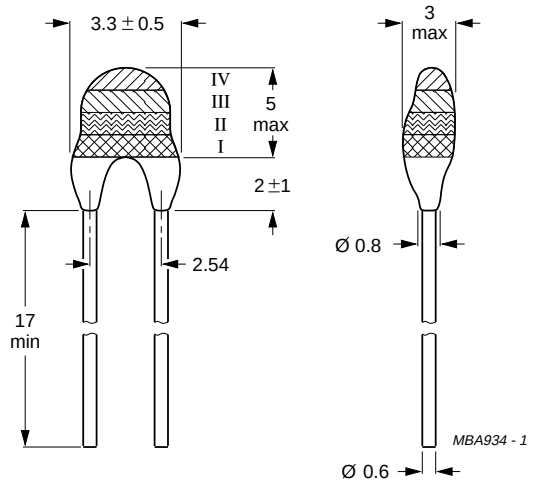
QUICK REFERENCE DATA

PARAMETER	VALUE	UNIT
Resistance value at 25 °C	2.2 to 470	kΩ
Tolerance on R_{25}-value	±2; ±3; ±5; ±10	%
Tolerance on $B_{25/85}$-value	2.5 to 0.75	%
Maximum dissipation	500	mW
Response time	1.2	s
Operating temperature range:		
at zero dissipation; continuously	−40 to +125	°C
at zero dissipation; for short periods; note 1	≤150	°C
at maximum dissipation (500 mW)	0 to 55	°C
Climatic category	40/125/56	
Mass	≈0.22	g

Note

1. For part of product range only; see Table 1.

Outline



Dimensions in mm.

Fig.1 Component outline.

ELECTRICAL CHARACTERISTICS

Unless otherwise stated, measurements are in accordance with *"IEC publication 539"*, see also Table 1.
Stability is in accordance with *"CECC 43 000"* and *"IEC 68-2"*, see Table 12.

PARAMETER	VALUE	UNIT
Standard selection tolerance on R_{25}	±2; ±3; ±5 and ±10	%
Climatic category	40/125/56	
Maximum dissipation	500	mW
Dissipation factor δ (for information only)	7	mW/K
Response time (for information only); note 1	1.2	s
Thermal time constant τ (for information only)	11	s
Operating temperature range:		
at zero dissipation; continuously	−40 to +125	°C
at zero dissipation; for short periods; note 2	≤150	°C
at maximum dissipation	0 to +55	°C

Notes

1. Response time in silicone oil MS 200/50. This is the time needed for the sensor to reach 63.2% of the total temperature difference when subjected to a temperature change from 25 °C in air to 85 °C in oil.
2. For part of product range only, see Table 1.

Derating

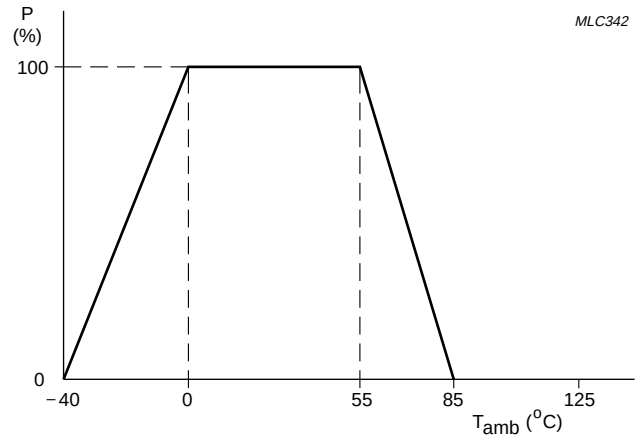


Fig.2 Power derating curve.

Table 1 R_{25}-values, catalogue numbers and coding; note 1

R_{25} (kΩ)	$B_{25/85}$-VALUE	CATALOGUE NUMBER 2322 640 6....				COLOUR CODE (see Fig.1 and note 2)		
		R_{25} ±2%	R_{25} ±3%	R_{25} ±5%	R_{25} ±10%	I	II	III
2.2	3977 K ±0.75%	4222	6222	3222	2222	red	red	red
2.7	3977 K ±0.75%	4272	6272	3272	2272	red	violet	red
3.3	3977 K ±0.75%	4332	6332	3332	2332	orange	orange	red
4.7	3977 K ±0.75%	4472	6472	3472	2472	yellow	violet	red
6.8	3977 K ±0.75%	4682	6682	3682	2682	blue	grey	red
10	3977 K ±0.75%	4103	6103	3103	2103	brown	black	orange
12	3740 K ±2%	4123	6123	3123	2123	brown	red	orange
15	3740 K ±2%	4153	6153	3153	2153	brown	green	orange
22	3740 K ±2%	4223	6223	3223	2223	red	red	orange
33	4090 K ±1.5%	4333	6333	3333	2333	orange	orange	orange
47	4090 K ±1.5%	4473	6473	3473	2473	yellow	violet	orange
68	4190 K ±1.5%	4683	6683	3683	2683	blue	grey	orange
100	4190 K ±1.5%	4104	6104	3104	2104	brown	black	yellow
150	4370 K ±2.5%	4154	6154	3154	2154	brown	green	yellow
220	4370 K ±2.5%	4224	6224	3224	2224	red	red	yellow
330	4570 K ±1.5%	4334	6334	3334	2334	orange	orange	yellow
470	4570 K ±1.5%	4474	6474	3474	2474	yellow	violet	yellow

Notes

1. Maximum operating temperature range at zero dissipation is 150 °C.
2. Dependent upon R_{25}-tolerance, the band IV is coloured as follows:
   a) for R_{25} ±2%; band IV is coloured red
   b) for R_{25} ±3%; band IV is coloured orange
   c) for R_{25} ±5%; band IV is coloured gold
   d) for R_{25} ±10%; band IV is coloured silver.

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 Tables 3, 4, 5, 6, 7 and 8, together with a formula to calculate the characteristics with a high precision.

Formulae to determine nominal resistance values(1)

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

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

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

where:

A, B, C, D, A_1, B_1, C_1 and D_1 are constant values depending on the material concerned; see Table 2.

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

T is the temperature in K.

(1) 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 'R_{25}-tolerance' and the 'resistance deviation due to B-tolerance'.

When:

X = R_{25}-tolerance

Y = resistance deviation due to B-tolerance

Z = complete resistance deviation,

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

or $Z \approx X + Y$.

When:

TC = temperature coefficient

ΔT = temperature deviation,

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

The temperature tolerances are plotted in Figs 3, 4, 5, 6, 7 and 8.

Example: at 0 °C, assume X = 5%, Y = 0.89% and TC = 5.08%/K (see Table 3), then:

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

$$= \{ 1.05 \times 1.0089 - 1 \} \times 100\% = 5.93\dot{4}5\% \ (\approx 5.93\%)$$

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

A NTC with a R_{25}-value of 10 kΩ has a value of 32.51 kΩ between –1.17 and +1.17 °C.

Table 2 Parameters for determining nominal resistance values

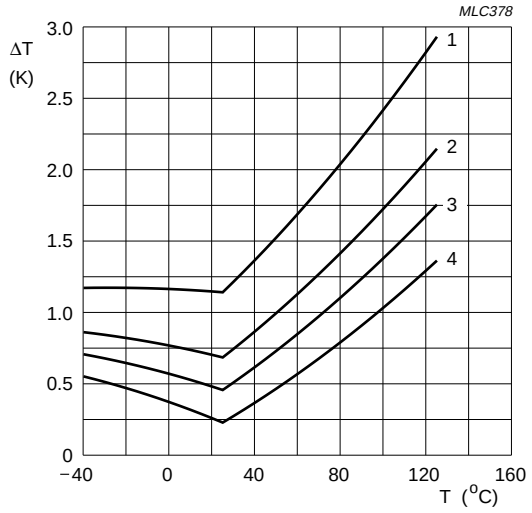
$B_{25/85}$-VALUE (K)	A	B (K)	C (K^2)	D (K^3)	$A_1 \times 10^{-3}$	$B_1 \times 10^{-4}$ (K)	$C_1 \times 10^{-6}$ (K^2)	$D_1 \times 10^{-7}$ (K^3)
3740	–13.8973	4557.725	–98275	–7522357	3.353832	2.744032	3.666944	1.375492
3977	–14.6337	4791.842	–115334	–3730535	3.353832	2.569355	2.626311	0.675278
4090	–15.5322	5229.973	–160451	–5414091	3.353832	2.519107	3.510939	1.105179
4190	–16.0349	5459.339	–191141	–3328322	3.353832	2.460382	3.405377	1.034240
4370	–16.8717	5759.150	–194267	–6869149	3.353832	2.367720	3.585140	1.255349
4570	–17.6439	6022.726	–203157	–7183526	3.353832	2.264097	3.278184	1.097628

Table 3 Resistance values at intermediate temperatures

T_{amb} (°C)	R_T/R_{25}	ΔR DUE TO B-TOLERANCE (%)	TC (%/K)	R_{25} (kΩ)					
				2322 640 .....; see Table 8, note 1					
				6.222	**6.272**	**6.332**	**6.472**	**6.682**	**6.103**
–40	33.21	2.66	6.57	73.06	89.67	109.6	156.1	225.8	332.1
–35	23.99	2.41	6.36	52.78	64.77	79.17	112.8	163.1	240.0
–30	17.52	2.17	6.15	38.55	47.31	57.82	82.35	119.1	175.2
–25	12.93	1.94	5.95	28.44	34.91	42.67	60.77	87.92	129.3
–20	9.636	1.71	5.76	21.20	26.02	31.80	45.30	65.53	96.36
–15	7.250	1.50	5.58	15.95	19.58	23.93	34.08	49.30	72.50
–10	5.505	1.29	5.40	12.11	14.86	18.16	25.87	37.43	55.05
–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

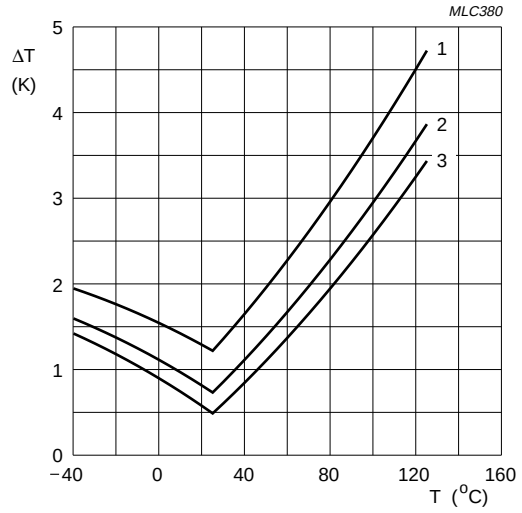
Table 4 Resistance values at intermediate temperatures

T_{amb} (°C)	R_T/R_{25}	ΔR DUE TO B-TOLERANCE (%)	TC (%/K)	R_{25} (kΩ)		
				2322 640 .....; see Table 8, note 1		
				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
35	0.6712	0.80	3.88	8.054	10.07	14.77
40	0.5543	1.19	3.77	6.652	8.315	12.20
45	0.4602	1.57	3.67	5.522	6.903	10.12
50	0.3839	1.94	3.57	4.607	5.759	8.447
55	0.3219	2.30	3.48	3.862	4.828	7.081
60	0.2710	2.65	3.39	3.252	4.067	5.963
65	0.2293	2.99	3.30	2.751	3.439	5.044
70	0.1947	3.33	3.22	2.337	2.921	4.284
75	0.1661	3.66	3.14	1.993	2.492	3.654
80	0.1422	3.98	3.06	1.707	2.134	3.129
85	0.1223	4.29	2.99	1.467	1.834	2.690
90	0.1055	4.60	2.92	1.266	1.583	2.321
95	0.09135	4.90	2.85	1.096	1.370	2.010
100	0.07937	5.19	2.78	0.9524	1.190	1.746
105	0.06919	5.48	2.71	0.8302	1.038	1.522
110	0.06050	5.76	2.65	0.7260	0.9075	1.331
115	0.05307	6.04	2.59	0.6369	0.7961	1.168
120	0.04670	6.31	2.53	0.5604	0.7005	1.027
125	0.04121	6.57	2.47	0.4945	0.6181	0.9065



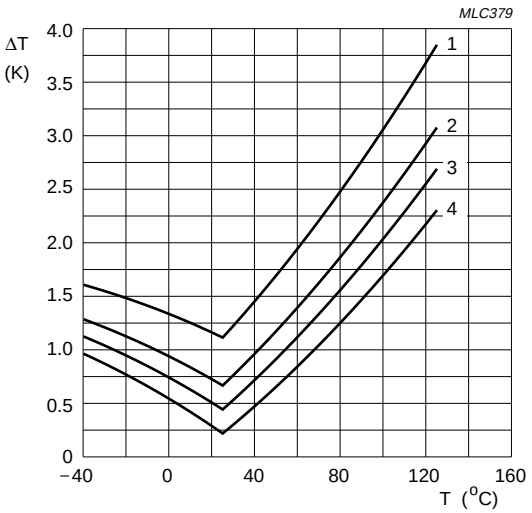
Curves valid for 2.2 to 10 kΩ.
Curve 1: $\Delta R_{25}/R_{25}$ = 5%.
Curve 2: $\Delta R_{25}/R_{25}$ = 3%.
Curve 3: $\Delta R_{25}/R_{25}$ = 2%.
Curve 4: $\Delta R_{25}/R_{25}$ = 1% (for 2322 640 5.... series only).

Fig.3 Temperature deviation as a function of the ambient temperature.



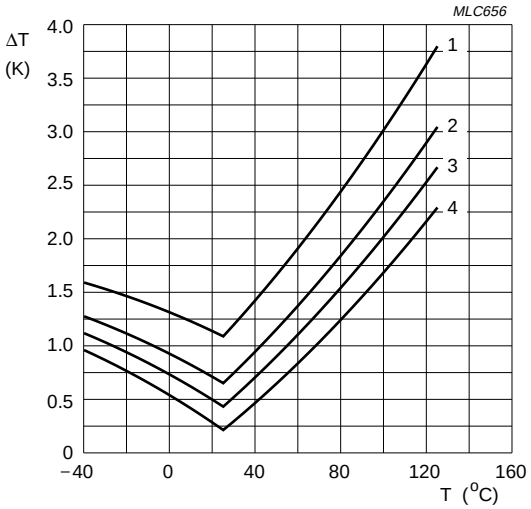
Curves valid for 12 to 22 kΩ.
Curve 1: $\Delta R_{25}/R_{25}$ = 5%.
Curve 2: $\Delta R_{25}/R_{25}$ = 3%.
Curve 3: $\Delta R_{25}/R_{25}$ = 2%.

Fig.4 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).

Fig.5 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).

Fig.6 Temperature deviation as a function of the ambient temperature.