

HTF3223, HTM1735 및 HTS2030 NTC 서미스터 : (R/T 특성 1011, B25/100=3730K, 10kΩ@25℃)

Thermistor 출력전압 : 10kΩ Pull up 저항을 NTC 단자에 직렬로 연결 하여 전압측정 (Vcc=5Vdc)

T	R nom	α	V 10kΩ	ADC
[°C]	[Ω]	%/K	[V]	[10bit]
-40	262960	6.2	4.82	986
-39	247217		4.81	983
-38	232539		4.79	981
-37	218845		4.78	978
-36	206064		4.77	976
-35	194110	6.0	4.76	973
-34	182852		4.74	970
-33	172332		4.73	967
-32	162498		4.71	964
-31	153299		4.69	960
-30	144790	5.8	4.68	957
-29	136664		4.66	953
-28	129054		4.64	949
-27	121925		4.62	945
-26	115243		4.60	941
-25	109030	5.6	4.58	937
-24	103115		4.56	933
-23	97565		4.54	928
-22	92354		4.51	923
-21	87460		4.49	918
-20	82923	5.4	4.46	913
-19	78581		4.44	908
-18	74497		4.41	902
-17	70655		4.38	896
-16	67039		4.35	890
-15	63591	5.2	4.32	884
-14	60381		4.29	878
-13	57356		4.26	871
-12	54503		4.22	864
-11	51813		4.19	858
-10	49204	5.1	4.16	850
-9	46767		4.12	843
-8	44467		4.08	835
-7	42296		4.04	827
-6	40247		4.00	819
-5	38279	4.9	3.96	811
-4	36455		3.92	803
-3	34731		3.88	794
-2	33100		3.84	786
-1	31557		3.80	777
0	30029	4.8	3.75	767
1	28627		3.71	758
2	27299		3.66	749
3	26042		3.61	739
4	24852		3.57	729
5	23773	4.6	3.52	720
6	22708		3.47	710
7	21698		3.42	700
8	20739		3.37	690
9	19829		3.32	680
10	18959	4.5	3.27	670
11	18128		3.22	659
12	17338		3.17	649
13	16588		3.12	638
14	15876		3.07	628
15	15207	4.3	3.02	617
16	14569		2.96	607
17	13962		2.91	596
18	13384		2.86	586
19	12834		2.81	575
20	12280	4.2	2.76	564
21	11777		2.70	553
22	11297		2.65	543
23	10840		2.60	532
24	10404		2.55	522
25	10000	4.1	2.50	512
26	9600		2.45	501
27	9218		2.40	491
28	8853		2.35	480
29	8506		2.30	470

T	R nom	α	V 10kΩ	ADC
[°C]	[Ω]	%/K	[V]	[10bit]
30	8178	3.9	2.25	460
31	7866		2.20	450
32	7568		2.15	441
33	7283		2.11	431
34	7011		2.06	422
35	6734	3.8	2.01	412
36	6484		1.97	402
37	6244		1.92	393
38	6015		1.88	384
39	5796		1.83	375
40	5575	3.7	1.79	366
41	5373		1.75	358
42	5180		1.71	349
43	4995		1.67	341
44	4817		1.63	333
45	4636	3.6	1.58	324
46	4473		1.55	316
47	4316		1.51	308
48	4166		1.47	301
49	4021		1.43	293
50	3874	3.6	1.40	286
51	3737		1.36	278
52	3606		1.33	271
53	3481		1.29	264
54	3360		1.26	257
55	3237	3.5	1.22	250
56	3126		1.19	244
57	3019		1.16	237
58	2917		1.13	231
59	2819		1.10	225
60	2720	3.4	1.07	219
61	2629		1.04	213
62	2542		1.01	207
63	2458		0.99	202
64	2378		0.96	197
65	2304	3.3	0.94	192
66	2229		0.91	186
67	2158		0.89	182
68	2089		0.86	177
69	2022		0.84	172
70	1960	3.2	0.82	168
71	1898		0.80	163
72	1839		0.78	159
73	1782		0.76	155
74	1727		0.74	151
75	1673	3.1	0.72	147
76	1622		0.70	143
77	1573		0.68	139
78	1526		0.66	135
79	1480		0.64	132
80	1432	3.0	0.63	128
81	1390		0.61	125
82	1349		0.59	122
83	1310		0.58	118
84	1272		0.56	115
85	1235	3.0	0.55	112
86	1199		0.54	109
87	1163		0.52	107
88	1130		0.51	104
89	1097		0.49	101
90	1067	2.8	0.48	99
91	1038		0.47	96
92	1009		0.46	94
93	982		0.45	91
94	955		0.44	89
95	927	2.8	0.42	87
96	901		0.41	85
97	877		0.40	82
98	853		0.39	80
99	830		0.38	78
100	809	2.8	0.37	77

Standardized R/T Characteristics

1 Introduction

The R/T characteristics tabulated in the following have been standardized for the resistance value at 25 °C. The actual resistance values of a particular NTC thermistor are obtained by multiplying the ratio R_T/R_{25} (tabulated value) by the resistance value at 25 °C (specified in the data sheets).

$$R_T = \frac{R_T}{R_{25}} \cdot R_{25} \quad (1)$$

Resistance values at intermediate temperatures within the range of the subsequent temperature interval can be calculated by means of the temperature coefficient α .

α is inserted in the following equation:

$$R_T = R_{T_x} \cdot \exp \left[\frac{\alpha_x}{100} \cdot (T_x + 273,15)^2 \cdot \left(\frac{1}{T + 273,15} - \frac{1}{T_x + 273,15} \right) \right] \quad (2)$$

R_T	Resistance value at temperature T
R_{T_x}	Resistance value at the beginning of the relevant temperature interval
T_x	Temperature in °C at the beginning of the relevant temperature interval
T	Temperature of interest in °C ($T_x < T < T_{x+1}$)
α_x	Temperature coefficient at temperature T_x

Example:

Given:	Curve 1006
	$R_{25} = 4,7 \text{ k}\Omega$
	$\alpha_5 = 4,4$
Unknown:	Resistance at 7 °C (R_7)

a) Calculation of the resistance value at the beginning of the relevant temperature interval ($T_x = 5 \text{ °C}$):

$$R_{T_x} = R_5 = 2,2739 \cdot 4,7 \text{ k}\Omega = 10,6873 \text{ k}\Omega$$

b) Substituting this value into equation (2) yields:

$$R_7 = R_5 \cdot \exp \left[\frac{\alpha_5}{100} \cdot (5 + 273,15)^2 \cdot \left(\frac{1}{7 + 273,15} - \frac{1}{5 + 273,15} \right) \right]$$

$$R_7 = 10,6873 \text{ k}\Omega \cdot \exp \left[\frac{4,4}{100} \cdot 278,15^2 \cdot \left(\frac{1}{280,15} - \frac{1}{278,15} \right) \right]$$

$$R_7 = 10,6873 \text{ k}\Omega \cdot \exp[-0,08737] = 10,6873 \cdot 0,9163$$

$$R_7 = 9,7932 \text{ k}\Omega$$

Standardized R/T Characteristics

2 Resistance tolerance

The tolerance range of resistance can be calculated proceeding from the rated temperature and the corresponding rated resistance tolerance (see also chapter 3.1.3).

In practice, the following equation is used:

$$\left| \frac{\Delta R_T}{R_T} \right| = \left| \frac{\Delta R_N}{R_N} \right| + \left| \frac{\Delta B}{B} \right| \cdot B \cdot \left(\frac{1}{T} - \frac{1}{T_N} \right) \quad (3)$$

$|\Delta R_T/R_T|$ Maximum spread of resistance at temperature T in %

$|\Delta R_N/R_N|$ Rated tolerance of resistance value at temperature T_N (given in data sheet) in %

$|\Delta B/B|$ Rated tolerance of B value (given in data sheet) in %

B $B_{25/100}$ value (given in data sheet) in K

T, T_N Temperatures in K

Example:

Given: NTC B57820-M561-A5

Curve 1009

$B_{25/100} = 3930$

B value tolerance $|\Delta B/B| = 1,5 \%$

Rated temperature $T_N = 100 \text{ }^\circ\text{C}$

Rated resistance $R_N = R_{100} = 39,6 \Omega$

Resistance tolerance at $100 \text{ }^\circ\text{C}$ $|\Delta R_N/R_N| = 5 \%$

Unknown: Resistance value at $35 \text{ }^\circ\text{C}$ ($R_T = R_{35}$)

Resistance tolerance at $35 \text{ }^\circ\text{C}$ ($|\Delta R_T/R_T| = |\Delta R_{35}/R_{35}|$)

a) Calculation of reference resistance R_{25} (required for working with the standardized R/T curve; if the rated temperature is $25 \text{ }^\circ\text{C}$ this step is omitted) by means of equation (1):

$$R_{100} = \frac{R_{100}}{R_{25}} \cdot R_{25} \qquad R_{25} = \left(\frac{R_{100}}{R_{25}} \right)^{-1} \cdot R_{100}$$

$$R_{25} = \frac{1}{0,070690} \cdot 39,6 \Omega = 560,2 \Omega$$

(0,070690 = Factor of curve 1009 at $100 \text{ }^\circ\text{C}$)

b) Calculation of resistance value at $35 \text{ }^\circ\text{C}$:

$$R_{35} = \frac{R_{35}}{R_{25}} \cdot R_{25} = 0,65726 \cdot 560,2 \Omega = 368,2 \Omega$$

(0,65726 = Factor of curve at $35 \text{ }^\circ\text{C}$)

c) Calculation of resistance tolerance by means of equation (3):

$$\begin{aligned} \left| \frac{\Delta R_{35}}{R_{35}} \right| &= \left[5 + 1,5 \cdot 3930 \cdot \left(\frac{1}{(35 + 273,15)} - \frac{1}{(100 + 273,15)} \right) \right] \% \\ &= \left[5 + 5895 \cdot \left| \frac{1}{308,15} - \frac{1}{373,15} \right| \right] \% \\ &= (5 + 5895 \cdot 0,00056529) \% \\ &= 5,0 \% + 3,3 \% = 8,3 \% \end{aligned}$$

If the R/T characteristics are computer-stored, the resistance tolerances for all temperatures can be easily determined by an appropriate calculation program.

3 Temperature tolerance

With given resistance tolerance, the temperature tolerance is determined as follows:

$$\Delta T = \frac{1}{\alpha} \cdot \frac{\Delta R_T}{R_T} \tag{4}$$

α Temperature coefficient at T in %/K (see R/T characteristic)
 $|\Delta R_T/R_T|$ Resistance tolerance in % at T

The following applies to the example given under point 2:

$$\Delta T(100 \text{ }^\circ\text{C}) = \frac{1}{2,9} \cdot 5 \text{ K} = 1,72 \text{ K}$$

$$\Delta T(35 \text{ }^\circ\text{C}) = \frac{1}{4,1} \cdot 8,3 \text{ K} = 2,02 \text{ K}$$

The calculation mode given here is to be regarded as an approximation of actual conditions (B value temperature-dependent, tolerances symmetrical); nevertheless, the results obtained are sufficiently accurate for practical applications.

Standardized R/T Characteristics

4 Characteristics

Number	1006		1008		1009		1010	
	$B_{25/100} = 3550 \text{ K}$		$B_{25/100} = 3560 \text{ K}$		$B_{25/100} = 3930 \text{ K}$		$B_{25/100} = 3530 \text{ K}$	
	R_T/R_{25}	α (%/K)	R_T/R_{25}	α (%/K)	R_T/R_{25}	α (%/K)	R_T/R_{25}	α (%/K)
-55,0	48,503	5,8	53,104	6,1	85,423	7,0	52,826	6,4
-50,0	36,524	5,7	39,318	6,0	60,781	6,8	38,643	6,1
-45,0	27,639	5,6	29,325	5,8	43,650	6,6	28,574	5,9
-40,0	21,021	5,5	22,030	5,7	31,629	6,4	21,346	5,7
-35,0	16,069	5,4	16,666	5,5	23,118	6,2	16,100	5,5
-30,0	12,348	5,3	12,696	5,4	17,040	6,1	12,256	5,4
-25,0	9,5313	5,1	9,7251	5,2	12,649	5,9	9,4071	5,2
-20,0	7,4185	5,1	7,5171	5,1	9,4864	5,8	7,2862	5,0
-15,0	5,7780	4,9	5,8353	4,9	7,1545	5,6	5,6835	4,9
-10,0	4,5373	4,9	4,5686	4,8	5,4479	5,4	4,4698	4,7
-5,0	3,5762	4,7	3,6050	4,7	4,1732	5,2	3,5385	4,6
0,0	2,8409	4,5	2,8665	4,5	3,2256	5,1	2,8222	4,5
5,0	2,2739	4,4	2,2907	4,4	2,5147	4,9	2,2649	4,3
10,0	1,8330	4,2	1,8438	4,3	1,9763	4,8	1,8300	4,2
15,0	1,4883	4,1	1,4920	4,1	1,5649	4,6	1,4872	4,1
20,0	1,2160	4,0	1,2154	4,0	1,2481	4,5	1,2161	4,0
25,0	1,0000	3,9	1,0000	3,9	1,0000	4,3	1,0000	3,9
30,0	0,82627	3,8	0,82976	3,8	0,80956	4,2	0,82677	3,8
35,0	0,68600	3,7	0,68635	3,7	0,65726	4,1	0,68708	3,6
40,0	0,57254	3,6	0,57103	3,6	0,53697	4,0	0,57401	3,5
45,0	0,48050	3,5	0,48015	3,5	0,44169	3,9	0,48181	3,5
50,0	0,40514	3,4	0,40545	3,4	0,36534	3,8	0,40638	3,4
55,0	0,34213	3,3	0,34170	3,3	0,30327	3,7	0,34427	3,3
60,0	0,29036	3,2	0,28952	3,2	0,25313	3,5	0,29296	3,2
65,0	0,24838	3,1	0,24714	3,1	0,21271	3,4	0,25035	3,1
70,0	0,21342	3,0	0,21183	3,1	0,17962	3,4	0,21478	3,0
75,0	0,18371	3,0	0,18194	3,0	0,15219	3,3	0,18501	2,9
80,0	0,15873	2,9	0,15680	2,9	0,12949	3,2	0,15995	2,9
85,0	0,13756	2,8	0,13592	2,8	0,11067	3,1	0,13881	2,8
90,0	0,11961	2,8	0,11822	2,8	0,094952	3,0	0,12088	2,7
95,0	0,10435	2,7	0,10340	2,7	0,081780	3,0	0,10563	2,7
100,0	0,091314	2,6	0,090741	2,6	0,070690	2,9	0,092597	2,6
105,0	0,080265	2,6	0,079642	2,6	0,061383	2,8	0,081442	2,5
110,0	0,070764	2,5	0,070102	2,5	0,053486	2,7	0,071842	2,5
115,0	0,062544	2,4	0,061889	2,4	0,046730	2,7	0,063571	2,4
120,0	0,055431	2,4	0,054785	2,4	0,040955	2,6	0,056407	2,4
125,0	0,049252	2,3	0,048706	2,3	0,036006	2,5	0,050196	2,3
130,0	0,043872	2,3	0,043415	2,3	0,031747	2,5	-	-
135,0	0,039254	2,2	0,038722	2,2	0,028097	2,4	-	-

Standardized R/T Characteristics

Number	1006		1008		1009		1010	
	$B_{25/100} = 3550 \text{ K}$		$B_{25/100} = 3560 \text{ K}$		$B_{25/100} = 3930 \text{ K}$		$B_{25/100} = 3530 \text{ K}$	
$T (^{\circ}\text{C})$	R_T/R_{25}	$\alpha (\%/K)$	R_T/R_{25}	$\alpha (\%/K)$	R_T/R_{25}	$\alpha (\%/K)$	R_T/R_{25}	$\alpha (\%/K)$
140,0	0,035209	2,2	0,034615	2,2	0,024935	2,4	–	–
145,0	0,031581	2,2	0,031048	2,1	0,022176	2,3	–	–
150,0	0,028389	2,1	0,027910	2,1	0,019772	2,3	–	–
155,0	0,025614	2,0	0,025193	2,0	0,017683	2,2	–	–
160,0	–	–	0,022790	2,0	–	–	–	–
165,0	–	–	0,020667	2,0	–	–	–	–
170,0	–	–	0,018780	1,9	–	–	–	–
175,0	–	–	0,017090	1,9	–	–	–	–
180,0	–	–	0,015582	1,8	–	–	–	–
185,0	–	–	0,014227	1,8	–	–	–	–
190,0	–	–	0,013012	1,8	–	–	–	–
195,0	–	–	0,011934	1,7	–	–	–	–
200,0	–	–	0,010964	1,7	–	–	–	–
205,0	–	–	0,010100	1,7	–	–	–	–
210,0	–	–	0,0093191	1,6	–	–	–	–
215,0	–	–	0,0085949	1,6	–	–	–	–
220,0	–	–	0,0079384	1,6	–	–	–	–
225,0	–	–	0,0073411	1,5	–	–	–	–
230,0	–	–	0,0067980	1,5	–	–	–	–
235,0	–	–	0,0063087	1,5	–	–	–	–
240,0	–	–	0,0058623	1,5	–	–	–	–
245,0	–	–	0,0054487	1,4	–	–	–	–
250,0	–	–	0,0050705	1,4	–	–	–	–

Standardized R/T Characteristics

Number	1011		1012		1013		1014	
	$B_{25/100} = 3730 \text{ K}$		$B_{25/100} = 4300 \text{ K}$		$B_{25/100} = 3900 \text{ K}$		$B_{25/100} = 4250 \text{ K}$	
	R_T/R_{25}	α (%/K)	R_T/R_{25}	α (%/K)	R_T/R_{25}	α (%/K)	R_T/R_{25}	α (%/K)
-55,0	70,014	6,9	87,237	6,8	77,285	7,0	83,935	6,8
-50,0	49,906	6,7	62,264	6,7	54,938	6,7	60,228	6,6
-45,0	36,015	6,4	44,854	6,5	39,507	6,5	43,593	6,4
-40,0	26,296	6,2	32,599	6,3	28,722	6,3	31,815	6,3
-35,0	19,411	6,0	23,893	6,1	21,099	6,1	23,404	6,1
-30,0	14,479	5,8	17,654	6,0	15,652	5,9	17,349	6,0
-25,0	10,903	5,6	13,098	5,8	11,715	5,7	12,946	5,8
-20,0	8,2923	5,4	9,8059	5,7	8,8541	5,6	9,7439	5,7
-15,0	6,3591	5,2	7,4266	5,5	6,7433	5,4	7,3737	5,5
-10,0	4,9204	5,1	5,6677	5,4	5,1815	5,2	5,6247	5,4
-5,0	3,8279	4,9	4,3213	5,3	4,0099	5,1	4,3063	5,3
0,0	3,0029	4,8	3,3208	5,1	3,1283	4,9	3,3221	5,2
5,0	2,3773	4,6	2,5842	5,0	2,4569	4,8	2,5779	5,0
10,0	1,8959	4,5	2,0238	4,9	1,9438	4,6	2,0144	4,9
15,0	1,5207	4,3	1,5858	4,8	1,5475	4,5	1,5848	4,8
20,0	1,2280	4,2	1,2507	4,7	1,2403	4,4	1,2547	4,6
25,0	1,0000	4,1	1,0000	4,5	1,0000	4,3	1,0000	4,6
30,0	0,81779	3,9	0,79640	4,4	0,81104	4,1	0,79913	4,4
35,0	0,67341	3,8	0,64053	4,3	0,66146	4,0	0,64287	4,3
40,0	0,55747	3,7	0,51772	4,2	0,54254	3,9	0,51991	4,2
45,0	0,46357	3,6	0,41958	4,1	0,44727	3,8	0,42299	4,1
50,0	0,38740	3,6	0,34172	4,1	0,37067	3,7	0,34573	4,1
55,0	0,32368	3,5	0,27877	4,0	0,30865	3,6	0,28298	4,0
60,0	0,27200	3,4	0,22861	3,9	0,25825	3,5	0,23277	3,8
65,0	0,23041	3,3	0,18872	3,8	0,21707	3,4	0,19262	3,8
70,0	0,19604	3,2	0,15645	3,7	0,18323	3,3	0,16005	3,7
75,0	0,16735	3,1	0,13012	3,6	0,15535	3,3	0,13349	3,6
80,0	0,14342	3,0	0,10863	3,6	0,13223	3,2	0,11175	3,5
85,0	0,12347	3,0	0,091115	3,5	0,11302	3,1	0,093934	3,5
90,0	0,10668	2,8	0,076700	3,4	0,096951	3,0	0,079231	3,4
95,0	0,092734	2,8	0,064867	3,3	0,083487	3,0	0,067054	3,3
100,0	0,080903	2,8	0,055047	3,3	0,072139	2,9	0,056932	3,2
105,0	0,070616	2,7	0,046797	3,2	0,062559	2,8	0,048591	3,1
110,0	0,061826	2,6	0,039904	3,1	0,054425	2,8	0,041605	3,1
115,0	0,054282	2,6	0,034255	3,1	0,047508	2,7	0,035653	3,1
120,0	0,047793	2,5	0,029498	3,0	0,041594	2,6	0,030636	3,0
125,0	0,042249	2,4	0,025448	3,0	0,036532	2,6	0,026454	2,9