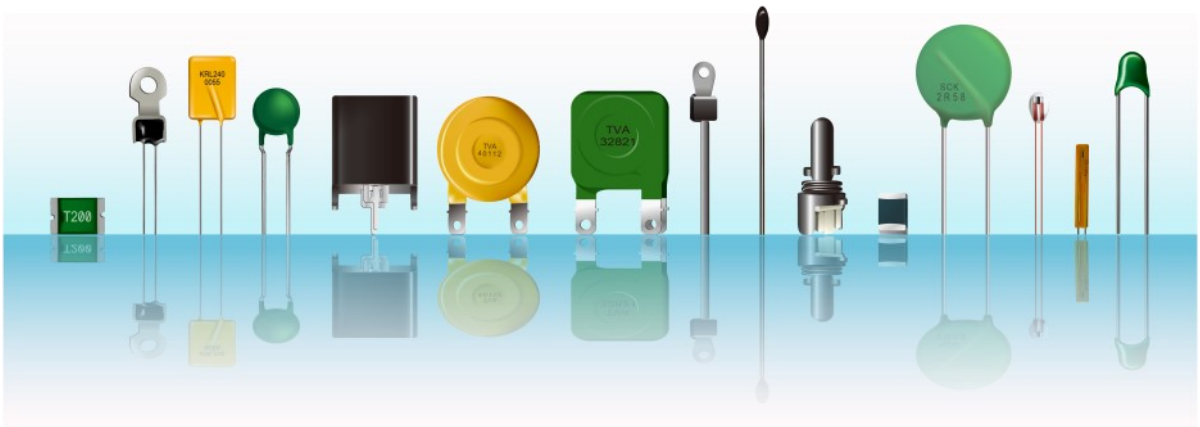
THINKING
Your Best Choice

Ring Terminal Temperature Sensor Design Guide

THINKING FOR PROTECTION

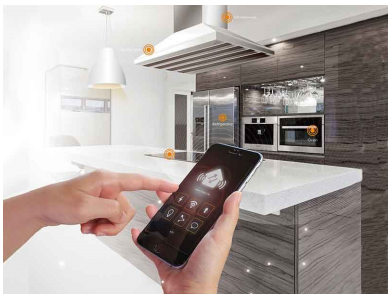
Thinking Electronic Industrial Co., Ltd. provides a broad line of protective circuit components, including over-voltage protection, over-temperature protection, and over-current protection. The product portfolio offers negative temperature coefficient thermistor (NTC thermistor), temperature sensors, zinc oxide varistors (MOV), ceramic positive temperature thermistors (PTC thermistor), polymer positive temperature coefficient thermistors (Polymer PTC resettable fuse), TVS diodes, and gas discharge tubes.

With more than 40 years experience in circuit protection component industry, THINKING owns advanced manufacturing process, material development, and overall verification. Its profound experience and advanced technology enable it to offer comprehensive service and reliable protective components to assist customers in overall protection design for diverse applications.



THINKING FOR TEMPERATURE SENSING

Designing temperature sensors is THINKING's specialty, and we provide a variety of NTC temperature sensor probes and assemblies to meet your requirements. Our design team has solved various thermal sensing design challenges and created thermal sensing solutions for leading power supplies, home appliances, industrial equipment, automobiles, telecommunications, and medical equipment manufacturers.





DESIGN A TEMPERATURE SENSOR

Surface temperature sensors come in many configurations, but ring terminal temperature sensors are usually the top choice of designers because they are easy to install.

Applications

Industrial

- Semiconductor heat sink
- Inverter
- Motor drive
- Fan control
- Charging pile

Home Appliance

- Refrigerator
- Boiler and heating system
- Kitchen appliance

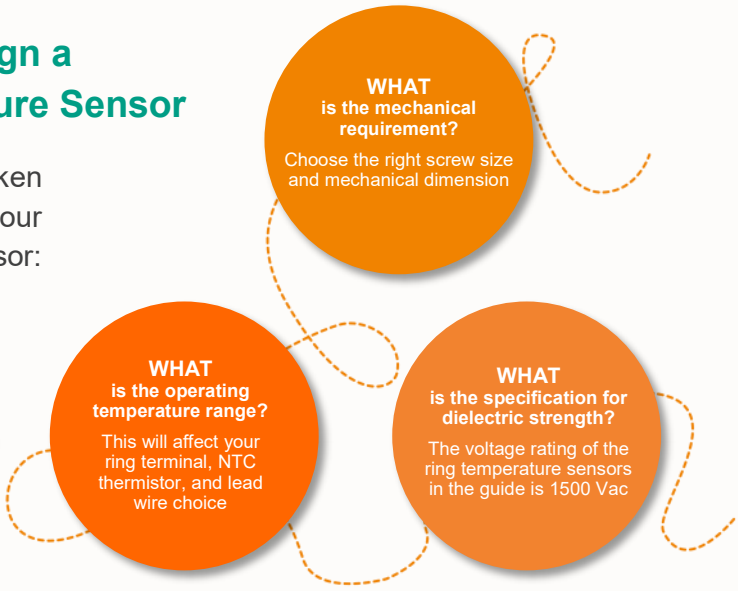
Automotive

- EV & HEV

Designing a temperature sensor is intricate because it involves several factors to consider. These include mechanical dimension specifications, electrical and mechanical strength requirements, and the installation environment of the sensor. Various ring terminal temperature sensors are available on the market, but designers may have difficulty finding the one that meets their design needs. For example, the wide variety of ring terminal sizes and types increases the difficulty of finding the matching screw size of the temperature sensor for their application. THINKING sensor design team developed the design guide to help designers find the optimal surface temperature sensor by simplifying and shortening the sensor-seeking process.

Before You Start to Design a Ring Terminal Temperature Sensor

The considerations should be taken into account when designing your ring terminal temperature sensor:



RING TERMINAL TEMPERATURE SENSOR DESIGN GUIDE

Throughout the design guide, you will learn how to design the ring terminal temperature sensor according to the requirements of your application. The design guide comprises four sections: ring terminal, characteristics of the NTC thermistor, lead wire, and connector.

A. Ring Terminal

Each ring terminal in the table provides several compatible NTC thermistors, lead wires, and connectors. Our temperature sensor experts carefully examine each combination to ensure the entire temperature sensor functions reliably.

With mounting hole sizes ranging from M2.5 to M10, the insulated or non-insulated ring terminals come in proven materials, including nickel-plated brass, tinned copper, tinned brass, and PA66. In addition, there is a configuration for ultrasonic welding. The standard dielectric strength for ring terminal temperature sensors in the design guide is 1500Vac. However, a higher voltage rating of 5000Vac is possible with customization. Please get in touch with THINKING sales representatives for details.

B. Characteristics of NTC Thermistor

This table shows the characteristics of the most commonly used NTC thermistor elements for ring terminal temperature sensors, including resistances, tolerances of resistances, B-values, tolerances of B-values and operating temperatures.

Thermistor is a thermally sensitive semiconductor resistor, and its resistance changes with the change of temperature.

Negative temperature coefficient (NTC) thermistor is a resistor whose resistance decreases following the increase of temperature. NTC thermistors are widely used in temperature measurement, temperature control, and temperature compensation applications for their high sensitivity, accuracy, and stability.

C. Lead Wire

The UL certified wires in the design guide provide the following operating temperature range: -40℃ to +105℃, -40℃ to +150℃, -60℃ to +200℃, and -60℃ to +250℃.
Wire gauge are ranging from 22 to 32 AWG. The insulation materials include PVC, XLPE, FEP, and PFA.

D. Connector

The connector types include wire-to-board connectors with pitches ranging from 1.0mm to 2.54mm and wire-to-wire connectors. When matching a connector to a lead wire, please note its applicable wire gauge.

Features and Advantages

Ring Terminal

Easy and secured surface mounting

NTC Thermistor

THINKING in-house manufactured NTC thermistor over-molded in plastic housing

Lead Wire

Options of UL certified wires to support temperature reading

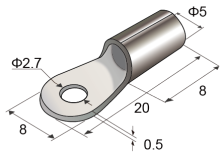
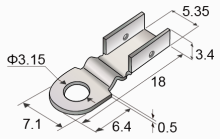
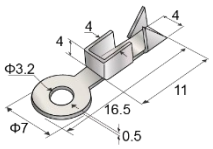
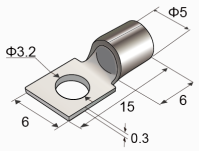
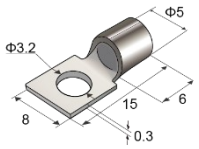
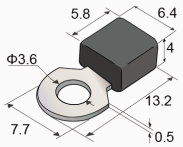
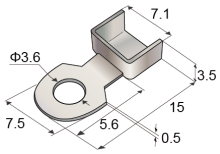
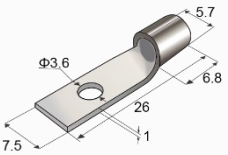
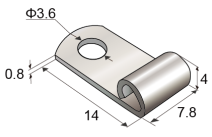
Electrical Connection

The wire ends can be attached to connectors, crimped, welded, or soldered to enable electric connection with the PCBs or devices

Contact THINKING for ordering details after selecting the ring terminal temperature sensor parts. If you require a temperature sensor that is not included in the design guide, our temperature sensor experts can help customize one to meet your requirements.

RING TERMINAL TEMPERATURE SENSOR DESIGN GUIDE

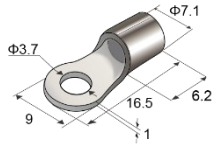
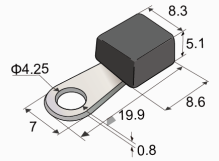
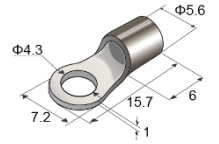
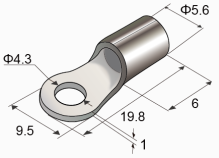
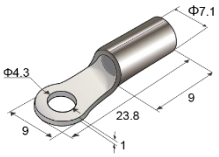
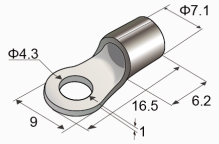
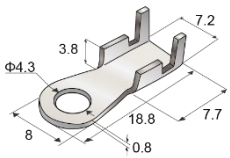
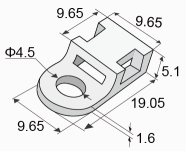
A. Ring Terminal

No.	A. Ring Terminal			B. Characteristics of NTC Thermistor	C. Lead Wire	D. Connector	Operating Temperature Range (℃)
	Dimensions (mm)	Stud Size	Material				
A1		M2.5	Nickel Plated Brass	B1 to B9	C1, C2, C3, C6, C7, C8, C9	D1 to D8	-40 to +150
A2		M3	Tinned Brass	B1 to B9	C1, C2, C3, C6, C7, C8, C9	D1 to D8	-40 to +150
A3		M3	Nickel Plated Brass	B10 to B13	C12, C13, C14, C17, C18, C19, C20	D3 to D8	-40 to +200 -40 to +250
A4		M3	Nickel Plated Brass	B1 to B9	C1, C2, C3, C6, C7, C8, C9	D1 to D8	-40 to +150
A5		M3	Nickel Plated Brass	B1 to B9	C1, C2, C3, C6, C7, C8, C9	D1 to D8	-40 to +150
A6		M3.5	Nickel Plated Brass, PA66	B1 to B9	C1, C2, C3, C6, C7, C8, C9	D1 to D8	-40 to +150
A7		M3.5	Tinned Brass	B1 to B9	C1, C2, C3, C6, C7, C8, C9	D1 to D8	-40 to +150
A8		M3.5	Tinned Brass	B1 to B9	C1, C2, C3, C6, C7, C8, C9	D1 to D8	-40 to +150
A9		M3.5	Nickel Plated Brass	B1 to B9	C1, C2, C3, C6, C7, C8, C9	D1 to D8	-40 to +150

Note: Check the connector and selected wire compatibility by reviewing table D's applicable wire gauge column.

RING TERMINAL TEMPERATURE SENSOR DESIGN GUIDE

A. Ring Terminal

No.	A. Ring Terminal			B. Characteristics of NTC Thermistor	C. Lead Wire	D. Connector	Operating Temperature Range (℃)
	Dimensions (mm)	Stud Size	Material				
A10		M3.5	Nickel Plated Brass	B1 to B9	C1 to C11	D1 to D8	-40 to +150
A11		M4	Nickel Plated Brass, PA66	B1 to B9	C1 to C11	D1 to D8	-40 to +150
A12		M4	Tinned Copper	B1 to B9	C1, C2, C3, C6, C7, C8, C9	D1 to D8	-40 to +150
A13		M4	Tinned Copper	B1 to B9	C1, C2, C3, C6, C7, C8, C9	D1 to D8	-40 to +150
A14		M4	Nickel Plated Brass	B1 to B9	C1 to C11	D1 to D8	-40 to +150
A15		M4	Nickel Plated Brass	B1 to B9	C1 to C11	D1 to D8	-40 to +150
A16		M4	Tinned Brass	B1 to B9	C1 to C11	D1 to D8	-40 to +150
A17		M4	PA66	B1 to B9	C1 to C11	D1 to D8	-40 to +150

Note: Check the connector and selected wire compatibility by reviewing table D's applicable wire gauge column.

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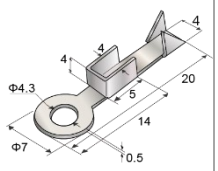
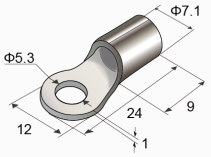
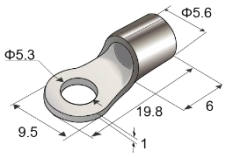
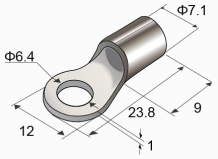
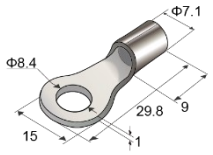
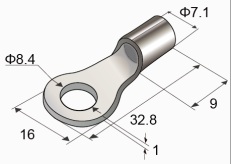
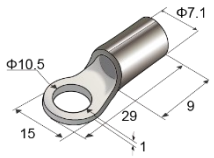
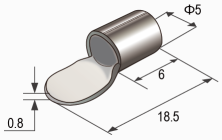
A. Ring Terminal

No.	A. Ring Terminal			B. Characteristics of NTC Thermistor	C. Lead Wire	D. Connector	Operating Temperature Range (℃)
	Dimensions (mm)	Stud Size	Material				
A18		M4	Nickel Plated Brass	B10 to B13	C12, C13, C14, C17, C18	D1 to D8	-40 to +200 -40 to +250
A19		M5	Nickel Plated Brass	B1 to B9	C1 to C11	D1 to D8	-40 to +150
A20		M5	Tinned Copper	B1 to B9	C1, C2, C3, C6, C7, C8, C9	D1 to D8	-40 to +150
A21		M6	Nickel Plated Brass	B1 to B9	C1 to C11	D1 to D8	-40 to +150
A22		M8	Nickel Plated Brass	B1 to B9	C1 to C11	D1 to D8	-40 to +150
A23		M8	Tinned Copper	B1 to B9	C1 to C11	D1 to D8	-40 to +150
A24		M10	Nickel Plated Brass	B1 to B9	C1 to C11	D1 to D8	-40 to +150
A25		--	Aluminum	B1 to B9	C1, C2, C3, C6, C7, C8, C9	D1 to D8	-40 to +150

Note: Check the connector and selected wire compatibility by reviewing table D's applicable wire gauge column.

B. Characteristics of NTC Thermistor

No.	Zero-Power Resistance at 25°C (KΩ)	Resistance Tolerance of R25 (±%)	B-Value (K)		Tolerance of B-Value (±%)	Operating Temperature Range (℃)
B1	30	1, 3, 5	25/85	3975	1, 3	-40 to +125
B2	10	1, 3, 5	25/85	3435	1, 3	-40 to +150
B3	10	1, 3, 5	25/85	3975	1, 3	-40 to +150
B4	10	1, 3, 5	25/50	4050	1, 3	-40 to +150
B5	15	1, 3, 5	25/50	4150	1, 3	-40 to +150
B6	20	3, 5	25/50	3950	3	-40 to +150
B7	50	1, 3, 5	25/50	3950	1, 3	-40 to +150
B8	100	1, 3, 5	25/50	3950	1, 3	-40 to +150
B9	100	1, 3, 5	25/85	4360	1, 3	-40 to +150
B10	3.3 (R100)	3, 5	0/100	3970	3	-40 to +250
B11	10	1, 3, 5	25/85	3435	1, 3	-40 to +250
B12	10	1, 3, 5	25/85	3975	1, 3	-40 to +250
B13	100	1, 3, 5	25/50	3950	1, 3	-40 to +250

- **Zero-Power Resistance (R_T)** is the resistance value measured under specified temperature conditions, and the self-heating during measurement can be negligible or the change of resistance caused by self-heating during measurement is less than 0.1%.
- **Rated Zero-Power Resistance (R25)** is the nominal value at standard temperature of 25℃.
- **B-Value** is an index of thermal sensitivity and represents slope of R/T curves. It can be showed by the formula below:

$$B = \frac{T_1 \cdot T_2}{T_2 - T_1} \cdot \mathrm{Log}_e \frac{R_1}{R_2}$$

Or

$$B = 2.303 \frac{T_1 \cdot T_2}{T_2 - T_1} \cdot \mathrm{Log}_{10} \frac{R_1}{R_2}$$

Note:
B: absolute temperature in Kelvins (K)
R1: resistance in ohms (Ω) at temperature T1
R2: resistance in ohms (Ω) at temperature T2
T1=298.15K (+25°C), T2=358.15K (+85°C) for B25/85
T1=298.15K (+25°C), T2=323.15K (+50°C) for B25/50

- **Operating Temperature Range** is ambient temperature range for thermistor's continuous operation at zero-power. Limits of the upper and lower operating temperatures are specified in each series.
- **Resistance/Temperature Characteristic (RT Characteristic)** is the relationship between zero-power resistance and body temperature of a thermistor. The resistance law follows approximately the formula below:

$$R = R_1 e^{B(\frac{1}{T} - \frac{1}{T_1})}$$

R and R1 are the values of a thermistor's zero-power resistance measured at temperature T and T1 respectively. The temperatures are expressed in absolute temperature (in Kelvins), and B is the thermal sensitivity index.

B. Characteristics of NTC Thermistor

R/T Characteristics

	B1	B2	B3	B4	B5	B6	B7
Resistance at 25°C	30KΩ	10KΩ	10KΩ	10KΩ	15KΩ	20KΩ	50KΩ
B-Value	B25/85 = 3975K	B25/85 = 3435K	B25/85 = 3975K	B25/50 = 4050K	B25/50 = 4150K	B25/50 = 3950K	B25/50 = 3950K
Temperature				Resistance (KΩ)			
-40	896.934	193.278	325.457	348.614	590.639	662.607	1580.99
-35	658.959	147.302	236.257	252.908	420.214	479.587	1153.44
-30	484.090	113.202	173.093	184.498	303.543	350.604	844.212
-25	362.178	87.6898	128.206	135.832	221.406	258.944	627.967
-20	274.752	68.4240	95.7367	101.059	162.731	192.888	472.377
-15	209.730	53.7788	72.0426	75.8868	120.650	144.864	357.937
-10	160.603	42.5856	54.6723	57.4196	90.3479	109.744	272.938
-5	123.499	33.9771	41.8672	43.7467	68.3333	83.9070	209.532
0	95.5904	27.3053	32.3526	33.5657	52.1454	64.7532	162.044
5	74.6070	22.0896	25.2148	25.9486	40.0986	50.4228	126.277
10	58.7455	17.9774	19.8062	20.2175	31.0464	39.5926	99.1464
15	46.6393	14.7104	15.6693	15.8746	24.1964	31.3246	78.4026
20	37.2935	12.0987	12.4787	12.5565	18.9849	24.9526	62.4151
25	30.0000	10.0000	10.0000	10.0000	15.0000	20.0000	50.0000
30	24.2573	8.30614	8.06207	8.01426	11.9357	16.1223	40.2918
35	19.7058	6.93339	6.53803	6.46059	9.56384	13.0669	32.6521
40	16.0814	5.81618	5.33276	5.23709	7.71430	10.6461	26.6049
45	13.1851	4.90282	4.37427	4.26798	6.26087	8.71848	21.7919
50	10.8633	4.15243	3.60777	3.49627	5.11008	7.17637	17.9409
55	8.99591	3.53274	2.99132	2.87862	4.19259	5.93705	14.8439
60	7.48809	3.01826	2.49276	2.38180	3.45666	4.93652	12.3407
65	6.26497	2.58891	2.08728	1.98021	2.86333	4.12502	10.3075
70	5.26754	2.22884	1.75574	1.65405	2.38284	3.46369	8.64786
75	4.44948	1.92552	1.48325	1.38790	1.99221	2.92211	7.28687
80	3.77457	1.66901	1.25821	1.16972	1.67345	2.47640	6.16562
85	3.21454	1.45135	1.07151	0.99010	1.41235	2.10776	5.23780
90	2.74731	1.26610	0.91598	0.84158	1.19761	1.80139	4.46678
95	2.35565	1.10805	0.78591	0.71829	1.02022	1.54554	3.82346
100	2.02597	0.97287	0.67674	0.61552	0.87298	1.33091	3.28460
105	1.74754	0.85699	0.58479	0.52951	0.75012	1.15007	2.83155
110	1.51175	0.75741	0.50709	0.45724	0.64707	0.99709	2.44928
115	1.31162	0.67162	0.44122	0.39626	0.56015	0.86721	2.12560
120	1.14146	0.59746	0.38520	0.34458	0.48645	0.75656	1.85059
125	0.99652	0.53313	0.33740	0.30060	0.42365	0.66202	1.61615
130		0.47708	0.29646	0.26303	0.36990	0.58103	1.41563
135		0.42799	0.26128	0.23081	0.32371	0.51149	1.24353
140		0.38476	0.23094	0.20308	0.28390	0.45167	1.09533
145		0.34644	0.20465	0.17915	0.24948	0.40012	0.96727
150		0.31224	0.18178	0.15847	0.21968	0.35564	0.85624
155							
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250							

B. Characteristics of NTC Thermistor

R/T Characteristics

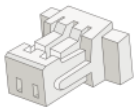
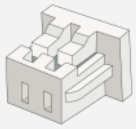
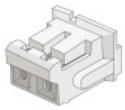
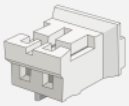
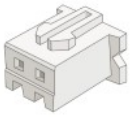
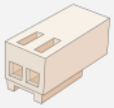
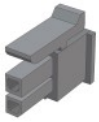
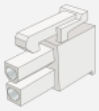
	B8	B9	B10	B11	B12	B13
Resistance at 25°C	100KΩ	100KΩ	R100 = 3.3KΩ	10KΩ	10KΩ	100KΩ
B-Value	B25/50 = 3950K	B25/85 = 4360K	B0/100 = 3970K	B25/85 = 3435K	B25/85 = 3975K	B25/50 = 3950K
Temperature			Resistance (KΩ)			
-40	3129.18	3537.91	1645.09	207.279	337.666	3204.41
-35	2298.37	2569.07	1190.77	156.100	243.825	2322.12
-30	1692.24	1884.89	864.527	118.828	176.187	1707.73
-25	1255.02	1385.82	638.235	91.2720	129.388	1268.16
-20	940.081	1029.66	476.701	70.6100	96.4686	948.124
-15	710.957	775.220	359.366	55.2600	72.6540	714.097
-10	542.270	589.993	273.332	43.5900	55.1515	542.736
-5	416.903	452.227	209.709	34.6300	42.1995	416.591
0	323.021	348.163	162.213	27.7100	32.5625	322.782
5	252.176	268.936	126.417	22.3200	25.3393	252.151
10	198.268	208.463	99.2050	18.1000	19.8759	198.345
15	156.897	162.287	78.3617	14.7600	15.7046	156.970
20	124.902	127.008	62.2907	12.1100	12.4923	124.934
25	100.000	100.000	49.8240	10.0000	10.0000	100.000
30	80.5183	79.2423	40.0962	8.30100	8.05395	80.5069
35	65.2086	63.1996	32.4611	6.92800	6.52565	65.1993
40	53.1233	50.7173	26.4331	5.81200	5.31877	53.1192
45	43.5345	40.9344	21.6459	4.90000	4.36042	43.5335
50	35.8818	33.2114	17.8221	4.15100	3.59509	35.8818
55	29.7339	27.0727	14.7505	3.53200	2.98036	29.7360
60	24.7607	22.1636	12.2697	3.01800	2.48374	24.7693
65	20.7105	18.2168	10.2556	2.59129	2.08025	20.7315
70	17.3916	15.0295	8.61219	2.23244	1.75064	17.4306
75	14.6579	12.4459	7.26468	1.92859	1.47998	14.7181
80	12.3970	10.3446	6.15462	1.67065	1.25664	12.4787
85	10.5210	8.63073	5.23595	1.45135	1.07151	10.6216
90	8.96080	7.22887	4.47227	1.26471	0.91739	9.07538
95	7.66034	6.07901	3.83466	1.10573	0.78856	7.78299
100	6.57407	5.13305	3.30000	0.97012	0.68044	6.69877
105	5.66433	4.35230	2.84981	0.85421	0.58935	5.78590
110	4.89994	3.70559	2.46921	0.75486	0.51233	5.01458
115	4.25501	3.16779	2.14618	0.66937	0.44695	4.36056
120	3.70820	2.71858	1.87101	0.59549	0.39126	3.80408
125	3.24207	2.34157	1.63578	0.53132	0.34365	3.32896
130	2.84250	2.02354	1.43401	0.47528	0.30278	2.92192
135	2.49827	1.75378	1.26043	0.42608	0.26759	2.57205
140	2.20059	1.52368	1.11066	0.38270	0.23718	2.27034
145	1.94273	1.32627	0.98108	0.34427	0.21081	2.00935
150	1.71967	1.15592	0.86871	0.31013	0.18786	1.78291
155			0.77103	0.27974	0.16784	1.58587
160			0.68594	0.25265	0.15031	1.41395
165			0.61167	0.22849	0.13492	1.26355
170			0.54671	0.20696	0.12138	1.13166
175			0.48981	0.18780	0.10943	1.01573
180			0.43986	0.17076	0.09887	0.91360
185			0.39594	0.15562	0.08950	0.82343
190			0.35726	0.14219	0.08119	0.74367
195			0.32312	0.13026	0.07379	0.67297
200			0.29293	0.11967	0.06720	0.61019
205			0.26620	0.11022	0.06131	0.55433
210			0.24246	0.10176	0.05604	0.50454
215			0.22135	0.09411	0.05133	0.46009
220			0.20252	0.08713	0.04710	0.42032
225			0.18569	0.08067	0.04329	0.38469
230			0.17061	0.07459	0.03987	0.35270
235			0.15706	0.06876	0.03678	0.32392
240			0.14484	0.06308	0.03399	0.29800
245			0.13380	0.05745	0.03147	0.27460
250			0.12379	0.05181	0.02918	0.25344

RING TERMINAL TEMPERATURE SENSOR DESIGN GUIDE

C. Lead Wire

No.	Lead Wire Type	Temperature Range(℃)	Rating	Gauge (AWG)
C1		-40 to +105	UL2651	30
C2		-40 to +105	UL2651	28
C3		-40 to +105	UL2651	26
C4		-40 to +105	UL2651	24
C5		-40 to +105	UL2651	22
C6		-40 to +150	UL4484	32
C7		-40 to +150	UL4484	30
C8		-40 to +150	UL4484	28
C9		-40 to +150	UL4484	26
C10		-40 to +150	UL4484	24
C11		-40 to +150	UL4484	22
C12		-60 to +200	UL1332	30
C13		-60 to +200	UL1332	28
C14		-60 to +200	UL1332	26
C15		-60 to +200	UL1332	24
C16		-60 to +200	UL1332	22
C17		-60 to +250	UL10362	28
C18		-60 to +250	UL10362	26
C19		-60 to +250	UL10362	24
C20		-60 to +250	UL10362	22

D. Connector

No.		Pitch	Connector Type	Applicable Wire (AWG)	Brand	Housing P/N	Mating Wafer/ Mating Housing
D1		1.0	Wire-to-Board	28 to 32	JST	SHR-02V-S-B	BM02B-SRSS-TP(180°), SM02B-SRSS-TB(90°)
D2		1.25	Wire-to-Board	28 to 32	JWT	A1251H00-2P	A1251WV0-2P(180°), A1251WR0-2P(90°)
D3		1.5	Wire-to-Board	28 to 30	JST	ZHR-2	B2B-ZR(180°), S2B-ZR(90°)
D4		2.0	Wire-to-Board	22 to 28	JST	PHR-2	B2B-PH-K-S(180°), S2B-PH-K-S(90°)
D5		2.5	Wire-to-Board	22 to 28	JST, JVT	SXH-001T-P0.6, JVT2001HN0-02	B2B-XH-A (180°), S2B-XH-A (90°), JVT1001WN0-0 (180°)
D6		2.54	Wire-to-Board	22 to 28	WST	I25004BS-2	M2-I25004
D7		3.0	Wire-to-Wire	22 to 28	MOLEX	43025-0200	43020-0200
D8		4.2	Wire-to-Wire	22 to 28	MOLEX	39-01-2025	39-00-0040

TEMPERATURE SENSOR DESIGN SERVICE

THINKING provides design services to develop high-quality temperature sensors for mission-critical applications. The services include designing and manufacturing thermistor and sensor probe housing and assembling them with lead wire and connector. Sensor performance is rigorously controlled from the beginning of its development. Our proprietary material design allows us to produce NTC chips of various sizes and control their electrical characteristics. Through simulation and analysis, we can evaluate the design feasibility of the sensor probe housing at an early stage. Moreover, our extensive range of reliability testing equipment can assist in meeting the requirements of demanding applications.

THINKING Temperature Sensor Design Capabilities

Mechanical Engineering

- Material design
- Physical configuration design
- Simulation and analysis
- Modeling and prototyping
- Tooling design

Electrical Engineering

- Electrical characteristics control
- Reliability
- Measurement method design

Manufacturing Engineering

- Manufacturing feasibility
- Automation

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THINKING ELECTRONIC INDUSTRIAL CO., LTD.
HEADQUARTER
8F, No.93, Dashun 1st Rd., Zuoying Dist.,
Kaohsiung City 81357, Taiwan
Tel: 886-7-5577660
E-mail: thinking@thinking.com.tw

MALAYSIA OFFICE
Tel: +6016-4323249

SINGAPORE OFFICE
Tel: +65-98307549

North America

THINKING ELECTRONIC USA, INC.
1300 E Main Street, Unit 109D
Alhambra, CA 91801, USA

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