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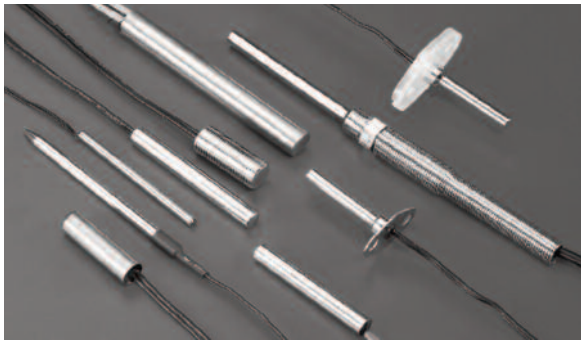
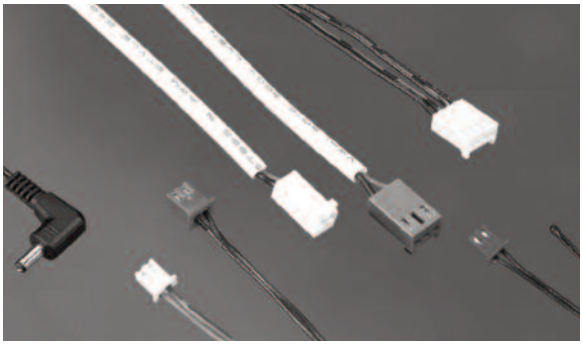
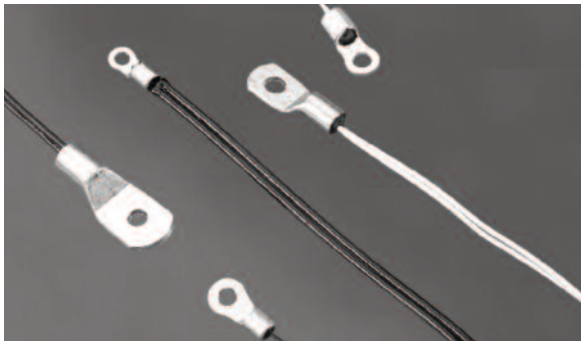
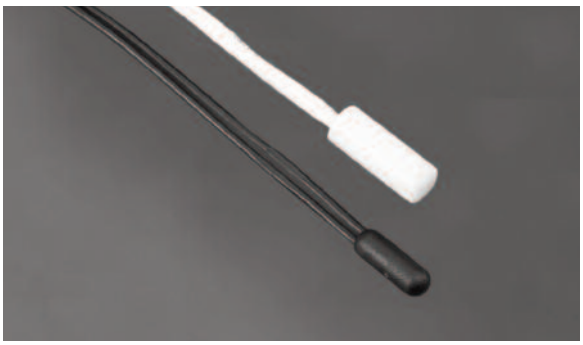
Custom NTC Thermistor Probes

CP Series









Temperature Sensor Applications

Household Appliances
- Dryers
- Heaters
- Toasters
- Refrigerators
- Coffee Makers
- Air Conditioners
- Washing Machines

Other Consumer Electronics
- Cooling Fan
- Battery Pack
- Wireless Card
- Audio Amplifiers
- Cellular Telephones
- Pool and Spa Control

Medical Electronics
- Infant Incubators
- Blood Analysis Equipment
- Skin Temperature Monitors
- Internal Temperature Sensor
- Respiration Rate Measurement
- Electronic Clinical Thermometer

Automotive
- Hybrid Battery Sensor
- Water / Oil Tank Sensor
- Automatic Climate Control
- Outside Air Temperature Sensor
- Engine Block Temperature Sensor

Industrial Electronics
- Fire Detectors
- Solar Collector
- HVAC Equipment
- Water Purification
- Plastic Laminating
- Vending Machines
- Welding Equipment
- Weather Monitoring
- Industrial Process Control
- Oceanography Monitoring
- Fruit Transportation Process Control

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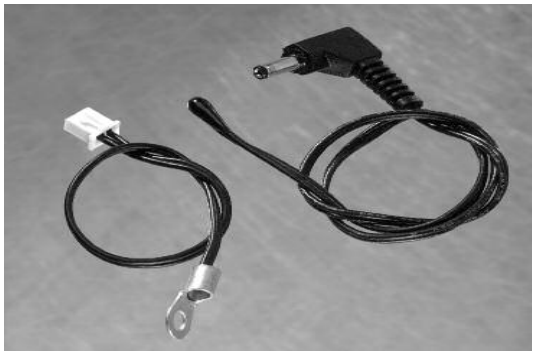
Custom NTC Thermistor Probes

CP Series



FEATURES

- Custom NTC thermistor probe assemblies
- Interchangeable or tolerance based assemblies
- Assemblies manufactured to meet your application
- RoHS Compliant

CP Series probes are designed to meet your specific application requirements. Custom probe designs have virtually unlimited options available. Their value-added features significantly reduce your labor costs.

Contact our applications engineering team for assistance to design, quote, and manufacture your custom NTC thermistor probe assembly.

SPECIFICATIONS

Temperature rating/ recommended operating	CP Series probes using an interchangeable IN Series or a tolerance based PM, Series Point matched thermistor may be intermittently cycled from -50ºC to 150ºC. Optimum stability is achieved when these thermistors are continuously operated at or below 125ºC.

Note: CP Series probes using a 250ºC rated DT Series can be intermittently operated from -50ºC to 250ºC with optimum stability when operated at or below 200ºC. A 300ºC rated DT or RG Series can be intermittently operated from -50ºC to 300ºC with optimum stability when operated at or below 260ºC.

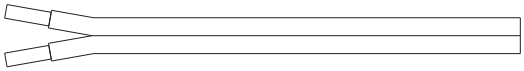
CP Series probes using interchangeable DT Series thermistors:
250ºC rated: Optimum stability is achieved when continuously operated at 180ºC or below.
300ºC rated: Optimum stability is achieved when continuously operated at 230ºC or below.

Resistance at 25°C	See CP Series ordering map - page 7
R-T curves	CP Series thermistors probes are available in all R-T curve materials. Detailed curve material information on pages 24-25.
Accuracies	±0.05°C, ±0.10°C, ±0.2°C, ±0.5°C, ±1.00°C
Accuracy temp ranges	See CP Series ordering map - page 7
Tolerances at 25°C	±1.0%, ±2.0%, ±3.0%, ±5.0%

Dissipation constant, thermal time constant and maximum power rating specifications vary depending on the discrete thermistor series used in the probe assembly.

Note: Selco can provide options such as corrosion resistant housings, plastic molded or over-molded housings, high pressure (PSI) rated housings, and moisture resistant thermistor probe assemblies. Contact Selco for more information.

The following are a few examples of the unlimited choices for the combination of wire and probe housings

Wire Styles	Configuration	Gauge	Insulation
	Single Conductor	18-32	PVC, XLPE Teflon
	Zipcord	22-30	PVC
	Jacketed	22-26	PVC, Teflon
	Twisted	22-24	PVC, Etched Teflon

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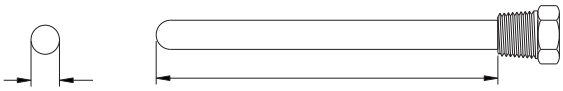
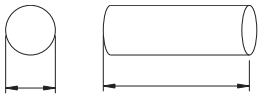
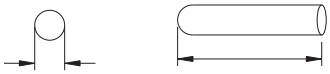
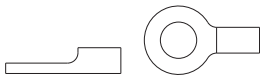
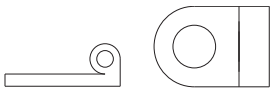
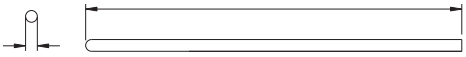
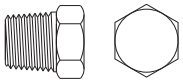
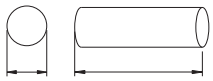
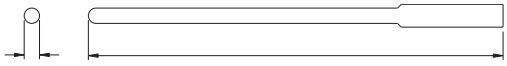
The following are a few examples of the unlimited choices for the combination of wire and probe housings

Housings	Type	Material
	Threaded NPT fitting round, close-end tube	Brass 316 Stainless Steel
	Flat closed-ended	PVC, Stainless Steel, Brass, Overmold
	Rounded, closed-end cup	Delrin, Stainless Steel, Brass, Overmold
	Ring lug terminal bolt	Steel, Copper
	Ring lug terminal bolt	Steel, Copper
	Probe	304 Stainless Steel, 316 Stainless Steel, Brass, Aluminum, Plastic
	Threaded NPT plug	304 Stainless Steel, 316 Stainless Steel, Brass, Aluminum, Plastic, Overmold
	Open-end tube	304 Stainless Steel, 316 Stainless Steel, Brass, Aluminum, Plastic
	Expanded Probe	304 Stainless Steel, 316 Stainless Steel, Brass, Aluminum, Plastic
	Tapered-end Probe	304 Stainless Steel, 316 Stainless Steel, Brass, Aluminum, Plastic
	Flange Mount Probe	304 Stainless Steel, 316 Stainless Steel, Brass, Aluminum, Plastic

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Custom NTC Thermistor Probes

CP Series - Ordering Map

ORDERING MAP

CP - _ _ _ _ _ - _ - X X X X

R-T Curve

A = Curve A	E = Curve E	H = Curve H
B = Curve B	F = Curve F	K = Curve K
C = Curve C	G = Curve G	P = Curve P
D = Curve D	X = New letter assigned for special curve	

Resistance at 25°C

0300 = 300 Ohms
001K = 1K Ohms
005K = 5K Ohms
006K = 6K Ohms
010K = 10K Ohms
100K = 100K Ohms
2252 = 2,252 Ohms
1MEG = 1 Million Ohms
X = Special base resistance value

IN Series Interchangeable Accuracies

A = ±1.0°C	D = ±0.1°C
B = ±0.5°C	E = ±0.05°C
C = ±0.2°C	X = Special

DT Series Interchangeable Accuracy

C = ±0.2°C

DT and RG Series Tolerance at 25°C
PM Series Tolerances at Point Matched Temperature

1 = ±1%	5 = ±5%
2 = ±2%	0 = ±10%
3 = ±3%	X = letter or digit assigned for specials

IN Series Accuracy Temperature Ranges

1 = 20°C to 45°C	6 = -40°C to 40°C
2 = -20°C to 50°C	7 = +50°C to 125°C
3 = 0°C to 70°C	8 = 0°C to 50°C
4 = 0°C to 100°C	9 = -20°C to 125°C
5 = +20°C to 90°C	X = Specials

DT Series Interchangeable Accuracy Temp. Range

3 = 0°C to 70°C

PM Series Point Matched Temperatures

A = -20°C	D = 37°C
B = 0°C	E = 70°C
C = 25°C	F = 100°C
X = Specials	

XXXX = System file number assigned

Note: 300°C rated DT Series thermistors may be identified as an option in the XXXX Special part number section of the catalog number.

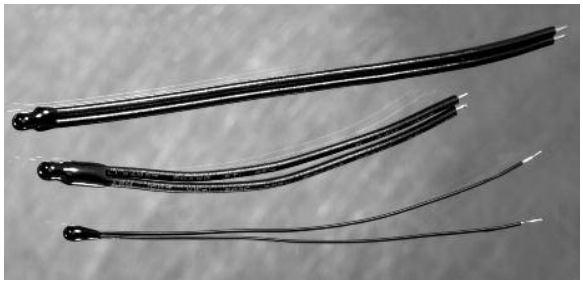
R-T Tables are listed on pages 24-25

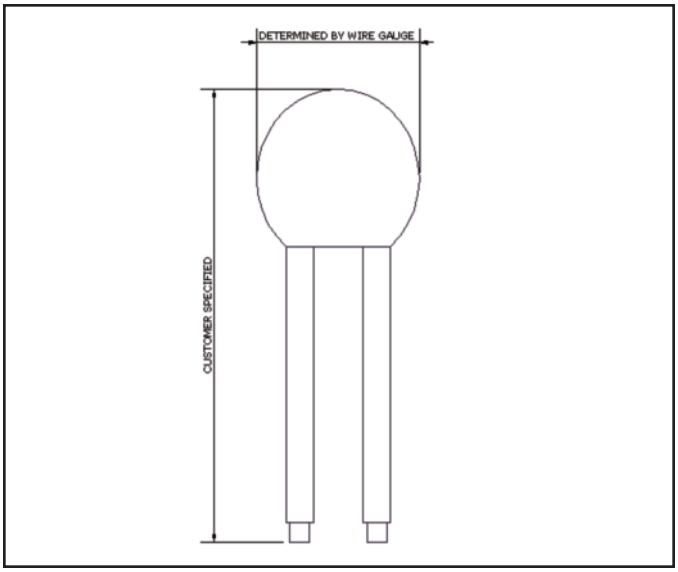
Note: Other thermistor base resistance values, thermistor curves or Beta values, or tolerances may be available. Please contact Selco Products.

TO ORDER SPECIFY ALL ITEMS BELOW

- **Lead length**
- **Wire gauge size**
- **Solid or stranded wire**
- **Probe type description**
- **Connectors if required (Molex, TE, or other)**
- **Blunt or stripped end and length of stripped wire**
- **Insulation material (Isomid, Kynar, Nylon, PVC, Teflon, etc.)**

Custom Epoxy NTC Thermistors
CS Series





FEATURES
- Epoxy encapsulated thermistors with insulated leads
- Application specific custom thermistors manufactured
- Interchangeable or tolerance based assemblies
- RoHS Compliant

CS Series thermistors are designed to meet your specific application requirements. For “turn-key” solutions, their value-added features can significantly reduce your labor costs. Contact your applications engineering personnel for assistance to design, quote and manufacture your custom CS thermistor.

SPECIFICATIONS

Temperature rating/ recommended operating ranges	CS Series probes using an interchangeable IN Series or a tolerance based PM Series thermistor may be intermittently cycled from -50°C to 150°C. Optimum stability is achieved when these thermistors are continuously operated at or below 125°C
Resistance at 25°C	See CS Series ordering map - page 9
R-T curves	CS Series thermistors are available in all R-T curve materials. R-T tables are available on pages 24-25.
Accuracies	±0.05°C, ±0.1°C, ±0.2°C, ±0.5°C ±1.0°C
Accuracy temp ranges	See CS Series ordering map - page 9
Tolerances at 25°C	±1%, ±2%, ±3%, ±5%, ±10%
Dissipation constant	Varies depending on the discrete series thermistor series used in the probe assembly
Thermal time constant	Typically 10.0 to 15.0 seconds in still air Typically 0.75 to 2.0 seconds in stirred oil
Maximum power rating	30 mW at 25°C to 1 mW at 100°C
Custom options	Various lead AWGs, insulation materials, lead lengths and connectors

Note: Several CS Series Thermistors are available with UL Component Recognition. Please contact Selco Products for availability.

Custom Epoxy NTC Thermistors

CS Series - Ordering Map

ORDERING MAP

CS - _ _ _ _ _ - _ _ - X X X X

R-T Curve

A = Curve A	E = Curve E	H = Curve H
B = Curve B	F = Curve F	K = Curve K
C = Curve C	G = Curve G	P = Curve P
D = Curve D	X = New letter assigned for special curve	

Resistance at 25°C

0300 = 300 Ohms
001K = 1K Ohms
005K = 5K Ohms
006K = 6K Ohms
010K = 10K Ohms
100K = 100K Ohms
2252 = 2,252 Ohms
1MEG = 1 Million Ohms
X = Special base resistance value

IN Series Interchangeable Accuracies

A = ±1.0°C	D = ±0.1°C
B = ±0.5°C	E = ±0.05°C
C = ±0.2°C	X = Special

PM Series at Point Matched Temperatures

1 = ±1%	5 = ±5%
2 = ±2%	0 = ±10%
3 = ±3%	X = Special

IN Series Accuracy Temperature Ranges

1 = +20°C to 45°C	6 = -40°C to 40°C
2 = -20°C to 50°C	7 = +50°C to 125°C
3 = 0°C to 70°C	8 = 0°C to 50°C
4 = 0°C to 100°C	9 = -20°C to 125°C
5 = +20°C to 90°C	X = Special

PM Series Point Matched Temperatures

A = -20°C	E = 70°C
B = 0°C	F = 100°C
C = 25°C	X = Special
D = 37°C	

XXXX = System file number assigned

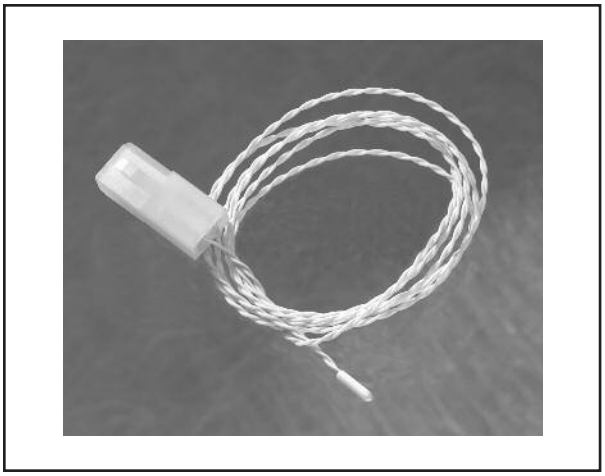
Note: Other thermistor base resistance values, thermistor curves or Beta values, or tolerances may be available. Please contact Selco Products.

TO ORDER SPECIFY ALL ITEMS BELOW

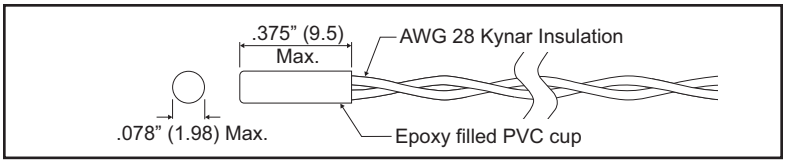
- **Lead wire length**
- **Wire gauge size**
- **Solid or stranded wire**
- **Connectors if required (Molex, TE, or other)**
- **Blunt or stripped end and length of stripped wire**
- **Insulation material (Isomid, Kynar, Nylon, PVC, Teflon, etc.)**

Tiny NTC Thermistor Probes

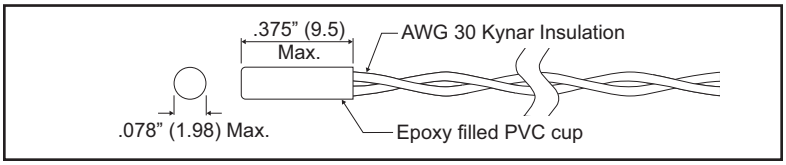
LS Series 0.078" (1.98) probe diameter



LS400 Series 2252 Ohms at 25°C "A" Curve



LS700 Series "A" or "B" Curve



Other values and curves available. Detailed values and curve information on pages 24-25.

FEATURES

- Interchangeable accuracies
- Moisture coating optional
- Quick Response
- RoHS Compliant

These LS series thermistors are precision thermistor assemblies and are an excellent choice for all types of applications. They are also very useful in applications where space is at a premium.

SPECIFICATIONS

Temperature rating/ recommended operating ranges	LS Series thermistors may be intermittently cycled at temperatures from -50°C to 150°C. Optimum stability is achieved when thermistors are operated at or below 125°C.	**Accuracies** **Accuracy temp range** **Tolerances at 25°C**	±0.1°C, ±0.2°C, ±0.5°C, ±1.0°C 0°C to 70°C ±1%, ±2%, ±3%, ±5%
Curves/Betas (25/85)	LS Series is manufactured with A curve (3977K) or B curve (3942K). Detailed curve material information on pages 24-25.	**Dissipation constant**	2.5 mW/°C in still air 13.0 mW/°C in stirred oil
		Thermal time constant	Typically 15 seconds in still air Typically 1.25 seconds in stirred oil
		Maximum power rating	10 mW at 25°C to 3.25 mW at 100°C

ORDERING MAPS

L S 4 0 0 A

Wire Gauge	R-T Curve	Resistance at 25°C	Accuracies over 0°C to 70°C	Tolerances at 25°C	Overall Length	Special Options
#28AWG	A = A Curve	2252 = 2,252 Ohms	A = ±1.0°C B = ±0.5°C C = ±0.2°C D = ±0.1°C	1 = ±1% 2 = ±2% 3 = ±3% 5 = ±5%	Example 04 = 4.0"	

Note: Other accuracy temperature ranges available upon request. Selco may be able to terminate connectors to the custom assemblies.

L S 7 0 0

Wire Gauge	R-T Curve	Resistance at 25°C	Accuracies over 0°C to 70°C	Tolerances at 25°C	Overall Length	Special Options
#30AWG	A = A Curve B = B Curve	006K = 6,000 Ohms 030K = 30,000 Ohms 100K = 100,000 Ohms	A = ±1.0°C B = ±0.5°C C = ±0.2°C D = ±0.1°C	1 = ±1% 2 = ±2% 3 = ±3% 5 = ±5%	Example 10 = 10.0"	

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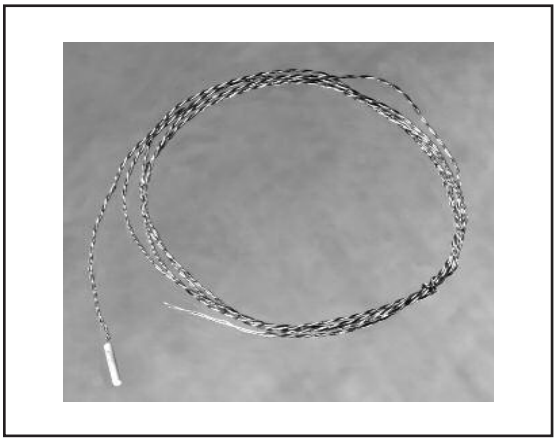
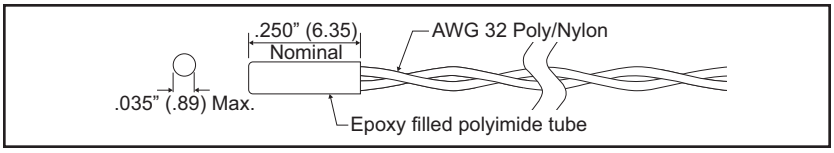
Miniature NTC Thermistor Probes

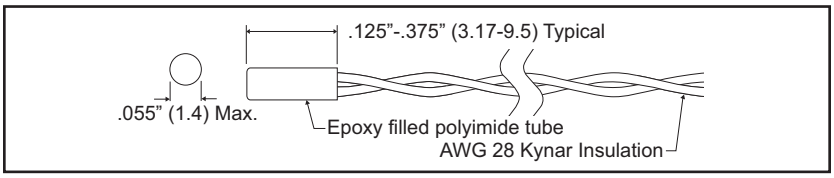
LSMN Series 0.035" (0.89) and 0.055" (1.40) probe diameters



LSMN 400 or 700 Series
400: 2252 Ohms at 25°C "A" Curve
700: "A" or "B" Curves



LSMN 400 Series
2252 Ohms at 25°C "A" Curve



Other base resistances may be available - Contact Selco. Detailed R-T table information can be found on pages 24-25.

FEATURES

- Interchangeable accuracies
- Quick response
- Moisture coating optional
- RoHS Compliant

These tiny thermistors can be used in applications that require fast response and small size. They feature interchangeable accuracies over 0°C to 70°C.

SPECIFICATIONS

Temperature rating/ recommended operating ranges	LSMN Series thermistors may be intermittently cycled at temperatures from -50°C to 150°C. Optimum stability is achieved when thermistors are operated at or below 125°C.	**Accuracies** **Accuracy temp range** **Tolerances at 25°C**	±0.1°C, ±0.2°C, ±0.5°C, ±1.0°C 0°C to 70°C ±1%, ±2% , ±3%, ±5%
Curves/Betas (25/85)	A curve (3977K) or B curve (3942K) Detailed curve material information on pages 24-25.	**Dissipation constant**	1.5 mW/°C in still air 10.0 mW/°C in stirred oil
		Thermal time constant	Typically 15.0 seconds in still air Typically 0.4 seconds in stirred oil
		Maximum power rating	10 mW at 25°C to 1mW at 100°C

ORDERING MAPS

LSMN400A

R-T Curve	Resistance at 25°C	Accuracies over 0°C to 70°C	Tolerances at 25°C	Wire Gauge and Probe Diameter	Overall Length or Special Options
A = A Curve	2252 = 2,252 Ohms	A = ±1.0°C B = ± 0.5°C C = ±0.2°C D = ±0.1°C	1 = ±1% 2 = ±2% 3 = ±3% 5 = ±5%	2 = #28AWG, 0.055" Probe Diameter 3 = #32AWG, 0.035" Probe Diameter	

LSMN700

R-T Curve	Resistance at 25°C	Accuracies over 0°C to 70°C	Tolerances at 25°C	Wire Gauge and Probe Maximum Diameter	Overall Length or Special Options
A = A Curve B = B Curve	006K = 6,000 Ohms 010K = 10,000 Ohms 030K = 30,000 Ohms	A = ±1.0°C B = ± 0.5°C C = ±0.2°C D = ±0.1°C	1 = ±1% 2 = ±2% 3 = ±3% 5 = ±5%	2 = #28AWG, 0.055" Probe Diameter 3 = #32AWG, 0.035" Probe Diameter	

Note: Other accuracy temperature ranges are available upon request.

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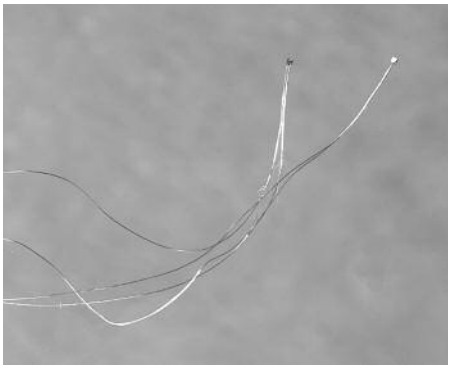
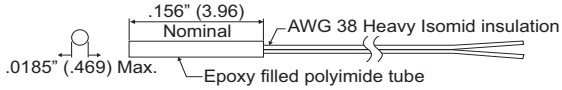
Micro NTC Thermistor Probes

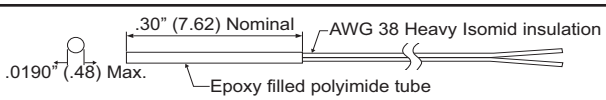
LSMC Series 0.0185" (0.469) and 0.0190" (0.0480) probe diameters



LSMC 700 Series
10K Ohms, 30K Ohms, or 100K Ohms at 25°C "A" Curve



LSMC 400 Series
2252 Ohms at 25°C "A" Curve



Other base resistances may be available - Contact Selco. Detailed R-T table information can be found on pages 24-25.

FEATURES

- Interchangeable accuracies
- Quick response
- Moisture coating optional
- RoHS Compliant

These tiny thermistors can be used in many Life Science applications. They are small enough to fit into a hypodermic needle. These quick response LSMC Series thermistors can be used to monitor temperature in many industry applications.

SPECIFICATIONS

Temperature rating/ recommended operating ranges	LSMC Series thermistors may be intermittently cycled at temperatures from -50°C to 150°C. Optimum stability is achieved when these thermistors are operated continuously at or below 125°C.	**Accuracies** **Accuracy Temp Range** **Tolerances at 25°C**	±0.1°C, ±0.2°C, ±0.5°C, ±1.0°C 0°C to 70°C ±1%, ±2% , ±3%, ±5%
Curves/Betas (25/85)	A curve (3977K) or B curve (3942K) Detailed curve material information on pages 24-25.	**Dissipation constant**	0.3 mW/°C in still air 2.5 mW/°C in stirred oil
		Thermal time constant	Typically 5.0 seconds in still air Typically 0.4 seconds in stirred oil
		Maximum power rating	10 mW at 25°C to 1 mW at 100°C

ORDERING MAP

L S M C 4 0 0 A

R-T Curve	Resistance at 25°C	Accuracies over 0°C to 70°C	Tolerances at 25°C	Overall Length or Special Options
A = A Curve	2252 = 2,252 Ohms	A = ±1.0°C B = ± 0.5°C C = ±0.2°C D = ±0.1°C	1 = ±1% 2 = ±2% 3 = ±3% 5 = ±5%	

L S M C 7 0 0 A

R-T Curve	Resistance at 25°C	Accuracies over 0°C to 70°C	Tolerances at 25°C	Overall Length or Special Options
A = A Curve	010K = 10,000 Ohms 030K = 30,000 Ohms 100K = 100,000 Ohms	A = ±1.0°C B = ± 0.5°C C = ±0.2°C D = ±0.1°C	1 = ±1% 2 = ±2% 3 = ±3% 5 = ±5%	

Note: Other accuracy temperature ranges are available upon request.

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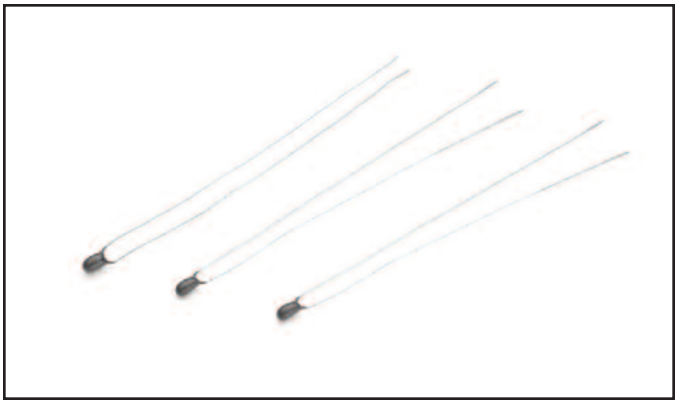
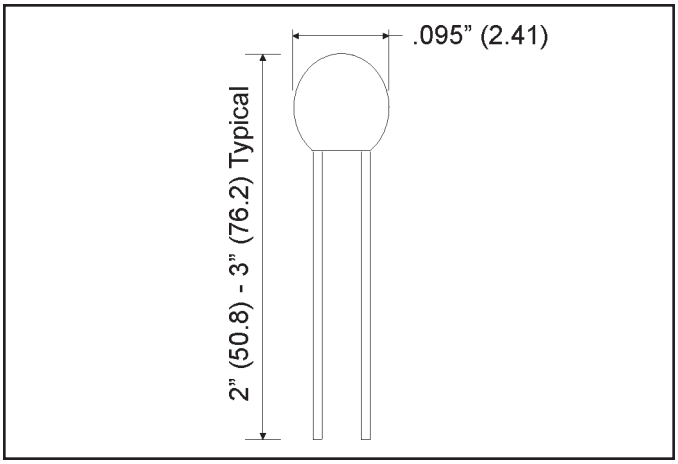
Interchangeable NTC Thermistors
IN Series





FEATURES
- Precision interchangeability
- Accuracies as high as ±0.05°C to ±0.10°C
- Quick thermal response
- Excellent field stability
- RoHS Compliant

Selco's IN Series NTC thermistors are interchangeable and have a variety of accuracy temperature range options. These IN Series thermistors can be PCB mounted or packaged in protective housings to meet application requirements

SPECIFICATIONS

Temperature rating/ recommended operating ranges	IN Series thermistors may be intermittently cycled at temperatures from -50°C to 150°C. Optimum stability is achieved when they are operated or below 125°C
Resistance at 25°C	See IN Series ordering map on page 14
Curves/Betas (25/85)	A Curve = 3977K B Curve = 3942K C Curve = 3695K D Curve = 4262K F Curve = 3435K K Curve = 3485K *Others available upon request*
Accuracies	±0.05°C ±0.10°C ±0.20°C ±0.50°C ±1.00°C

Accuracy temperature ranges	-20°C to 50°C 0°C to 50°C 20°C to 45°C 0°C to 70°C 0°C to 100°C	20°C to 90°C -40°C to 40°C 50°C to 125°C -20 to 125°C
Dissipation constant	3.0 mW/°C in still air 13.0 mW/°C in stirred oil	
Thermal time constant	Typically 15.0 seconds in still air Typically 0.75 seconds in stirred oil	
Maximum power rating	30 mW at 25°C to 1 mW at 100°C	

Note: The 10K Ohm base resistance, with a 3977K (25/85) Beta (A Curve), is UL 1434 certified.

ORDERING MAP

IN- ____ ____ ____ ____ ____ **-** ____ ____ ____ **- XX**

R-T Curve

A = Curve A	D = Curve D
B = Curve B	F = Curve F
C = Curve C	K = Curve K

X = New letter assigned for special curve

Resistance at 25°C

001K = 1K Ohms
003K = 3K Ohms
006K = 6K Ohms
010K = 10K Ohms
020K = 20K Ohms
030K = 30K Ohms
100K = 100K Ohms
2252 = 2,252 Ohms
X = special base resistance value

Interchangeable Accuracies

A = ±1.0°C	D = ±0.1°C
B = ±0.5°C	E = ±0.05°C
C = ±0.2°C	X = Special

Accuracy Temperature Ranges

1 = +20°C to 45°C	6 = -40°C to 40°C
2 = -20°C to 50°C	7 = +50°C to 125°C
3 = 0°C to 70°C	8 = 0°C to 50°C
4 = 0°C to 100°C	9 = -20°C to 125°
5 = +20°C to 90°C	X = new digit assigned for specials

2" Overall Length

Code	AWG	Lead O.D.	Lead Type	Chip Coating
05	26	0.0169"	Tinned Copper	Epoxy
06	28	0.0126"	Tinned Copper	Epoxy
07	32	0.008"	Tinned Copper	Epoxy
08	30	0.010"	Nickel	Epoxy
09	26	0.0159"	Tinned Alloy 180	Epoxy
10	26	0.0159"	Tinned Copper	Epoxy
11	32	0.008"	Nickel	Epoxy
12	32	0.008"	Tinned Copper	Epoxy
13	30	0.010"	Tinned Alloy 180	Epoxy
14	30	0.010"	Tinned Copper	Epoxy
16	28	0.0126"	Tinned Alloy 180	Epoxy
18	32	0.008"	Tinned Alloy 180	Epoxy
20	28	0.0126"	Nickel	Epoxy

3" Overall Length

Code	AWG	Lead O.D.	Lead Type	Chip Coating
21	32	0.008"	Nickel	Epoxy
22	32	0.008"	Tinned Copper	Epoxy
24	30	0.010"	Tinned Copper	Epoxy
26	28	0.0126"	Tinned Copper	Epoxy
28	32	0.008"	Tinned Alloy 180	Epoxy
30	30	0.010"	Tinned Alloy 180	Epoxy
31	30	0.010"	Teflon	Epoxy
41*	30	0.010"	Ag/Cu Twisted Kynar	Epoxy

* 6K to 30K only

For optional overall lengths other than 2" or 3" substitute XX with lengths in inches

Example: 04 = 4.0"

The ±0.05°C accuracy, over 0°C to 50°C, may be available with a number of base resistances and Betas. Please contact Selco for availability.

The IN Series 10K Ohm base resistance, with a 3977K Beta, has UL 1434 Certification. Contact Selco for assistance

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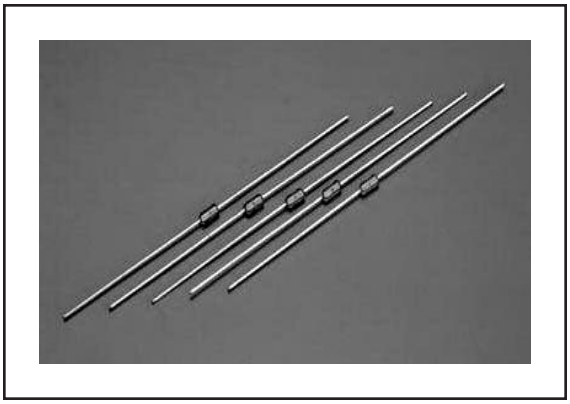
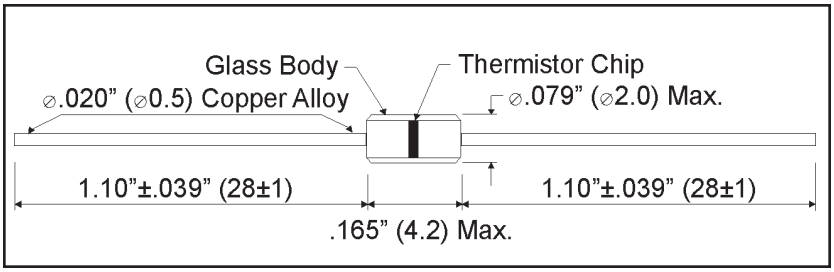
DO-35 Glass Encapsulated NTC Thermistors

DT Series





FEATURES

- Glass sealed body for high reliability
- Excellent thermal cycle endurance
- Optional interchangeable accuracy
- Some DTs with UL1434 Certification
- High stability and low cost
- Leads may be cut or formed
- 250C or 300C thermal rating
- RoHS Compliant

The DT thermistor is a DO-35 NTC thermistor and is available with a tolerance at 25°C or with an interchangeable accuracy of ±0.2°C over 0° to 70°C. This is highly stable thermistor can be PCB mounted or packaged in a protective housing to meet your application requirements.

SPECIFICATIONS

Temperature range	-50°C to 250°C
Continuous operating temp range	-50°C to 200°C
Optional temperature range	-50°C to 300°C
Continuous operating temp range	-50°C to 260°C
Resistance at 25°C	10,000 Ohms 15,000 Ohms 30,000 Ohms 47,000 Ohms 50,000 Ohms 100,000 Ohms 200,000 Ohms 500,000 Ohms
Curves/Betas (25/85)	A Curve = 3977K B Curve = 3942K D Curve = 4262K F Curve = 3425K Other Curves/Betas available upon request
Accuracy	±0.2°C over 0°C to 70°C
Tolerances at 25°C	±1%, ±3%, ±5%
Dissipation constant	2.0 mW/°C in still air 2.5 mW/°C in stirred oil
Thermal time constant	Typically 3.0 seconds in still air Typically 1.0 seconds in stirred oil
Maximum power rating	250 mW at 25°C to 100 mW at 100°C

ORDERING MAP

DT - - -

R-T Curve
A = Curve A
C = Curve C
D = Curve D
F = Curve F
X = Special

Resistance at 25°C
010K = 10K Ohms
015K = 15K Ohms
030K = 30K Ohms
047K = 47K Ohms
050K = 50K Ohms
100K = 100K Ohms
200K = 200K Ohms
500K = 500K Ohms
X = Special base resistance value

Accuracies
C = ±0.2°C

Tolerances at 25°C
1 = ±1%
3 = ±3%
5 = ±5%

Accuracy Temperature Range
3 = 0°C to 70°C
Tolerance
0 = *

Optional 300°C Rating
H = 300°C rating

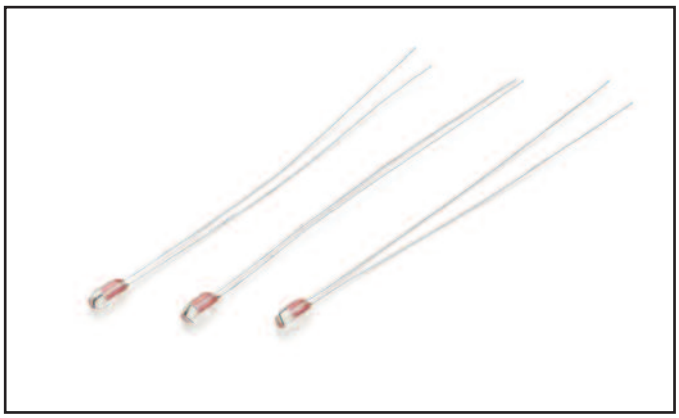
Optional Special Specification

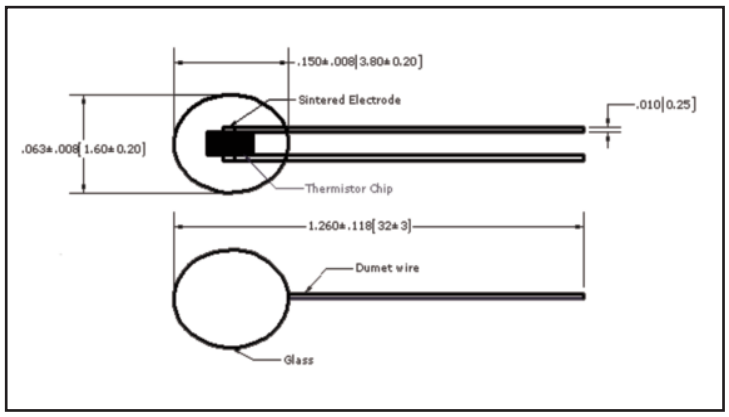
**Use 0 when the DT series is tolerance based and has a 300°C maximum temperature rating.*

Note: Some of the DT Series part numbers may have UL 1434 certification. Please contact Selco Products or visit our website for availability.

Radial Glass Bead Thermistors

RG Series





FEATURES

- Glass sealed radial lead thermistors
- Quick response time
- Excellent stability and moisture resistance
- RoHS Compliant

These tiny radial glass bead thermistors are moisture resistant. They can be PCB mounted or easily packaged into small diameter custom probe assemblies.

SPECIFICATIONS

Temperature range	-50°C to 300°C
Continuous operating temp range	-50°C to 260°C
Resistance at 25°C	10,000 Ohms 50,000 Ohms 100,000 Ohms
Curves/Betas (25/85)	A Curve = 3977K F Curve = 3435K
Tolerances at 25°C	±1%, ±2%, ±3%, ±5%
Dissipation constant	1.3 mW/°C in still air 3.0 mW/°C in stirred oil
Thermal time constant	Typically 13.0 seconds in still air Typically 2.9 seconds in stirred oil
Maximum power rating	10 mW at 25°C to 2.87 mW at 100°C

ORDERING MAP

R G - ____ ____ ____ ____ **-** ____ ____ ____ ____ ____

R-T Curve
A = Curve A
F = Curve F
X = New letter assigned for special curve

Resistance at 25°C
010K = 10K Ohms
050K = 50K Ohms
100K = 100K Ohms

Tolerance at 25°C
1 = ±1%
2 = ±2%
3 = ±3%
5 = ±5%

Glass Bead Diameter
A = 0.063”

Optional Special Specification

Note: Other glass bead diameters may be available upon request

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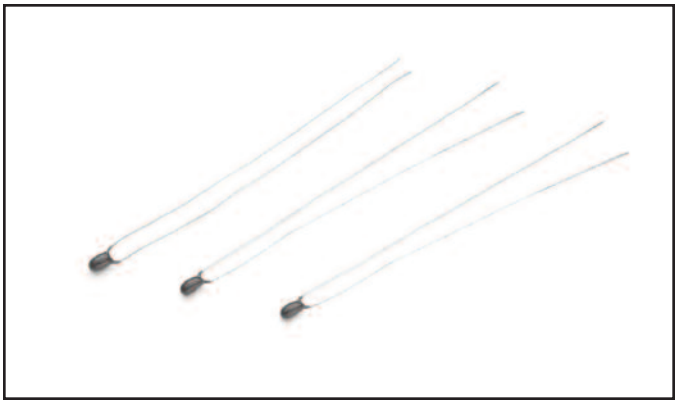
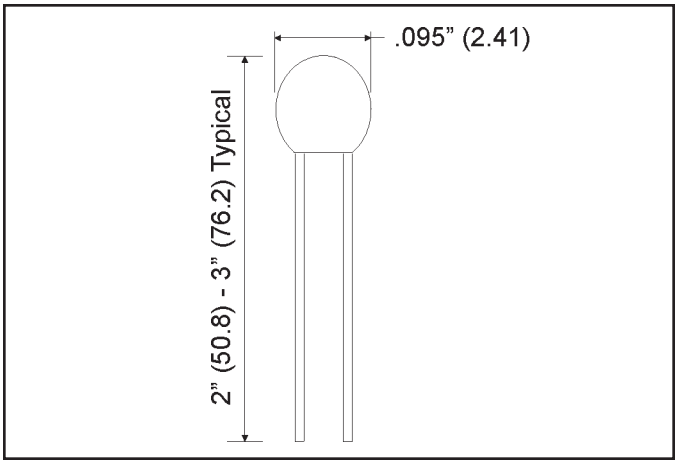
Point Matched NTC Thermistors

PM Series





FEATURES

- Tolerance resistance matched to specific temperature
- Excellent field stability
- Cost effective discrete thermistor
- RoHS Compliant

PM Series thermistors are precision tested at a chosen tolerance for a specific temperature. This cost effective thermistor provides an advantage to industries with high volume applications, such as in HVAC, automotive, and industrial markets.

SPECIFICATIONS

Temperature rating/ recommended operating ranges	PM Series thermistors may be intermittently cycled at temperatures from -50°C to 150°C. Optimum stability is achieved when they operated at or below 125°C
Curves/Betas (25/85)	A Curve = 3977K B Curve = 3942K C Curve = 3695K D Curve = 4262K F Curve = 3435K
Tolerances at temperature points	±1.0°C ±1% ±2% ±3% ±5% ±10%
Temperature points	-20°C 0°C 25°C 37°C 70°C 100°C ***Other temperature points available upon request***
Dissipation constant	3.0 mW/°C in still air 13.0 mW/°C in stirred oil
Thermal time constant	Typically 15.0 seconds in still air Typically 0.75 seconds in stirred oil
Maximum power rating	30 mW at 25°C to 1mW at 100°C

ORDERING MAP

PM - _____ - _____ - XX

R-T Curve

A = Curve A
B = Curve B
C = Curve C
D = Curve D
F = Curve F
X = New letter assigned for special curve

Resistance at 25°C

001K = 1K Ohms
005K = 5K Ohms
006K = 6K Ohms
010K = 10K Ohms
100K = 100K Ohms
2252 = 2,252 Ohms
1MEG = 1 Million Ohms
X = Special base resistance value

Tolerance at Temperature Point

1 = ±1%
2 = ±2%
3 = ±3%
5 = ±5%
0 = ±10%
A = 1.0°C
X = Special

Temperature Points

A = -20°C
B = 0°C
C = 25°C
D = 37°C
E = 70°C
F = 100°C
X = Specials

2" Overall Length

Code	AWG	Lead O.D.	Lead Type	Chip Coating
05	26	0.0169"	Tinned Copper	Epoxy
06	28	0.0126"	Tinned Copper	Epoxy
07	32	0.008"	Tinned Copper	Epoxy
08	30	0.010"	Nickel	Epoxy
09	26	0.0159"	Tinned Alloy 180	Epoxy
10	26	0.0159"	Tinned Copper	Epoxy
11	32	0.008"	Nickel	Epoxy
12	32	0.008"	Tinned Copper	Epoxy
13	30	0.010"	Tinned Alloy 180	Epoxy
14	30	0.010"	Tinned Copper	Epoxy
16	28	0.0126"	Tinned Alloy 180	Epoxy
18	32	0.008"	Tinned Alloy	Epoxy
20	28	0.0126"	Nickel	Epoxy

3" Overall Length

Code	AWG	Lead O.D.	Lead Type	Chip Coating
21	32	0.008"	Nickel	Epoxy
22	32	0.008"	Tinned Copper	Epoxy
24	30	0.010"	Tinned Copper	Epoxy
26	28	0.0126"	Tinned Copper	Epoxy
28	32	0.008"	Tinned Alloy 180	Epoxy
30	30	0.010"	Tinned Alloy 180	Epoxy
31	30	0.010"	Teflon	Epoxy
41*	30	0.010"	Ag/Cu Twisted Kynar	Epoxy

* 6K to 30K only

For optional overall lengths other than 2" or 3" substitute XX with lengths in inches
Example: 04 = 4.0"

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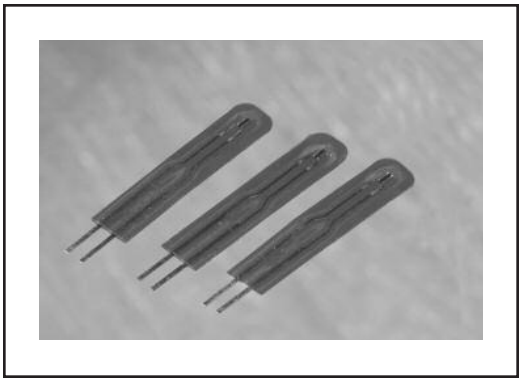
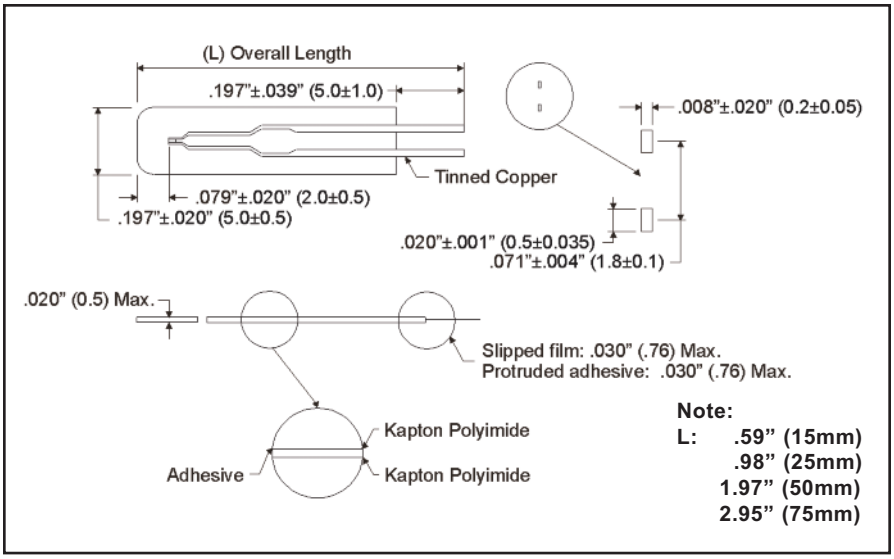
Thin Film NTC Thermistors
TF Series





FEATURES
- UL 1434 certified
- Thin film insulated
- Leads can be attached
- RoHS compliant

The TF Series thin film thermistor is able to monitor temperature in small spaces and is perfect for battery pack or charger applications.

SPECIFICATIONS

Temperature range	-50°C to 90°C	**Dissipation constant**	0.3 mW/°C in still air 0.7 mW/°C in stirred oil
Continuous operating temp range	-50°C to 76°C		
Optional temperature range	-50°C to 125°C	**Thermal time constant**	Typically 2.0 seconds in still air Typically 0.8 seconds in stirred oil
Continuous operating temp range	-50°C to 105°C		
Resistance at 25°C	10,000 Ohms	**Maximum power rating**	3.5 mW at 25°C to 1.1 mW at 100°C
Curves/Betas (25/85)	A Curve=3977K F Curve=3435K		
Tolerances at 25°C	±1% ±3% ±5%		

ORDERING MAP

TF - __ - 010K - __ - __ __ __ __ __

R-T Curve
A = A Curve
F = Curve F
X = Special

Resistance at 25°C
010K = 10K Ohms
X = Special base resistance value

Tolerances
1 = ±1%
3 = ±3%
5 = ±5%

Overall Length
1 = .59" (15mm)
2 = .98" (25mm)
3 = 1.97" (50mm)
4 = 2.95" (75mm)

Optional Special Specification

Note: TF Series thermistors are UL certified.
Note: 125°C temperature rating is identified by optional special specification

Note: Other thermistor base resistance values, thermistor curves or Beta values, or tolerances may be available. Please contact Selco Products.

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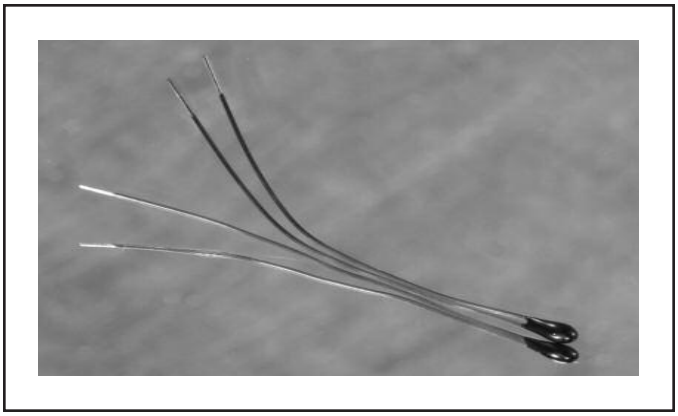
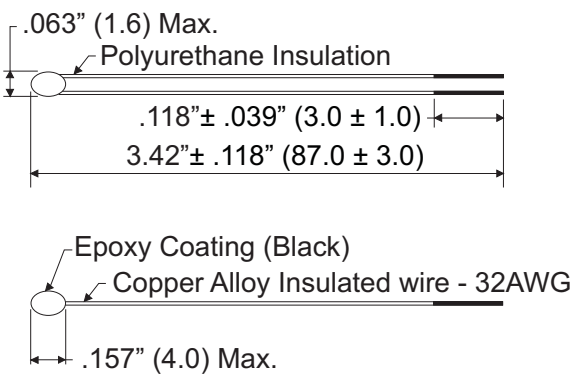
Insulated Lead Epoxy Thermistors
TS Series





FEATURES
- Quick response time
- Bead diameter of 0.063"
- Polyurethane insulated leads
- RoHS Compliant

The TS Series thermistor features a very small bead, insulated leads, and quick thermal time constant.

SPECIFICATIONS

Temperature range	-50°C to 110°C
Continuous operating temp range	-50°C to 92°C
Resistance at 25°C	1,000 Ohms 2,000 Ohms 2,252 Ohms 4,000 Ohms 5,000 Ohms 10,000 Ohms 20,000 Ohms 30,000 Ohms 50,000 Ohms 100,000 Ohms 232,000 Ohms
Curves/Betas (25/85)	A = Curve A B = Curve B C = Curve C D = Curve D F = Curve F X = New letter assigned for special curve
Tolerances at 25°C	±1%, ±3%, ±5%
Dissipation constant	0.3 mW/°C in still air 0.7 mW/°C in stirred oil
Thermal time constant	Typically 1.0 seconds in still air Typically 0.8 seconds in stirred oil
Maximum power rating	3.5 mW at 25°C to 1.25 mW at 100°C

ORDERING MAP

TS - _ _ _ _ - _ _ _ _ _

R-T Curve
A = Curve A
B = Curve B
C = Curve C
D = Curve D
F = Curve F
X = New letter assigned for special curve

Resistance at 25°C
001K = 1K Ohms
002K = 2K Ohms
2252 = 2252 Ohms
004K = 4K Ohms
005K = 5K Ohms
010K = 10K Ohms
020K = 20K Ohms
030K = 30K Ohms
050K = 50K Ohms
100K = 100K Ohms
232K = 232K Ohms
X = Special base resistance value

Tolerance at 25°C
1 = ±1%
3 = ±3%
5 = ±5%

Optional Special Specification

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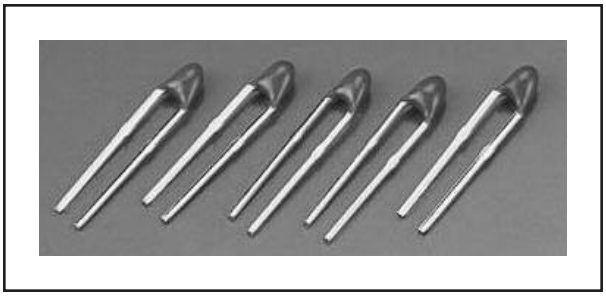
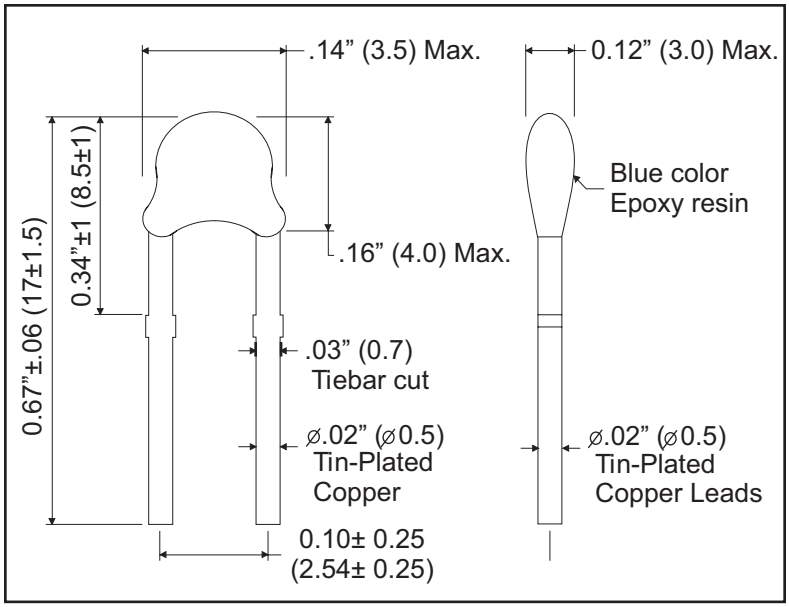
Short Lead NTC Epoxy Thermistors

HP Series





FEATURES

- High stability and low cost
- Tiebar cut allows consistent PCB placement
- RoHS Compliant

The HP thermistor is a low cost, tolerance based thermistor.

SPECIFICATIONS

Temperature range	-50°C to 110°C
Continuous operating temp range	-50°C to 92°C
Resistance at 25°C	1,000 Ohms 2,000 Ohms 5,000 Ohms 10,000 Ohms 20,000 Ohms 47,000 Ohms 100,000 Ohms
Curves/Betas (25/85)	A Curve = 3977K B Curve = 3942K C Curve = 3695K D Curve = 4162K F Curve = 3435K
Tolerances at 25°C	±1%, ±3%, ±5%
Dissipation constant	0.5 mW/°C in still air 2.0 mW/°C in stirred oil
Thermal time constant	Typically 3.0 seconds in still air Typically 0.9 seconds in stirred oil
Maximum power rating	10 mW at 25°C to 0.25 mW at 100°C

ORDERING MAP

HP - _____ - _____ - _____

R-T Curve

A = Curve A
B = Curve B
C = Curve C
D = Curve D
F = Curve F
X = New letter assigned for special curve

Resistance at 25°C

001K = 1K Ohms
002K = 2K Ohms
005K = 5K Ohms
010K = 10K Ohms
020K = 20K Ohms
047K = 47K Ohms
100K = 100K Ohms
X = Special base resistance value

Tolerances

1 = ±1%
3 = ±3%
5 = ±5%

Optional Special Specification

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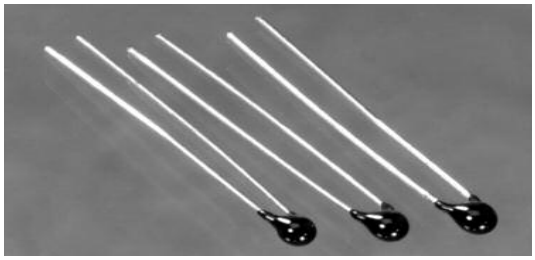
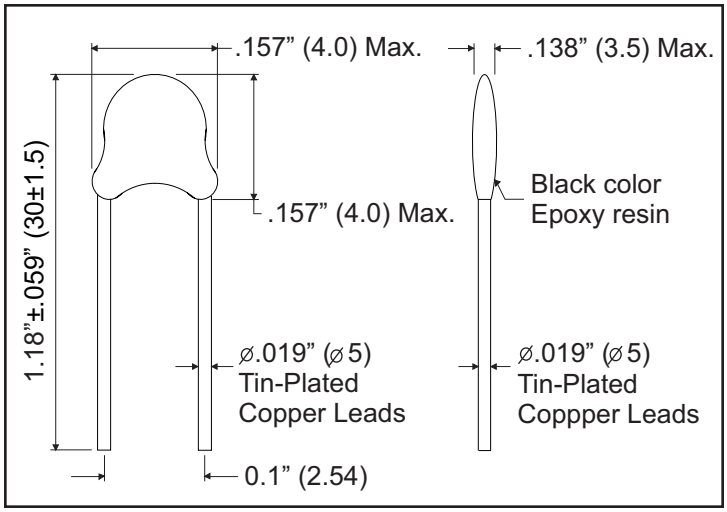
Long Lead NTC Epoxy Thermistors

HT Series





FEATURES

- High stability/low cost
- Long leads for PCB positioning
- RoHS compliant

The HT thermistor is a low-cost, tolerance based thermistor with longer leads than the HP Series.

SPECIFICATIONS

Temperature range	-50°C to 110°C
Continuous operating temp range	-50°C to 92°C
Resistance at 25°C	1,000 Ohms 2,000 Ohms 5,000 Ohms 10,000 Ohms 20,000 Ohms 47,000 Ohms 100,000 Ohms
Curves/Betas (25/85)	A Curve = 3977K B Curve = 3942K C Curve = 3695K D Curve = 4262K F Curve = 3435K
Tolerances at 25°C	±1%, ±3%, ±5%
Dissipation constant	0.5 mW/°C in still air 2.0 mW/°C in stirred oil
Thermal time constant	Typically 3.0 seconds in still air Typically 0.9 seconds in stirred oil
Maximum power rating	12 mW at 25°C to 0.25 mW at 100°C

ORDERING MAP

HT - _ _ _ _ _ - _ - _ _ _ _

R-T Curve

A = Curve A
B = Curve B
C = Curve C
D = Curve D
F = Curve F
X = New letter assigned for special curve

Resistance at 25°C

001K = 1K Ohms
002K = 2K Ohms
005K = 5K Ohms
010K = 10K Ohms
020K = 20K Ohms
047K = 47K Ohms
100K = 100K Ohms
X = Special

Tolerances

1 = ±1%
3 = ±3%
5 = ±5%

Optional Special Specification

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Thermistor Definition

The word thermistor is derived from its description “thermal sensitive resistor” Thermistors are passive semiconductors, which produce resistance values dependent on temperature.

A Negative Temperature Coefficient (NTC) thermistor decreases in resistance as its body temperature increases. In fact, NTC thermistors exhibit two characteristics, which make them extremely useful in a variety of applications. Their change in resistance is predictable and it is relatively large per degree change in temperature.

Manufacturing Process

This is a two-step process of chip manufacturing and thermistor assembly. Manufactured chips are processed by metal oxide powders into ceramic sheets. These sheets are metalized with silver to allow for electrical contact. After metalization, the ceramic sheets are diced into chips. Each chip is tested to meet our superior quality standards.

After a chip has been manufactured and tested, leads are attached. The chip is trimmed to meet the specified tolerance, and then a protective coating is added. Further customizing of the assembly can be done by adding housings, cables, and connectors.

Thermistor quality is assured with in-process inspection and Statistical Process Control (SPC). This process takes place at each manufacturing and assembly step. All finished products are 100% tested both electrically and mechanically to guarantee all specifications are met.

Resistance-Temperature (R/T) Curves and Negative Temperature Coefficient

Nine different materials are made, each with its own unique and predictable resistance-temperature characteristics. These characteristics are called ‘curves’. Thermistors are most often specified by their curve and by their resistance value at 25°C.

The NTC (Negative Temperature Coefficient) is the negative percent resistance change per degree C. Our thermistors have NTC values at 25°C ranging from -3.7%/°C to -6.4%/°C. Resistance values at 25°C range from 300 ohms to 1 meg ohms. The tables on pages 26-27 detail this information.

Thermal Time Constant

Time constant, expressed in seconds, is the time required for a thermistor to indicate 63.2% of a newly impressed temperature. The time constant of a thermistor is directly affected by the mass of the thermistor and thermal coupling to the environment. An epoxy or phenolic coated thermistor with a 0.095” O.D., will typically have a time constant of 0.75 seconds in stirred oil and 10 seconds in still air.

Dissipation Constant

Dissipation constant is the power required to raise the temperature of a thermistor 1°C above the surrounding environment. Power is expressed in watts. The dissipation constant of a thermistor with a 0.095” O.D., coated with epoxy or phenolic, is typically 13 mW/°C in stirred oil and 2 mW/°C in still air.

Voltage/Current Requirements

Very low current is required for a thermistor being used in temperature measurement, control or compensation applications. Current levels should typically be less than 100mA for a thermistor to dissipate “zero power”. As previously discussed, power dissipation for a thermistor in still air is approximately 2mW/°C. Therefore, in order to keep the thermal error (self-heat) below 0.1°C, the power dissipation must be less than 0.2 mW.

Self-heating is desirable in applications such as air flow measurement and liquid level control. Standard epoxy or phenolic coated thermistors with a 0.095” O.D., have a maximum power rating of 30 milliwatts at 25°C to 1 milliwatt at 100°C.

Beta

The Beta value describes the steepness of R/T curve. The larger value Beta equals a steeper R/T curve. The Beta value of a thermistor is one way to characterize its resistance temperature relationship. Beta is dependent on two reference temperatures. Selco Products uses 25°C and 85°C as its standard. Beta is calculated as follows:

$$\beta\ T2/T1 = Ln(RT2/RT1)/(1T2 - 1T/1)$$

Temperature is in degrees Kelvin; RT1 is the resistance at temperature T1; RT2 is the resistance at temperature T2.

Steinhart-Hart Equation

The Steinhart-Hart Equation is an empirically developed polynomial which best represents the resistance-temperature relationships of NTC thermistors. The Steinhart-Hart Equation is more accurate than previous methods. Specifically, it is more accurate over wider temperature ranges. To solve temperature when resistance is known, the form of the equation is:

$$1/T=a+b(Ln(R))+c(Ln(R))^3$$

To solve for resistance when temperature is known, the form of the equation is:

$$R=e(\exp)[-a/2+(a^2/4+a^3/27)^{-2})^{-3}+(-a/2-(a^2/4+a^3/27)^2)^3]$$

where alpha = (a-1/T)/c and β = b/c

For both forms of the equation T is temperature expressed in degrees Kelvin; a, b, and c can be solved simultaneously using the following:

$$1/T1=a+b(LnR1)+c(LnR1)^3$$

$$1/T2=a+b(LnR2)+c(LnR2)^3$$

$$1/T3=a+b(LnR3)+c(LnR3)^3$$

The data calculated by these equations will be accurate to better than ±0.01°C when -40°C is less than or equal to 150°C and |T1-T2| is less than or equal to 50°C and |T2-T3| is less than or equal to 50°C and T1, T2, and T3 are evenly spaced.

Maximum Temperature Rating/Recommended Operating Ranges

Our thermistors may be intermittently cycled at temperatures from -50°C to 150°C. Stability is achieved when the thermistors are stored at temperatures less than 50°C and operated continuously at temperatures less than 100°C. The DT Series thermistor has a temperature range from -50°C to +250°C. For interchangeable thermistors, optimum stability is achieved when the thermistors are operated at temperatures within the specified temperature range.

Stability

Years of experience in thermistor manufacturing, coupled with stringent process controls, ensures that highly stable thermistors are produced. In fact, our thermistors typically exhibit less than 0.02°C thermometric drift per year when stored or operated at temperatures less than 50°C. The stability of a thermistor is greatly dependent on environmental conditions such as humidity, excessive temperatures and thermal shock. These effects should be minimized to guarantee stability.

Resistance - Temperature Table

Ratio is the resistance at temperature divided by the resistance at 25°C. To find the actual resistance value at the temperatures listed in the charts, multiply the R25 value by the number listed in the Ratio column next to the corresponding temperature.

As an example, a Curve A thermistor with a temperature tolerance of ±1°C over the temperature range 0° to 70°C would have the following resistance tolerance: 0°C = ±5.1%; 25°C = ±4.4%; 70°C = ±3.4%

NTC (Negative Temperature Coefficient) is the negative percent resistance change per degree C. To determine the resistance tolerance of a precision thermistor at any temperature point multiply the temperature tolerance times the NTC.

	Curve A		Curve B		Curve C		Curve D		Curve E	
β at 25°C/85°C	3977K		3942K		3695K		4262K		4434K	
β at 0°C/50°C	3892K		3813K		3575K		4141K		4276K	
Temperature °C	Typical R_{25} = 1K to 100K		Typical R_{25} = 10K to 100K		Typical R_{25} = 5K to 20K		Typical R_{25} = 25K to 100K		Typical R_{25} = 1K to 200K	
	R_T/R_{25} RATIO		R_T/R_{25} RATIO		R_T/R_{25} RATIO		R_T/R_{25} RATIO		R_T/R_{25} RATIO	
	RATIO	NTC	RATIO	NTC	RATIO	NTC	RATIO	NTC	RATIO	NTC
-50	67.13	7.1	56.39	6.7	44.13	6.3	82.36	7.4	89.69	7.4
-45	47.26	6.9	40.56	6.5	32.36	6.1	57.30	7.1	62.25	7.2
-40	33.69	6.7	29.48	6.3	23.97	5.9	40.34	6.9	43.69	7.0
-35	24.29	6.4	21.64	6.1	17.92	5.3	28.72	6.7	30.98	6.8
-30	17.71	6.2	16.03	5.9	13.52	5.6	20.67	6.5	22.20	6.6
-25	13.05	6.0	11.99	5.7	10.29	5.4	15.02	6.3	16.06	6.4
-20	9.711	5.8	9.040	5.6	7.891	5.2	11.03	6.1	11.73	6.2
-15	7.297	5.6	6.875	5.4	6.102	5.1	8.174	5.9	8.644	6.0
-10	5.534	5.4	5.270	5.2	4.754	4.9	6.113	5.7	6.425	5.8
-5	4.234	5.3	4.071	5.1	3.731	4.8	4.611	5.6	4.816	5.7
0	3.266	5.1	3.168	4.9	2.949	4.6	3.507	5.4	3.638	5.5
5	2.540	5.0	2.483	4.8	2.346	4.5	2.689	5.2	2.770	5.4
10	1.991	4.8	1.959	4.7	1.879	4.4	2.077	5.1	2.125	5.2
15	1.572	4.7	1.556	4.5	1.514	4.3	1.617	4.9	1.642	5.1
20	1.249	4.5	1.244	4.4	1.227	4.1	1.267	4.8	1.277	5.0
25	1.000	4.4	1.000	4.3	1.000	4.0	1.000	4.7	1.000	4.8
30	0.8056	4.3	0.8088	4.2	0.8196	3.9	0.7943	4.5	0.7881	4.7
35	0.6530	4.1	0.6579	4.1	0.6754	3.8	0.6349	4.4	0.6250	4.6
37	0.6014	4.1	0.6066	4.0	0.6260	3.8	0.5815	4.4	0.5706	4.5
40	0.5325	4.0	0.5380	4.0	0.5594	3.7	0.5106	4.3	0.4986	4.5
45	0.4367	3.9	0.4423	3.9	0.4655	3.6	0.4130	4.2	0.4001	4.3
50	0.3601	3.8	0.3654	3.8	0.3893	3.5	0.3359	4.1	0.3228	4.2
55	0.2985	3.7	0.3034	3.7	0.3270	3.4	0.2747	4.0	0.2619	4.1
60	0.2487	3.6	0.2531	3.6	0.2760	3.4	0.2259	3.9	0.2136	4.0
65	0.2082	3.5	0.2121	3.5	0.2338	3.3	0.1866	3.8	0.1750	3.9
70	0.1752	3.4	0.1785	3.4	0.1990	3.2	0.1549	3.7	0.1441	3.8
75	0.1480	3.3	0.1508	3.3	0.1700	3.1	0.1293	3.6	0.1193	3.7
80	0.1256	3.2	0.1280	3.2	0.1457	3.0	0.1083	3.5	0.09915	3.7
85	0.1071	3.2	0.1091	3.2	0.1254	3.0	0.09115	3.4	0.08278	3.6
90	0.09161	3.1	0.09327	3.1	0.1084	2.9	0.07704	3.3	0.06941	3.5
95	0.07870	3.0	0.08006	3.0	0.09392	2.8	0.06538	3.2	0.05844	3.4
100	0.06786	2.9	0.06897	2.9	0.08168	2.8	0.05570	3.2	0.04940	3.3
105	0.05873	2.9	0.05962	2.9	0.07127	2.7	0.04764	3.1	0.04192	3.2
110	0.05100	2.8	0.05171	2.8	0.06237	2.6	0.04089	3.0	0.03571	3.2
115	0.04444	2.7	0.04500	2.8	0.05476	2.6	0.03522	2.9	0.03053	3.1
120	0.03885	2.7	0.03928	2.7	0.04821	2.5	0.03045	2.9	0.02619	3.0
125	0.03408	2.6	0.03439	2.6	0.04257	2.5	0.02641	2.8	0.02254	3.0
130	0.02997	2.5	0.03020	2.6	0.03769	2.4	0.02298	2.8	0.01947	2.9
135	0.02645	2.5	0.02660	2.5	0.03346	2.4	0.02006	2.7	0.01687	2.8
140	0.02340	2.4	0.02349	2.5	0.02979	2.3	0.01756	2.6	0.01467	2.8
145	0.02076	2.4	0.02080	2.4	0.02658	2.3	0.01542	2.6	0.01279	2.7
150	0.01487	2.3	0.01846	2.4	0.02377	2.2	0.01358	2.5	0.01118	2.7

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Resistance - Temperature Table

	Curve F		Curve G		Curve H		Curve I		Curve K		Curve P	
β at 25°C/85°C	3435K		4390K		4847K		3535K		3485K		4144K	
β at 0°C/50°C	3320K		4269K		4669K		3419K		3405K		3988K	
Temperature °C	Typical R_{25} = 10K		Typical R_{25} = 10K		Typical R_{25} = 1MEG		Typical R_{25} = 2K to 20K		Typical R_{25} = 200 to 2K		Typical R_{25} = 100K	
	R_T/R_{25} RATIO		R_T/R_{25} RATIO		R_T/R_{25} RATIO		R_T/R_{25} RATIO		R_T/R_{25} RATIO		R_T/R_{25} RATIO	
	RATIO	NTC	RATIO	NTC	RATIO	NTC	RATIO	NTC	RATIO	NTC	RATIO	NTC
-50	32.95	6.2	95.84	8.1					39.18	6.2		
-45	24.77	6.0	65.66	7.8					28.88	6.0		
-40	18.85	5.8	45.72	7.5			20.68	6.0	21.50	5.8	33.58	6.5
-35	14.41	5.6	32.06	7.2			15.67	5.7	16.18	5.6	24.41	6.3
-30	11.13	5.4	22.82	7.0			11.998	5.5	12.28	5.4	17.91	6.3
-25	8.643	5.2	16.37	6.7			9.241	5.3	9.415	5.2	13.26	5.9
-20	6.777	5.0	11.91	6.5	14.65	6.1	7.189	5.2	7.278	5.1	9.898	5.8
-15	5.341	4.8	8.727	6.3	10.51	6.6	5.623	5.0	5.673	4.9	7.452	5.6
-10	4.247	4.7	6.472	6.0	7.607	6.4	4.439	4.8	4.457	4.7	5.655	5.4
-5	3.39	4.5	4.834	5.8	5.556	6.2	3.518	4.7	3.528	4.6	4.325	5.3
0	2.728	4.4	3.65	5.7	4.093	6.0	2.812	4.5	2.813	4.5	3.331	5.1
5	2.205	4.2	2.772	5.5	3.041	5.9	2.258	4.4	2.259	4.3	2.585	5.0
10	1.796	4.1	2.125	5.3	2.277	5.7	1.828	4.2	1.826	4.2	2.019	4.9
15	1.469	4.0	1.64	5.1	1.718	5.6	1.486	4.1	1.485	4.1	1.587	4.7
20	1.209	3.9	1.277	5.0	1.306	5.4	1.16	4.0	1.215	4.0	1.256	4.6
25	1.000	3.7	1.000	4.8	1.000	5.3	1.000	3.9	1.000	3.8	1.000	4.5
30	0.8313	3.6	0.7888	4.7	0.7710	5.1	0.8267	3.7	0.8277	3.7	0.8008	4.4
35	0.694	3.5	0.6259	4.5	0.5984	5.0	0.6865	3.6	0.6887	3.6	0.6450	4.3
37					0.5417	5.0	0.6384	3.6	0.6408	3.6	0.5924	4.2
40	0.5827	3.4	0.5003	4.4	0.4675	4.9	0.5735	3.5	0.5760	3.5	0.5224	4.2
45	0.4912	3.3	0.402	4.3	0.3675	4.8	0.4809	3.4	0.4842	3.4	0.4253	4.1
50	0.4161	3.2	0.3251	4.1	0.2907	4.6	0.4054	3.3	0.4089	3.3	0.3480	4.0
55	0.3536	3.1	0.2642	4.0	0.2312	4.5	0.3430	3.2	0.3469	3.2	0.2862	3.9
60	0.302	3.1	0.2161	3.9	0.1580	4.4	0.2916	3.2	0.2956	3.2	0.2365	3.8
65	0.2588	3.0	0.1775	3.8	0.1488	4.3	0.2488	3.1	0.2530	3.1	0.1964	3.4
70	0.2228	2.9	0.1466	3.7	0.1204	4.2	0.2133	3.0	0.2174	3.0	0.1638	3.6
75	0.1924	2.8	0.1215	3.6	0.09784	4.1	0.1834	2.9	0.1875	2.9	0.1372	3.5
80	0.1668	2.7	0.1013	3.5	0.07993	4.0	0.1584	2.8	0.1623	2.8	0.1154	3.4
85	0.1451	2.7	0.08483	3.4	0.06561	3.9	0.13724	2.8	0.1411	2.8	0.09742	3.3
90	0.1266	2.6	0.07135	3.3	0.05411	3.8	0.11929	2.7	0.1230	2.7	0.08260	3.3
95	0.1108	3.0	0.06025	3.3	0.04483	3.7	0.10402	2.6	0.1076	2.6	0.07030	3.2
100	0.09731	2.5	0.05111	3.2	0.03730	3.6	0.09102	2.6	0.09450	2.6	0.06005	3.1
105	0.08572	2.4	0.04351	3.1	0.03117	3.6	0.07990	2.5	0.08322	2.5	0.05148	3.0
110	0.07576	2.4	0.0372	3.0	0.02615	3.5	0.07038	2.4	0.07351	2.5	0.04429	3.0
115			0.0319	2.9	0.02203	3.4	0.06216	2.4	0.06512	2.4	0.03823	2.9
120			0.02746	2.9	0.01863	3.3	0.05505	2.3	0.05786	2.3	0.03310	2.8
125			0.02371	2.8	0.01581	3.2	0.04888	2.3	0.05154	2.3	0.02876	2.8
130					0.01347	3.2	0.04351	2.2			0.02506	2.7
135					0.01152	3.1	0.03883	2.2			0.02190	2.7
140					0.00988	3.0	0.03472	2.1			0.01920	2.6
145					0.00850	3.0	0.03112	2.1			0.0168	2.6
150					0.00734	2.9	0.02796	2.0			0.01487	2.5

NTC Thermistor Applications
Introduction

Our NTC chip thermistors are excellent solutions in applications requiring temperature measurement and compensation from -50° to 150°C.

RTDs, thermocouples and silicon semiconductors cannot compete with the thermistor's sensitive response to temperature. This sensitivity is crucial for accurate temperature measurement.

Unlike RTDs and thermocouples, thermistors are virtually unaffected by lead resistance. This makes NTC thermistors the sensor of choice for remote sensing applications. With their excellent long term stability characteristics, design engineers utilize thermistors in critical applications for the medical, military, aerospace, industrial and scientific industries.

Systems utilizing thermistors are less expensive to produce than other solutions because fewer associated components are required for a high performance system. Chip thermistors can be ordered with tight tolerances to ±0.1°C, eliminating the costly calibration process required by temperature sensors such as silicon semiconductors, RTDs, thermocouples and glass beaded and disk thermistors with loose tolerances.

NTC thermistors provide the design engineer with desirable sensor performance advantages in a variety of applications. The following notes provide a few examples of how to utilize the NTC thermistor.

"Zero Power" Sensing - Dissipation Constant

When utilizing a thermistor for temperature measurement, control, and compensation applications, it is very important not to "self-heat" the thermistor. Power, in the form of heat, is produced when current is passed through the thermistor. Since a thermistor's resistance changes when temperature changes, this "self generated heat" will change the resistance of the thermistor, producing an erroneous reading.

The power dissipation constant is the amount of power required to raise a thermistor's body temperature 1°C. A standard chip thermistor has a power dissipation constant of approximately 2mW/°C in still air. In order to keep the "self-heat" error below 0.1°C power dissipation must be below 0.2mW. Very low current levels are required to obtain such a lower power dissipation factor. This mode of operation is called "zero power" sensing.

Thermistor Linearization - Voltage Mode
Wheatstone Bridge - Voltage Mode

To produce a voltage output that varies linearly with temperature, utilize the NTC thermistor as the active leg in a Wheatstone Bridge. As temperature increases, the voltage output increases. The circuit in **Figure 1** produces an output voltage that is linear with ±0.06°C from 25°C to 45°C. This circuit is designed to produce 1V at 25°C and 200mW at 45°C; this is achieved by the selection of R2 and R3. The value of R1 is selected to best provide linearization of the 10K ohm thermistor over the 25°C to 45°C temperature range. **Figure 2** illustrates the output voltage of the Wheatstone Bridge as a function of temperature.

The circuit in **Figure 3** provides improved output accuracy over a wide temperature range by substituting a 6K/30K ohm thermistor network in place of the single thermistor in the Wheatstone Bridge. This circuit is designed to provide 0V at 0°C and 537mV at 100°C. The maximum linear deviation of this circuit is ±0.234°C from 0°C to 100°C.

Figure 1: Wheatstone Bridge - Voltage Mode

T1 = 10K ohm "A" Curve
R1 = 4980 ohm
R2 = 4980 ohm
R3 = 10K ohm

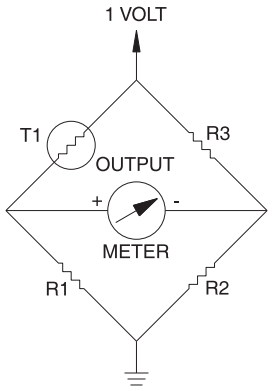


Figure 2: Wheatstone Bridge - Voltage Mode

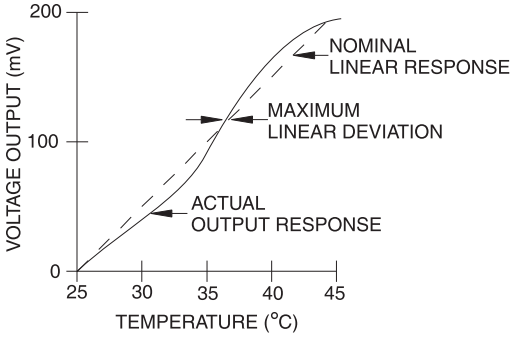
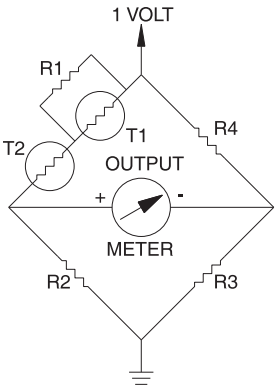


Figure 3: Wheatstone Bridge - Voltage Mode

T1 = 30K ohm "B" Curve
T2 = 6K ohm "A" Curve
R1 = 5420 ohm
R2 = 3970 ohm
R3 = 3970 ohm
R4 = 24720 ohm



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Thermistor Linearization
Operational Amplifier - Resistance Mode

A linear voltage output that varies with temperature can also be produced by utilizing an operational amplifier and a linearized thermistor network as illustrated in **Figure 4**. The voltage output decreases linearly as temperature increases. This circuit may be calibrated by adjusting R3 for an output voltage of 200mW at 25°C and 0V at 45°C.

Temperature Measurement and Control
Digital Thermometer

The most common application for the NTC thermistor is temperature measurement. Accurate temperature measurement can easily be accomplished by interfacing a Wheatstone Bridge, 6K/30K ohm thermistor network and a digital voltmeter integrated circuit as illustrated in **Figure 5**. The IC consist of an analog to digital converter with built-in 3-1/2 digit LCD driver providing resolution of 0.1°C. Using the 6K/30K ohm thermistor network makes it possible to achieve an overall system accuracy of ±0.4°C from 0°C to 100°C. This digital thermometer can easily be interfaced with additional circuitry to provide a temperature control circuit with a digital display.

Micro Controller System

The advent of low cost micro controllers used with precision interchangeable NTC thermistors, provides the design engineer with unlimited design possibilities for temperature measurement and control systems. These systems are relatively inexpensive to produce yet offer very high temperature accuracy and various software controlled outputs.

For example, a micro controller system utilizing remote thermistor sensors can monitor and control the temperature in several locations in an office building. For this case, the micro controller is comprised of a built-in microprocessor, analog to digital converter, RAM and several digital inputs/outputs. The complete system **Figure 6** utilizes the micro controller, multiplexer, EPROM, digital display, keypad and display driver.

The micro controller is programmed in assembler language. The temperature measurement is calculated within the micro controller using the resistance versus temperature algorithm and the a, b and c, constants for the specific thermistor resistance and curve material. Refer to the Steinhart Equation on page 5. An alternative method to convert the thermistor resistance to temperature is to program a “look-up” table in EPROM. After programming, the micro controller tells the multiplexer to send back temperature data from a particular zone (room in the office building) and converts the resistance of the thermistor into a temperature reading.

The micro controller can then turn on or off the heating or air conditioning systems in a specific zone.

The thermistor/micro controller system can be used for security, temperature control, monitoring activities and many other applications. The possibilities are endless.

Figure 4: Linearization - Resistance Mode

T1 = 10K ohm “A” Curve
R1 = 4980 ohm
R2 = 5K ohm
R3 = 10K ohm potentiometer

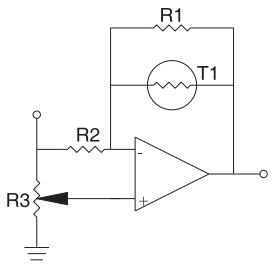


Figure 5: Digital Thermometer

R7 = 1.50K ohm
R8 = 100K ohm
R9 = 470K ohm
R10 = 15K ohm
C1 = 100 pF
C2 = 0.22
C4 = 0.1

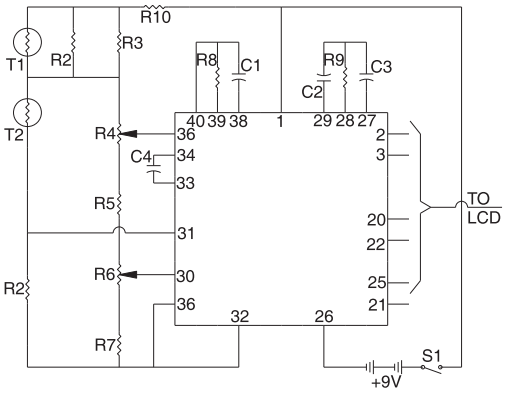
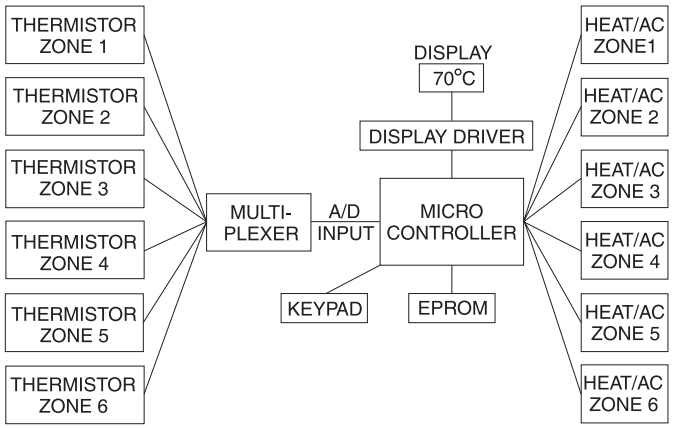


Figure 6: Micro Controller System



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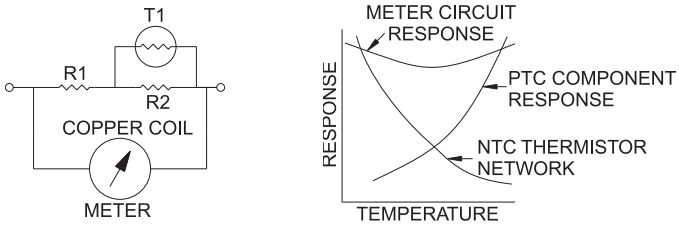
Temperature Compensation

NTC thermistors can be used to compensate for the temperature coefficient response of various components such as crystal oscillators, mechanical meters and infrared LEDs. A thermistor/ resistor network **Figure 7** is placed in series with a PTC component requiring compensation. The resistor values are selected to provide the proper NTC slope to offset the PTC component. The net effect is a constant circuit response that is independent of temperature.

Figure 7: Temperature Compensation



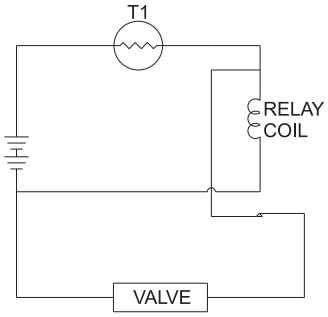
"Self-Heat" Sensing Applications

To "self-heat" a thermistor, it must be subjected to power levels that raise the thermistor's body temperature above the environmental surroundings. Self-heat applications include the sensing of liquid, air level, and flow rates. This application is dependent on the fact that the environment surrounding a thermistor directly affects the amount of power the thermistor can dissipate. For example, submerged in liquid, a thermistor can typically dissipate 500% to 600% more power than it can air.

Therefore, a thermistor being "self-heated" in air is able to dissipate much more power when transferred to a fluid environment. This increase in power dissipation generates a significant increase in resistance. It is this change in resistance, which makes it possible to sense the fluid level.

A simple liquid level control system can be designed by putting a thermistor in series with a coil **Figure 8**, which operates a valve that releases the liquid in the tank. The thermistor is placed in the tank and operated in a "self-heat" mode.

Figure 8: Self-Heat Applications



In air, the thermistor's resistance is low and allows enough current flow to energize the relay coil and keep the relay contact closed. When the fluid level in the tank surrounds the thermistor, its resistance increases and de-energizes the relay, which opens a valve and releases the fluid. As the fluid is released from the tank, the thermistor's resistance decreases and the relay coil energizes and closes the valve.

Fuel injection in automobiles utilize the thermistor in the "self-heat" mode in order to properly control the air/fuel mixture. Forced air heaters may use the NTC thermistor in the "self-heat" mode in order to maintain proper air flow characteristics. This technology is utilized to monitor the flow rate and level of air and fluids in a variety of applications.