GE
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Features

- Low cost, solid state device for inrush current suppression
- Excellent mechanical strength
- Wide operating temperature range: -58°F to 347°F (-50°C to 175°C)
- Suitable for PCB mounting
- Available as a standard with kinked or straight leads and on tape and reel to EIS RS-468A for automatic insertion

Applications

Control of the inrush current in switching power supplies, flourescent lamp, inverters, motors, etc.

- Low steady resistance and accompanying power loss
- Small size
- Low cost solid state sensor

NTC Inrush Current Limiter

Thermometrics Thermistors

NTC Inrush Current Limiter is a Thermometrics product. Thermometrics has joined other GE high-technology sensing businesses under a new name—GE Industrial, Sensing.

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Type CL Specifications

NTC discs for inrush current limiting

Description

Disc thermistor with uninsulated lead-wires.

Options

- For kinked leads, add suffix “A”
- For tape and reel, add suffix “B”
- Other tolerances in the range 0.7 Ω to 120 Ω
- Other tolerances, tolerances at other temperatures
- Alternative lead lengths, lead materials, insulations

Data

*maximum rating at 77°F (25°C) or
$I_{derated} = \sqrt{(1.1425-0.0057 \times T_A)} \times I_{max}$ @ 77°F (25°C) for ambient temperatures other than 77°F (25°C).
**maximum ratings
***$R_0=XI^Y$ where X and Y are found in the table below

Type Fig. 1	Res @ 77°F (25°C) ±25% (Ω)	Max* Steady State Current AMPS (RMS)	Disc Dia. (Max) in (mm)	Disc Thick. (Max) in (mm)	Lead Spacing (Ref.) in (mm)	Lead Dia. AWG	C_x (max)** µ Farads		Equation constants for resistance under load ***			Approx. Res. Under Load at % Maximum Rated Current					
							@120 VAC	@240 VAC	X	Y	Current Range Min. I / Max. I	25%	50%	75%	100%	Diss. Const. (mW/°C)	Time Const. (sec.)
CL-11	0.7	12	0.77 (19.55)	0.22 (5.58)	0.328 (8.33)	18	2700	600	0.50	-1.18	4.0≤ I≤12	14	0.06	0.04	0.02	25	100
CL-21	1.3	8	0.55 (13.97)	0.21 (5.334)	0.328 (8.33)	18	800	200	0.60	-1.25	3.0≤ I≤ 8.0	0.25	0.09	0.06	0.04	15	60
CL-30	2.5	8	0.77 (19.55)	0.22 (5.58)	0.328 (8.33)	18	6000	1500	0.81	-1.25	2.5≤ I≤ 8.0	0.34	0.14	0.09	0.06	25	100
CL-40	5	6	0.77 (19.55)	0.22 (5.58)	0.328 (8.33)	18	5200	1300	1.09	-1.27	1.5≤ I≤ 6.0	0.65	0.27	0.16	0.11	25	100
CL-50	7	5	0.77 (19.55)	0.26 (6.60)	0.328 (8.33)	18	5000	1250	1.28	-1.27	1.5≤ I≤ 5.0	0.96	0.40	0.24	0.16	25	120
CL-60	10	5	0.77 (19.55)	0.22 (5.58)	0.328 (8.33)	18	5000	1250	1.45	-1.30	1.2≤ I≤ 5.0	1.09	0.44	0.26	0.18	25	100
CL-70	16	4	0.77 (19.55)	0.22 (5.58)	0.328 (8.33)	18	5000	1250	1.55	-1.26	1.0≤ I≤ 4.0	1.55	0.65	0.39	0.27	25	100
CL-80	47	3	0.77 (19.55)	0.22 (5.58)	0.328 (8.33)	18	5000	1250	2.03	-1.29	0.5≤ I≤ 3.0	2.94	1.20	0.71	0.49	25	100
CL-90	120	2	0.93 (23.62)	0.22 (5.58)	0.328 (8.33)	18	5000	1250	3.04	-1.36	0.5≤ I≤ 2.0	7.80	3.04	1.75	1.18	30	120
CL-101	0.5	16	0.93 (23.62)	0.22 (5.58)	0.328 (8.33)	18	4000	1000	0.44	-1.12	4.0≤ I≤ 16	0.09	0.04	0.03	0.02	30	120
CL-110	10	3.2	0.40 (10.16)	0.17 (4.31)	0.250 (6.35)	24	600	150	0.83	-1.29	0.7≤ I≤ 3.2	1.10	0.45	0.27	0.18	8	30
CL-120	10	1.7	0.40 (10.16)	0.17 (4.31)	0.250 (6.35)	24	600	150	0.61	-1.09	0.4≤ I≤ 1.7	1.55	0.73	0.46	0.34	4	90
CL-130	50	1.6	0.45 (11.45)	0.17 (4.31)	0.250 (6.35)	24	600	150	1.45	-1.38	0.4≤ I≤ 1.6	5.13	1.97	1.13	0.75	8	30
CL-140	50	1.1	0.45 (11.45)	0.17 (4.31)	0.250 (6.35)	24	600	150	1.01	-1.28	0.2≤ I≤ 1.1	5.27	2.17	1.28	0.89	4	90
CL-150	5	4.7	0.55 (13.97)	0.18 (4.57)	0.328 (8.33)	22	1600	400	0.81	-1.26	1.0≤ I≤ 4.7	0.66	0.27	0.16	0.11	15	110
CL-160	5	2.8	0.55 (13.97)	0.18 (4.57)	0.328 (8.33)	22	1600	400	0.60	-1.05	0.8≤ I≤ 2.8	0.87	0.42	0.27	0.20	9	130
CL-170	16	2.7	0.55 (13.97)	0.18 (4.57)	0.328 (8.33)	22	1600	400	1.18	-1.28	0.5≤ I≤ 2.7	1.95	0.80	0.48	0.33	15	110
CL-180	16	1.7	0.55 (13.97)	0.18 (4.57)	0.328 (8.33)	22	1600	400	0.92	-1.18	0.4≤ I≤ 1.7	2.52	1.11	0.69	0.49	9	130
CL-190	25	2.4	0.55 (13.97)	0.18 (4.57)	0.328 (8.33)	22	800	200	1.33	-1.34	0.5≤ I≤ 2.4	2.63	1.04	0.60	0.41	15	110
CL-200	25	1.7	0.55 (13.97)	0.18 (4.57)	0.328 (8.33)	22	800	200	0.95	-1.24	0.4≤ I≤ 1.7	2.74	1.18	0.70	0.49	9	130
CL-210	30	1.5	0.40 (10.16)	0.20 (5.08)	0.250 (6.35)	24	600	150	1.02	-1.35	0.3≤ I≤ 1.5	3.83	1.50	0.87	0.60	8	30

Inrush CurrentLimiters In Switching Power Supplies

The problem of current surges in switch-mode power supplies is caused by the large filter capacitors used to smooth the ripple in the rectified 60 Hz current prior to being chopped at a high frequency. The diagram above illustrates a circuit commonly used in switching power supplies.

In the circuit above the maximum current at turn-on is the peak line voltage divided by the value of R; for 120 V, it is approximately $120 \times \sqrt{2}/R_I$. Ideally, during turn-on R_I should be very large, and after the supply is operating, should be reduced to zero. The NTC thermistor is ideally suited for this application. It limits surge current by functioning as a power resistor which drops from a high cold resistance to a low hot resistance when heated by the current flowing through it. Some of the factors to consider when designing NTC thermistor as an inrush current limiter are:

- Maximum permissible surge current at turn-on
- Matching the thermistor to the size of the filter capacitors
- Maximum value of steady state current
- Maximum ambient temperature
- Expected life of the power supply

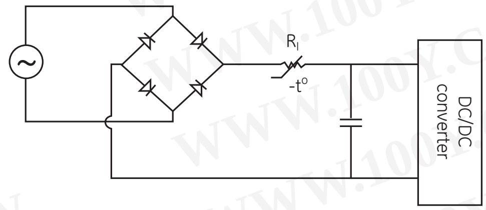
Maximum Surge Current

The main purpose of limiting inrush current is to prevent components in series with the input to the DC/DC convertor from being damaged. Typically, inrush protection prevents nuisance blowing of fuses or breakers as well as welding of switch contacts. Since most thermistor materials are very nearly ohmic at any given temperature, the minimum no-load resistance of the thermistor is calculated by dividing the peak input voltage by the maximum permissible surge current in the power supply ($V_{peak/Imax\ surge}$).

Energy Surge at Turn-On

At the moment the circuit is energized, the filter caps in a switcher appear like a short circuit which, in a relatively short period of time, will store an amount of energy equal to $1/2CV^2$. All of the charge that the filter capacitors store must flow through the thermistor. The net effect of this large current surge is to increase the temperature of the thermistor very rapidly during the period the capacitors are charging. The amount of energy generated in the thermistor during this capacitor-charging period is dependent on the voltage waveform of the source charging the capacitors. However, a good approximation for the energy generated by the thermistor during this period is $1/2CV^2$ (energy stored in the filter capacitor). The ability of the NTC thermistor to handle this energy surge is largely a function of the mass of the device. This logic can be seen in the energy balance equation for a thermistor being self-heated:

Input Energy = Energy Stored + Energy Dissipated



Typical power supply circuit

or in differential form:

$$Pdt = HdT + \delta(T - T_A)dt$$

where:
P = Power generated in the NTC
t = Time
H = Heat capacity of the thermistor
T = Temperature of the thermistor body
δ = Dissipation constant
T_A = Ambient temperature

During the short time that the capacitors are charging (usually less than 0.1 second), very little energy is dissipated. Most of the input energy is stored as heat in the thermistor body. In the table of standard inrush limiters there is listed a recommended value of maximum capacitance at 120 V and 240 V. This rating is not intended to define the absolute capabilities of the thermistors; instead, it is an experimentally determined value beyond which there may be some reduction in the life of the inrush current limiter.

Maximum Steady-State Current

The maximum steady-state current rating of a thermistor is mainly determined by the acceptable life of the final products for which the thermistor becomes a component. In the steady-state condition, the energy balance in the differential equation already given reduces to the following heat balance formula:

$$\text{Power} = I^2R = \delta(T - T_A)$$

As more current flows through the device, its steady-state operating temperature will increase and its resistance will decrease. The maximum current rating correlates to a maximum allowable temperature.

In the table of standard inrush current limiters is a list of values for resistance under load for each unit, as well as a recommended maximum steady-state current. These ratings are based upon standard PC board heat sinking, with no air flow, at an ambient temperature of 77° (25°C). However, most power supplies have some air flow, which further enhances the safety margin that is already built into the maximum current rating. To derate the maximum steady state current for operation at elevated ambient temperatures, use the following equation:

$$\text{Iderated} = I_{derated} = \sqrt{(1.1425 - 0.0057 \times T_A)} \times I_{max} \text{ @ } 77°F\ (25°C)$$

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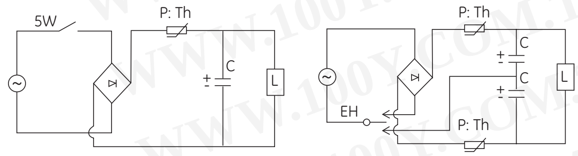
Power Thermistor Specification



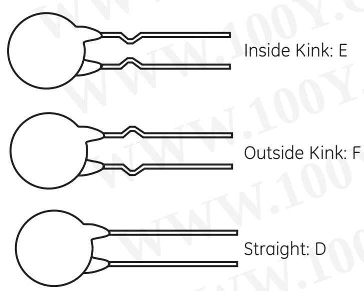
Power thermistor application circuits

For the Reduction of Inrush Current

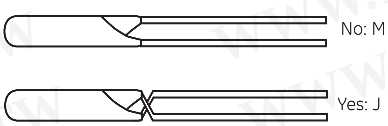
A power thermistor is a type of NTC thermistor used for the reduction of large inrush currents. These large inrush currents are typically caused by charging of filter capacitors in switching power supplies.

Parts	D	T(max.)	L	d	F	H1(±2.5)	W1(min.)
7	7.0±1.5	5.2	18.5	0.6	5.0	15.5	1.5
9	9.0±1.5	6.0	18.5	0.6	5.0	17.0	1.5
11	11.0±1.5	6.5	18.5	0.8	7.5	19.5	2.0
13	13.5±1.5	8.0	18.5	0.8	7.5	21.5	2.0
15	15.0±1.5	9.0	18.5	0.8	7.5	23.5	2.0
18	18.0±1.5	9.0	18.5	1.0	10.0	27.0	3.0

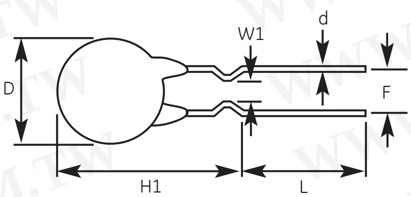
Lead Wire Style

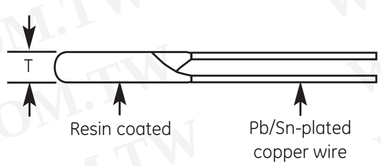


Y-Form



Units: in (mm)





Power thermistor standard dimensions

Parts Diam (mm)	Type	Normal no load resistance (Ω)	Normal β constant (K)	Dissipation factor (mW/°C)	Max. Permissible Current at 77°F (25°C)	Time Constant (sec)
	TP7D7	7	3000	9.8	2.4	70
	TP8D7	8	3000	10.0	2.3	70
7Φ	TP10D7	10	3000	10.3	2.0	80
	TP16D7	16	3000	10.5	1.6	100
	TP22D7	22	3100	9.5	1.4	120
	TP5D9	5	3000	11.0	3.0	110
	TP8D9	8	3000	14.2	2.7	120
9Φ	TP10D9	10	3000	12.9	2.3	130
	TP16D9	16	3100	10.2	1.7	160
	TP4R7D11	4.7	3000	15.0	3.7	90
	TP5D11	5	3000	15.0	3.3	130
11Φ	TP8D11	8	3000	17.6	2.6	160
	TP10D11	10	3100	17.4	2.4	170
	TP4R7D13	4.7	3000	15.0	4.3	110
	TP5D13	5	3000	15.0	3.4	125
13Φ	TP8D13	8	3100	17.0	2.7	160
	TP10D13	10	3100	13.8	2.5	180
	TP3D15	3	3000	16.5	4.0	165
	TP5D15	5	3100	17.7	3.7	170
15Φ	TP8D15	8	3100	21.7	3.1	180
	TP10D15	10	3100	19.9	2.9	200
	TP4D18	4	3000	22.2	4.1	170
18Φ	TP5D18	5	3000	24.0	3.8	180
	TP8D18	8	3100	26.8	3.1	220
	TP10D18	10	3100	27.8	2.8	260

* *The resistance tolerance is ± 10% for standard devices.*
* *The b constant is determined by the equation : β = 1779.7 ln (R25/R85) ...R25 and R85 represent the thermistor resistance at 77°F and 185°F (25°C and 85°C) respectively.*
* *For non-standard devices consult Thermometrics global business.*

Code Designation

T P	8	D 13	L	K	B	E	S	M	N	R
1	2	3	4	5	6	7	8	9	10	11

1	Shape: Power thermistor
2	Resistance at 77°F (25°C): 8 = 8 Ω, 4R7 = 4.7 Ω
3	Diameter size: D7, D9, ...D18
4/5	Resistance and B constant tolerance: K: ±10%, L: ±15%
6	Lead wire center-to-center: (F): A: 0.19 in (5 mm), B: 0.29 in (7.5 mm), C: 0.39 in (10 mm)
7	Lead wire style: D: Straight, E: Inside kink, F: Outside kink
8	Lead wire length: G: 0.19 in (5 mm), H: 0.27 in (7 mm), I: 0.35 in (9 mm), ...S: Other dimensions
9	Y-Form: J: Yes, M: No
10	MK part number marking: N: No, O: Yes
11	Packing form: Taping P: 15 pitch, Q: 30 pitch, Others: R: Bulk, S: Paper pad, T: Element

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