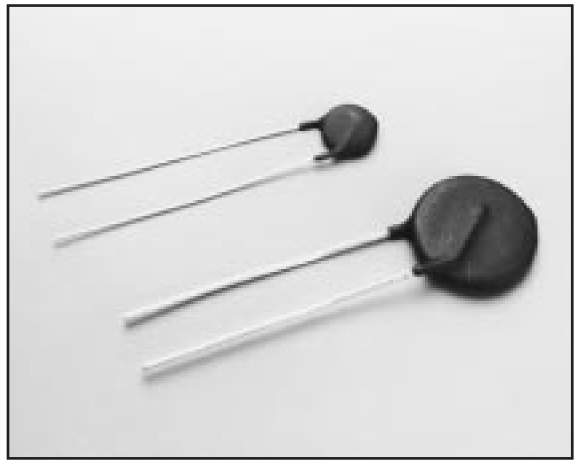
NTC THERMISTORS: TYPE CL

NTC DISCS FOR INRUSH CURRENT LIMITING

DESCRIPTION:

Disc thermistor with uninsulated lead-wires.



FEATURES:

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

TYPE Fig. 1	Res @ 25°C ±25% (ohms)	Max* Steady State Current AMPS (RMS)	Disc Dia. (Max) (in.)	Disc Thick. (Max) (in.)	Lead Spacing (Ref.) (in.)	Lead Dia. AWG	C_X (max)** µFarads		Equation constants for resistance under load ***			Approx. Res. Under Load at % Max. Rated Current				Diss. Const. (mW/°C)	Time Const. (sec.)
							@120 VAC	@240 VAC	X	Y	Current Range Min. I / Max. I	25%	50%	75%	100%		
CL-11	0.7	12	0.77	0.22	0.328	18	2700	600	0.50	-1.18	4.0≤ I≤ 12	14	.06	.04	.02	25	100
CL-21	1.3	8	0.55	0.21	0.328	18	800	200	0.60	-1.25	3.0≤ I≤ 8.0	.25	.09	.06	.04	15	60
CL-30	2.5	8	0.77	0.22	0.328	18	6000	1500	0.81	-1.25	2.5≤ I≤ 8.0	.34	.14	.09	.06	25	100
CL-40	5	6	0.77	0.22	0.328	18	5200	1300	1.09	-1.27	1.5≤ I≤ 6.0	.65	.27	.16	.11	25	100
CL-50	7	5	0.77	0.26	0.328	18	5000	1250	1.28	-1.27	1.5≤ I≤ 5.0	.96	.40	.24	.16	25	120
CL-60	10	5	0.77	0.22	0.328	18	5000	1250	1.45	-1.30	1.2≤ I≤ 5.0	1.09	.44	.26	.18	25	100
CL-70	16	4	0.77	0.22	0.328	18	5000	1250	1.55	-1.26	1.0≤ I≤ 4.0	1.55	.65	.39	.27	25	100
CL-80	47	3	0.77	0.22	0.328	18	5000	1250	2.03	-1.29	0.5≤ I≤ 3.0	2.94	1.20	.71	.49	25	100
CL-90	120	2	0.93	0.22	0.328	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	0.22	0.328	18	4000	1000	0.44	-1.12	4.0≤ I≤ 16	.09	.04	.03	.02	30	120
CL-110	10	3.2	0.40	0.17	0.250	24	600	150	0.83	-1.29	0.7≤ I≤ 3.2	1.10	.45	.27	.18	8	30
CL-120	10	1.7	0.40	0.17	0.250	24	600	150	0.61	-1.09	0.4≤ I≤ 1.7	1.55	.73	.46	.34	4	90
CL-130	50	1.6	0.45	0.17	0.250	24	600	150	1.45	-1.38	0.4≤ I≤ 1.6	5.13	1.97	1.13	.75	8	30
CL-140	50	1.1	0.45	0.17	0.250	24	600	150	1.01	-1.28	0.2≤ I≤ 1.1	5.27	2.17	1.28	.89	4	90
CL-150	5	4.7	0.55	0.18	0.328	22	1600	400	0.81	-1.26	1.0≤ I≤ 4.7	.66	.27	.16	.11	15	110
CL-160	5	2.8	0.55	0.18	0.328	22	1600	400	0.60	-1.05	0.8≤ I≤ 2.8	.87	.42	.27	.20	9	130
CL-170	16	2.7	0.55	0.18	0.328	22	1600	400	1.18	-1.28	0.5≤ I≤ 2.7	1.95	.80	.48	.33	15	110
CL-180	16	1.7	0.55	0.18	0.328	22	1600	400	0.92	-1.18	0.4≤ I≤ 1.7	2.52	1.11	.69	.49	9	130
CL-190	25	2.4	0.55	0.18	0.328	22	800	200	1.33	-1.34	0.5≤ I≤ 2.4	2.63	1.04	.60	.41	15	110
CL-200	25	1.7	0.55	0.18	0.328	22	800	200	0.95	-1.24	0.4≤ I≤ 1.7	2.74	1.18	.70	.49	9	130
CL-210	30	1.5	0.40	0.20	0.250	24	600	150	1.02	-1.35	0.3≤ I≤ 1.5	3.83	1.50	.87	.60	8	30

OPTIONS:

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

DATA:

*maximum rating at 25ºC or

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

for ambient temperatures other than 25ºC.

**maximum ratings

***$R_0 = X I^Y$ where X and Y are found in the table above

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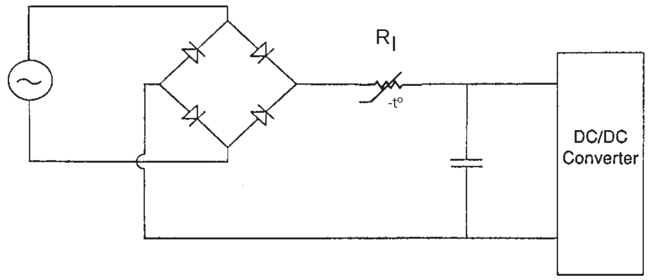

TYPICAL POWER SUPPLY CIRCUIT

INRUSH CURRENT LIMITERS 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 60Hz 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 120v, 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 ($V_{peak/Imax\ surge}$).

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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

or in differential form:

$$\mathbf{P}dt = \mathbf{H}d\mathbf{T} + \delta(\mathbf{T} - \mathbf{T_A})dt$$

where:

- **P** = Power generated in the NTC
- **t** = Time
- **H** = Heat capacity of the thermistor
- **T** = Temperature of the thermistor body
- δ = Dissipation constant
- $\mathbf{T_A}$ = 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 volts and 240 volts. 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

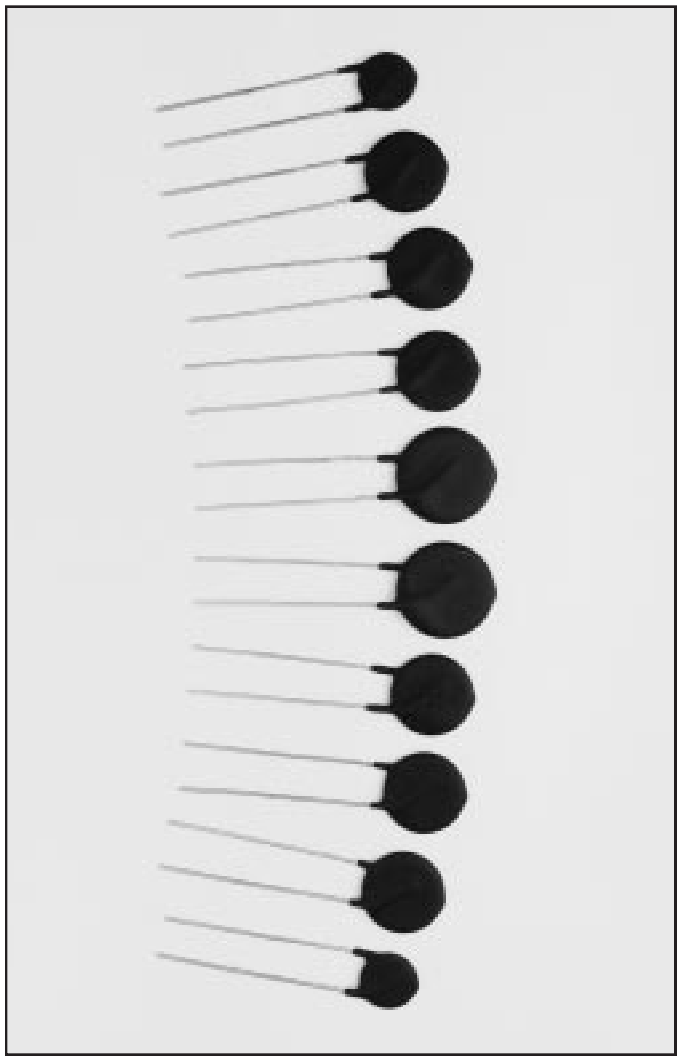
The maximum steady-state current rating of a thermistor is mainly determined by the acceptable life of the final products for which the thermistor becomes a component. In the steady-state condition, the energy balance in the differential equation already given reduces to the following heat balance formula:

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

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 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:

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



Inrush Current Limiters

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