

DISCLAIMER

This information has not been peer-reviewed, approved, or certified. The selection of inrush current limiters can be extremely critical, affecting the performance of many different types of machines including medical devices, which can in turn affect such things as life.

INTRODUCTION

Inrush current limiters (sometimes called surge limiters) are devices or circuits used to limit the amount of current through a circuit. Their most common application is to limit the current drawn by switching power supplies (but also AC motors, transformers, and lamp ballasts) immediately after power-on (the inrush current). When 120Vac or 230Vac is first applied to uncharged input bulk capacitors (100 μ F for my 75W power supply), the initial current can be very large (remember the equation for current in a

capacitor: $I = C \frac{dV}{dt}$). If unchecked, this inrush current can cause circuit damage,

unnecessarily trip fuses and circuit breakers, or overload your power source.

There are two main types of inrush current limiters: NTC (negative temperature coefficient – as temperature increases, resistance decreases) thermistors and active current limiters. NTC thermistors are cheaper, simpler, and smaller than active current limiters. Active current limiters are better when “hot restart” conditions are necessary, since NTC thermistors need some time to cool down before operating as intended.

An NTC thermistor works as follows:

1. Thermistors are rated to have a certain resistance at room temperature.
2. They are generally placed in series with the circuit that needs current limiting.
3. When the circuit is switched on, the thermistor’s resistance limits the inrush current per Ohm’s law.
4. The current that does pass through the thermistor heats up the thermistor.
5. As the thermistor heats up, its resistance decreases.
6. The thermistor’s resistance decreases to a negligible amount and the circuit can function normally.

I recently had to pick a thermistor for a power supply. It’s not difficult. In case you were wondering, here are the basic steps. The first step determines the only parameter that affects whether or not your inrush current will be limited to the specified value. The rest of the steps listed below affect whether or not your chosen thermistor and circuit will function within specifications.

HOW TO PICK A NTC THERMISTOR INRUSH CURRENT LIMITER

1. Determine the thermistor’s least allowable resistance in ambient (“cold”) conditions, given your specified inrush current limit and your highest possible instantaneous input

voltage. Pick a thermistor whose minimum resistance (while factoring tolerance) is higher than this value.

Example:

Assume your application's inrush current specification is 50A maximum.

Assume your application is expected to run on European mains power, where the highest instantaneous input voltage (at the peak of a cycle at worst reasonable tolerance) is $264V_{ac} * \sqrt{2} \approx 373V$.

The minimum rated resistance of the surge limiter in ambient conditions is then

determined using Ohm's law: $R_{min} = \frac{V_{max}}{I_{inrush max}} = \frac{373V}{50A} \approx 7.5\Omega$.

You might then select a thermistor rated 8Ω . But tolerances generally run between 10% and 20%, so perhaps a thermistor rated 10Ω would be a better selection.

2. Determine the amount of energy your inrush current limiter is expected to absorb on power-on. Pick a thermistor whose maximum energy rating is greater than this value. This will guarantee that the thermistor is not damaged.

Example:

Assume your application is a switched-mode power supply that will run on European mains power which can have a worst-case peak voltage level of 373V.

Assume there are two 1200pF EMI capacitors and one 120 μ F bulk capacitor on the input. For these calculations, the EMI capacitors are negligible.

When switched on, the circuit will instantaneously attempt to fully charge the capacitors.

When fully charged, the capacitors will store $E_{tot} = \frac{1}{2}CV^2 = 8.3J$ of energy.

You need to select a thermistor which can absorb 8.3J of energy without failing.

3. Determine your application's steady-state current. Pick a thermistor whose maximum rated current is greater than this value. This will guarantee that the thermistor is not damaged.

4. Determine the voltage drop across the thermistor at your application's steady-state current. Guarantee that your design still functions at the minimum end of your input voltage range with this voltage drop.

Example:

Suppose your power supply is intended to be sold in the U.S. and Europe. UL will want to rate your power supply with an input range of 100Vac to 240Vac, which means it will test your power supply with an input range of 90Vac to 264Vac.

Suppose your application's steady-state current is 0.6A.

Suppose your thermistor's resistance is 0.5Ω at 0.6A.

The voltage drop across the thermistor will be $0.6A * 0.5\Omega = 0.3V$.

So, in order to guarantee that your power supply functions when 90Vac is input, your power supply needs to be designed to operate at 89.7Vac.

5. Inrush current limiters can be very critical components. Depending on what kind of certifications your application needs, choosing a UL recognized component may be necessary / recommended. UL-certified thermistors are found under UL category code XGPU2. You can search all the recognized manufacturers for this category code at the UL website. (<http://database.ul.com/cgi-bin/XYV/template/LISEXT/1FRAME/index.htm>)

MORE INFORMATION:

WIKIPEDIA ARTICLES

http://en.wikipedia.org/wiki/Inrush_current_limiter

<http://en.wikipedia.org/wiki/Thermistors>

http://en.wikipedia.org/wiki/Inrush_current

APPLICATION NOTES

Epcos document on using NTC Thermistors to limit current:

http://www.epcos.com/web/generator/Web/Sections/ProductCatalog/NonlinearResistors/NTCThermistors/ApplicationNotes/02__InrushCurrentLimitingAN2/PDF__InrushCurrentLimiting__AN2,property=Data__en.pdf;/PDF__InrushCurrentLimiting__AN2.pdf

Bear Power Supplies datasheet on inrush current in power supplies:

http://www.bearpwr.com/pdfs/BEAR_TechNote_InrushCurrent.pdf

Power-One app note on inrush current control, including active circuits:

<http://huqixin.blog.dianyuan.com/u/43/1152163498.pdf>

PARTIAL LIST OF NTC THERMISTOR MANUFACTURERS:

Ametherm, Cantherm, Epcos, GE Sensing, Murata, Panasonic, US Sensor, Vishay