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POWER SUPPLIES

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White Paper Inrush Current

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1 INDEX

2 INTRODUCTION

This document describes the necessity of an inrush-current-limiter at the input of a power-supply.

At the input of each power-supply, bulk capacitors are needed for following reasons:

- Bypassing of converter-stage.
- EMC-filtering.
- Holdup time: Short interruptions of the input voltage supply do not cause any equipment failure (class S2 according to EN50155).

At power-supply turn-on, the bulk capacitors of the power-supply are completely discharged. The equivalent series resistance of the bulk-capacitors is way below 1 Ohm. This combination results in huge charging currents at power-supply turn-on.
These inrush-currents can reach hundreds of amperes, especially at higher input voltages (e.g. 110V-battery). The high inrush current can trigger a circuit breaker or burn a fuse unless you take precautions.

3 SOLUTIONS TO LIMIT INRUSH-CURRENT

3.1 NTC

The inrush-current is limited by a NTC-resistor. At the first power-supply turn-on, the NTC is cold and has a high resistance, which limits the current effectively. After a relatively short time, the NTC heats up due to its own internal dissipation and becomes low resistant. Therefore, the power-dissipation during normal operation is reduced.

Advantages:
- Simple

Disadvantages:
- The effectiveness of this solution is very dependent on the ambient temperature: At high ambient temperatures, the inrush-current might not be limited sufficiently and at low temperatures, startup of the power-supply is not guaranteed because the NTC limits the current excessively (example: see table below with a 5 Ohm-NTC).
- At short interruption of the input-voltage (couple of 100 ms) the input capacitor is discharged but the NTC remains still hot and does not limit the current.
- The NTC dissipates and reduces the efficiency.
- During normal operation of the power-supply, the NTC heats up until it reaches steady state (approx. 110 °C). Therefore, the NTC heats up adjacent circuitry and the power-supply unnecessarily.

Ambient Temperature	NTC-resistance at turn-on	Inrush-current @ 110 VDC
-40 °C	68 Ohm	1.6 A
-20 °C	27 Ohm	4.1 A
0 °C	12 Ohm	9.2 A
+25 °C	5.0 Ohm	22 A
+50 °C	2.4 Ohm	46 A
+70 °C	1.4 Ohm	79 A

3.2 INRUSH LIMITER TECHNOLOGY BY intreXis

intreXis uses a fixed resistors to limit the inrush-current which can handle safely the high energy during the charging of the input capacitors. After the input capacitors have been charged, the resistor is bridged with a very low-resistant active component. When an interruption of the input-voltage discharges the input-capacitors, the active bridging component is deactivated and the inrush-current is limited again by the fixed resistor.

Advantages:

- The effectiveness of the solution is independent of the ambient temperature. It avoids false circuit breaker tripping and guarantees proper start-up of the power-supply.
- At short interruption of the input-voltage (couple of 100 ms) the input capacitor is discharged, the bridging component deactivated and the inrush-current is limited again by the fixed resistor.
- The active bridging component dissipates much less than the NTC and does not heat up the power-supply. The efficiency of the converter remains high.

Disadvantages:

- More complex.

The advantages of the inrush-limiter technology by intreXis outweigh the higher complexity of the circuit. The effectiveness and robustness of the circuit have been proven by field-experience and severe tests in the EMC-laboratory.