Inrush Current

Definition

The inrush current is the waveform of the input current I_i, measured immediately after the input voltage is connected.

Characteristics

The inrush current depends on the external input voltage U_i, the source and supply line impedance $R_{s\,ext}$ and $L_{s\,ext}$, the internal input inductance L_i, the internal input resistance R_i as well as capacitance and ESR of the internal input capacitor C_i of the power supply. The peak value $I_{inr\,p}$ of the inrush current can be estimated as follows:

$$I_{inr\,p} < \frac{U_i}{R_{s\,ext} + R_i}$$

The rise time $t_{inr\,r}$ is given by:

$$t_{inr\,r} \approx \frac{L_{s\,ext} + L_i}{R_{s\,ext} + R_i}$$

The time to half value $t_{inr\,h}$ is given by:

$$t_{inr\,h} \approx 0.7 \cdot (R_{s\,ext} + R_i) \cdot C_i + t_{inr\,r}$$

The inrush current determines the rating of input switches, relays, fuses, connectors and cables.

The integration $\int I^2\,dt$ of the inrush current can be calculated as follows:

$$\int I^2\,dt \approx I_{inr\,p}{}^2 \cdot (0.72 \cdot t_{inr\,h} - 0.39 \cdot t_{inr\,r})$$
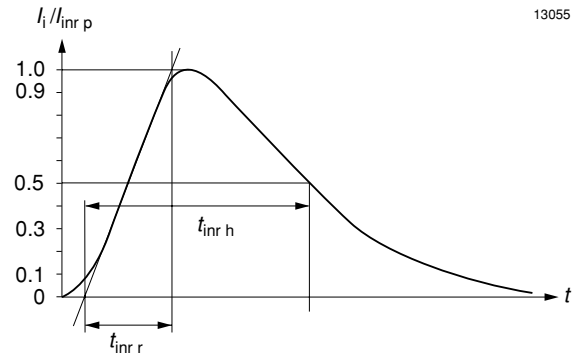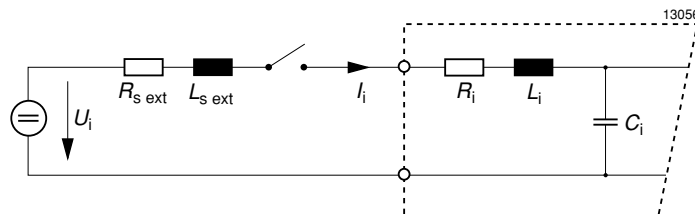

Fig. 1
Inrush current

Fig. 2
Input circuitry

Limitation of the Inrush Current

The peak value of the inrush current can be limited by means of an NTC resistor or by an active limitation circuitry (resistor, being short-circuited after the switch-on by a relay, thyristor or transistor; or option E, available with some of the Power-One converters).