life.augmented

AN4647
Application note

Circuit breaker with transient voltage suppression based on the CBTVS2Axx-1F3: input capacitor sizing of portable equipment

Mathieu ROUVIERE

Introduction

The CBTVS2A12-1F3 / CBTVS2A16-F3 (CBTVSAxx-1F3) is a single line diode TVS integrating a non-resettable fuse designed specifically for the protection of integrated circuits in portable equipment and miniaturized electronics devices subject to ESD, OVP and OCP.

Inrush current, resulting from portable equipment plugin and input capacitor charging, can be higher than fuse current itself. The non-resettable fuse functional reliability must then be validated.

This document presents:

- Inrush current examples with typical application case for Vbus charging
- Higher voltages with high value charger capacitance are also tested.

Severe conditions (ambient temperature, number of inrush surges) are applied to validate fuse robustness and to determine the highest portable equipment input capacitor.

Contents

1 Description 3

2 USB grid charger 4

3 Computer USB port charger 6

4 Final recommendation 7

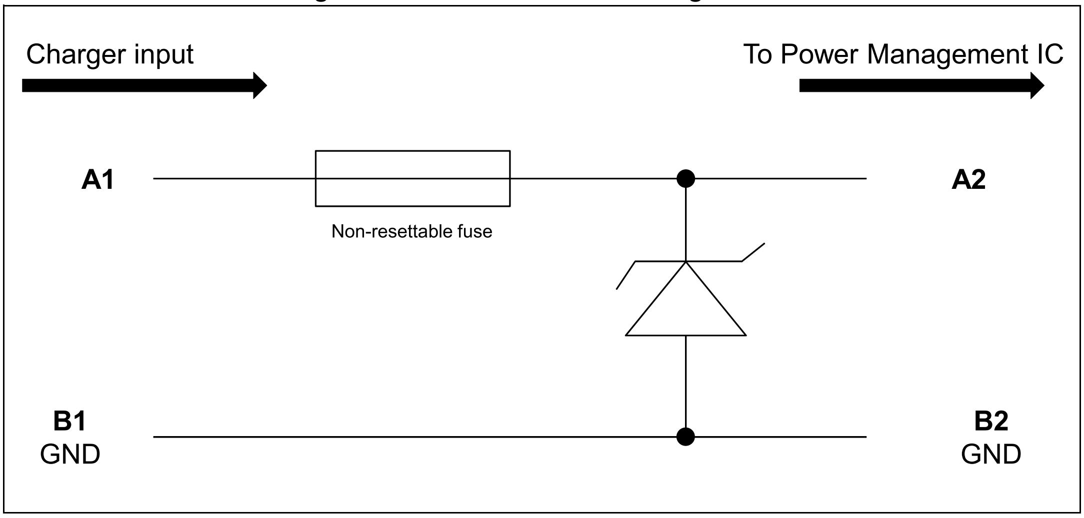
5 Conclusion 8

6 Revision history 8

1 Description

CBTVS2Axx-1F3 integrates a non-resettable over current protection (see *Figure 1*).

Figure 1. CBTVS2Axx-1F3 configuration



This non-resettable overcurrent protection grants the user safety in case of shortage between charger input and battery.

It also protects charger side in case of Vbus to GND shortage.

Maximum fuse opening is specified as:

- 100 ms with 5 A DC current
- 24 hours with 3.2 A DC current

The associated temperature range is -30°C / 85°C.

2 USB grid charger

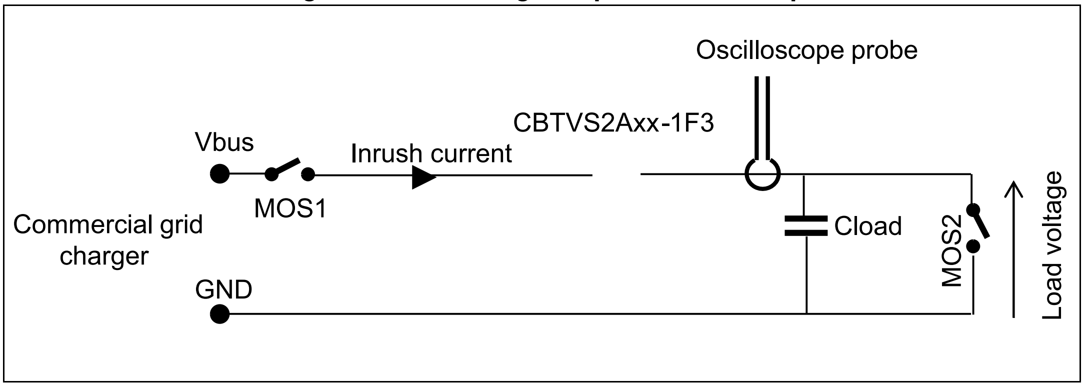
To measure inrush current in fuse, a commercial grid USB charger is used.

Following severe conditions are applied:

- 100 000 inrush surges (50 plug-in by day during 5 years)
- Ambient temperature = -30, 25°C and 85°C

Figure 2 shows the experimental setup used to measure inrush current with a grid charger.

Figure 2. Grid charger experimental setup

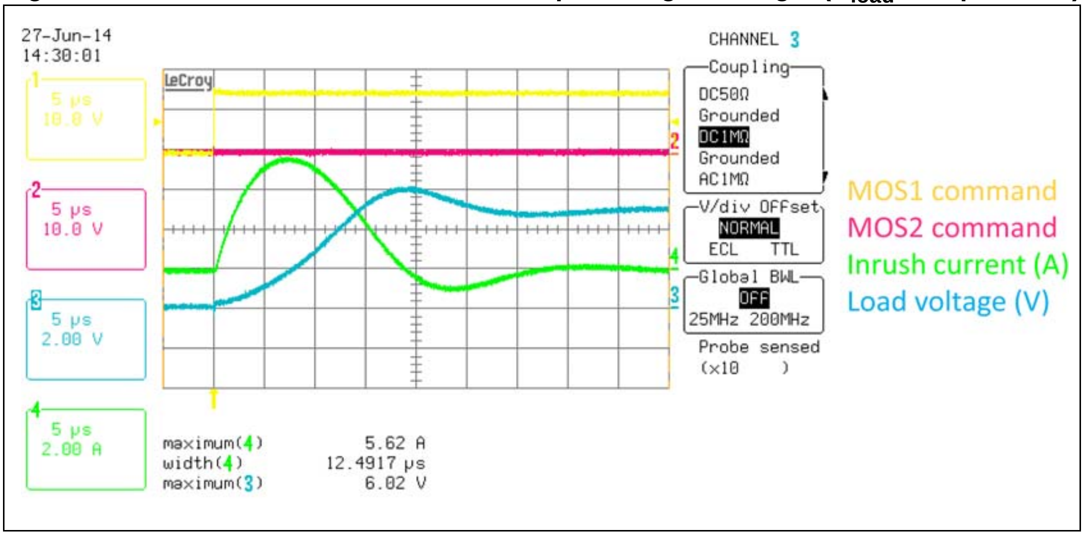


The grid charger is connected between Vbus and GND of the characterization board.

To charge C_{load}, the current flows through the CBTVS2Axx-1F3 and oscilloscope current probe measures it. A voltage probe measures voltage at C_{load} edge.

With MOS2 open, switching on MOS1 connects charger to CBTVS2Axx-1F3 and C_{load}. *Figure 3* shows a measurement of inrush current with C_{load} = 22 µF and 85 °C.

Figure 3. Inrush current measurement example with grid charger (C_{load} = 22 µF / 85°C)



It presents 5.6 A maximum and 12.5 µs width. A small oscillation is present due to the LC circuit formed by cable inductances and C_{load} capacitor. When load voltage is stabilized at 5 V, inrush current is at 0 A.

Table 1 presents, for several CMS C_{load} capacitors (1 µF, 2.2 µF, 4.7 µF, 10 µF and 22 µF), maximal inrush current and inrush current width at Tamb = 85°C. No unexpected fuse opening has been observed.

Table 1. Inrush current with grid charger and various C_{load} capacitors at 85 °C

C_{load} capacitor (µF)	Max. inrush current (A)	Inrush current width (µs)
1.0	2.3	3.4
2.2	3.1	4.6
4.7	4.0	7.9
10	5.0	11.2
22	5.6	12.5

To be able to perform repetitive inrush current measurements, MOS2 discharges C_{load} with MOS1 open.

3 Computer USB port charger

On computer USB port charger, the voltage regulator is following by an output capacitor. This output capacitor value, observed on various laptops, is always lower than 220 µF.

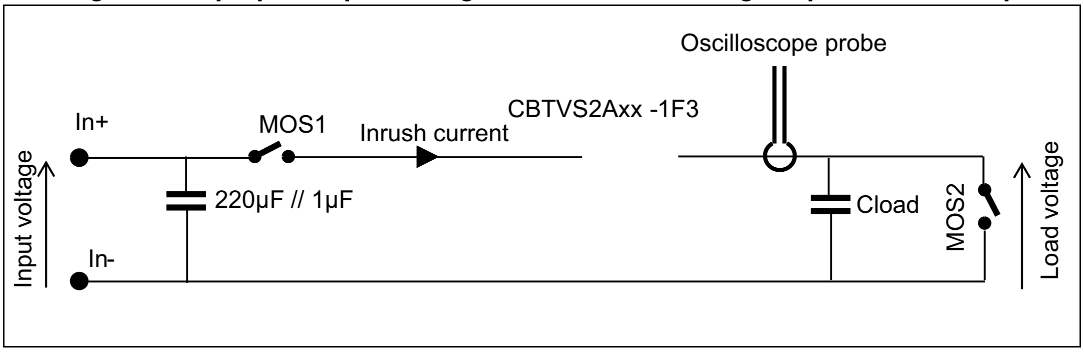
This output capacitor value is much more important than C_{load} capacitor and it can be consider as a decoupling capacitor.

Then previous experimental setup has been modified. The grid charger is replaced by:

- 2 capacitors in parallel, 220 µF chemical and 1 µF monolithic ceramic
- laboratory power supply

Test setup is shown *Figure 4*.

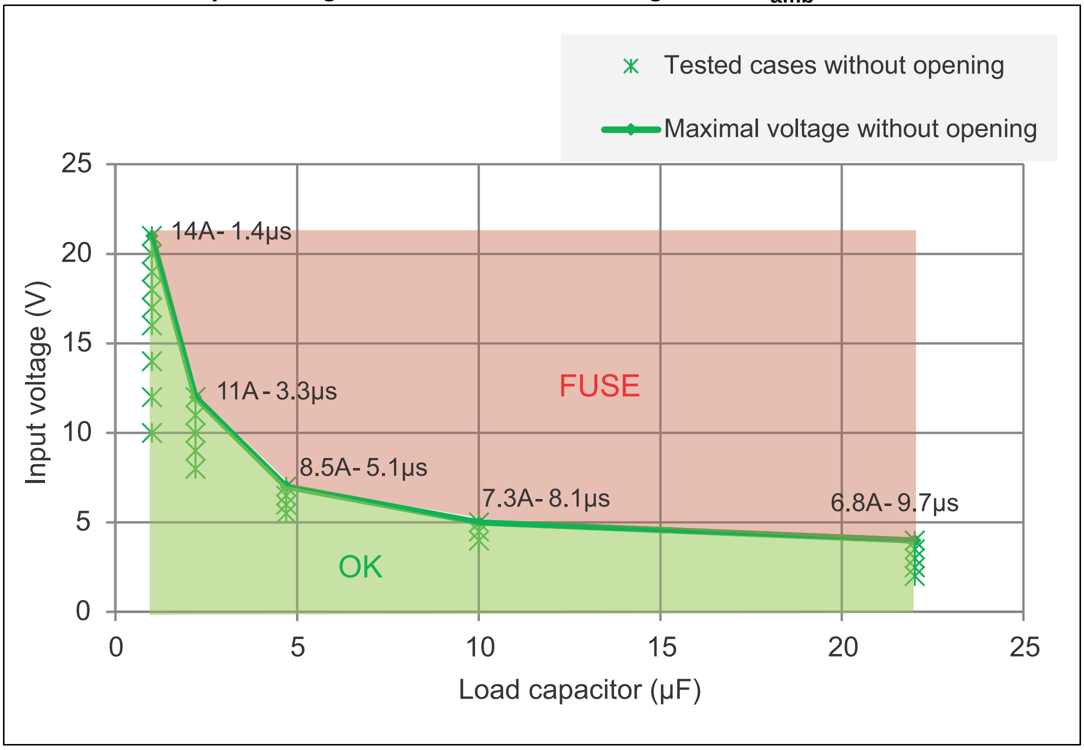
Figure 4. Laptop USB port charger with variable voltage experimental setup



Input voltage of laboratory power supply allows, for a given C_{load} CMS capacitor, to find the voltage fuse opening limit (i.e. the maximal voltage without fuse opening). For USB condition, input voltage is then fixed to 5 V.

Figure 5 presents tested cases (load capacitors with various input voltages) without fuse opening. Solid line shows the maximal voltage for a given capacitor without opening. The maximal inrush current and the associated width value are also reported.

Figure 5. CBTVS2Axx-1F3 fuse current and time according to C_{load} capacitor and input voltage with 100000 inrush surges and T_{amb}=85 °C



85 °C ambient temperature is the worst case. As example, with 1 µF C_{load} capacitor, the maximal voltage without opening is 24 V with -30 °C and 21 V with 85 °C ambient temperature.

For USB port charger (5 V), the maximum capacitor without opening is 4.7 µF with a 2 V secure margin.

4 Final recommendation

Taken into account USB grid charger results and USB port charger, ST recommends not exceeding 4.7 µF capacitor on mobile device after CBTVS2Axx-1F3 on Vbus. A 30% secure margin on voltage is then present.

For other voltages, *Figure 5* presents maximal capacitor value.

5 Conclusion

This document presents non-resettable fuse of CBTVS2Axx-1F3 functional reliability.

It describes experimental setups and the test conditions.

For Vbus charging, ST recommends not to exceed 4.7 µF. For other voltages recommendations for capacitor sizing are given.

6 Revision history

Table 2. Document revision history

Date	Revision	Changes
02-Feb-2015	1	Initial release.