

Surge Filter Recommendations for 50W up to 200W Modules

- To comply with transient requirements of :
 - EN50155 standard
 - 61000-4-5 standard
- To comply with EN55011 class A
- Power range up to 200W
- Small surface
- Temperature range : -40°C/+85°C (ambient)



1- Subject

This design note describes an electrical schematics that enables GAIA Converter DC/DC module to be protected against surges generally occurring in railways applications.

Surges are short term high transient voltage on the input bus that are mainly generated by lightning strokes, arcing faults, load changing or short circuits.

A surge may be of either polarity. The effective value of the source impedance will depend upon the manner of its generation but will in many circumstances be very low and energetic. Stand alone DC/DC modules cannot sustain such levels. This design note will cover the surge levels described in different standards as follow:

- Surges requirement of :
 - EN50155
 - Direct spike line to line :
 - Level 1,8 KV waveform 5/50µs impedance 100 Ohm
 - Level 1,8 KV waveform 5/50µs impedance 5 Ohm
 - Direct spike line to earth :
 - Level 4 KV waveform 5/50µs impedance 100w
 - EN61000-4-5 (IEC-801-5)
 - Direct spike line to line :
 - Level 4 KV waveform 1,2/50µs impedance 2 Ohm
 - Level 4 KV waveform 10/700µs impedance 42 Ohm
 - Direct spike line to earth :
 - Level 4 KV waveform 1,2/50µs impedance 12 Ohm
 - Level 4 KV waveform 10/700µs impedance 42 Ohm
 - EN60255-4 part 2
 - Direct spike line to earth and line to line :
 - Level 5 KV waveform 1.2/50µs impedance 500 Ohm

GAIA Converter proposes 2 schematics depending on the input bus nominal voltage :

- **Schematics 1** : adapted for 24 or 37,5 VDC nominal input bus and GAIA Converter modules with 9-36 VDC (H series) or 16-40 VDC (J series) input range.
- **Schematics 2** : adapted for 48, 72, 96, 125 VDC nominal input bus and GAIA Converter modules with 36-140 VDC (Q series) input range.

These 2 schematics are based on the same basic principle. They include a filter cell and a surge protection cell with transil diodes.

2- Major Standards Related to Surges

The following standards for surges are covered :

- **EN50155** : «Railways application electronic equipment used on rolling stock»
- **EN61000-4-5** : «Electromagnetic, compatibility, testing and measurement. Immunity Standard - Surge Immunity»
- **HN-46-R01** : «General guidelines for the design and manufacturing of control, protection and telecommunication equipment for electrical network»
- **EN60255** : «Electrical Relays- section 4 part 1»

The standards EN61000-4-5 and EN50155 specify that the input voltage supply shall be present.

The standards HN-46R01 and EN60255 specify that no input voltage supply shall be present during the test.

2-1 EN61000-4-5

This standard specifies two different surge wave forms :

- one with a rise time of 1.2µs and a time to half value of 50µs
- the other with a rise time of 10µs and a time to half value of 700µs.

The source impedance for the 1.2/50µs is 2 Ohm for line to line coupling and 12 Ohm for line to earth coupling. The 10/700µs surge impedance is 42 Ohm both for line to line coupling and line to earth coupling.

Coupling for both waveforms is performed via a coupling/decoupling network with coupling capacitors of 0.1, 0.5, 9 or 18 µF, or with arrestors, depending on the kind of lines to be tested. The following levels are applied :

Test level	Open circuit test voltage KV	Impedance
1	0.5 KV	2 or 42 Ohm
2	1 KV	2 or 42 Ohm
3	2 KV	2 or 42 Ohm
4	4 KV	2 or 42 Ohm

2-2 EN50155

This standard specifies :

- one surge wave forms with a rise time of 5µs and a time to half value of 50µs with a level of 1,8 KV.
- one surge wave forms with a rise time of 0.05µs and a time to half value of 0.1µs with a level of 8,4 KV.

The source impedance is 100 Ohm and can be 5 Ohm in specific cases.

Test level	Test voltage KV	Impedance
Direct spikes level D	1.8 KV	5 or 100 Ohm
Direct spikes level G	8,4 KV	5 or 100 Ohm
Indirect spikes level H	1,8 KV	100 Ohm
Indirect spikes level L	8,4 KV	100 Ohm

2-3 HN-46-R01

This standard specifies a surge wave forms with a rise time of 5µs and a time to half value of 50µs. The source impedance is 500 Ohm and the following levels applied depending of the class of equipement. No input voltage is applied on the DC/DC converter.

Class	Level line earth	Level line to line	Impedance
A1	8 KV	8 KV	500 Ohm
A2	5 KV	5 KV	500 Ohm
B	5 KV	5 KV	500 Ohm
C1	5 KV	5 KV	500 Ohm
C2	3 KV	3 KV	500 Ohm
D	1 KV	1 KV	500 Ohm
E	0.5 KV	0.5 KV	500 Ohm

2-4 EN60255

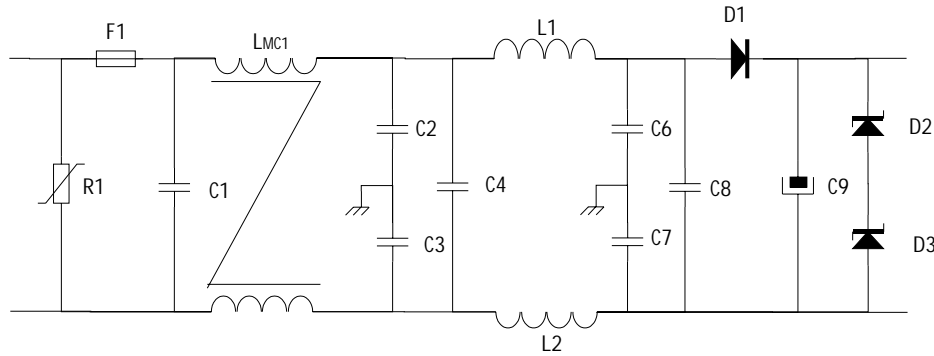
This standard specifies a surge wave forms with a rise time of 1.2µs and a time to half value of 50µs. The source impedance is 500 Ohm and the following levels applied depending of the class of equipement. No input voltage is applied on the DC/DC converter.

Test level	Open circuit test voltage KV	Impedance
2	1 KV	500 Ohm
3	5 KV	500 Ohm

3- Schematics Adapted for Nominal Bus of 72, 96, 110, 125 VDC

To sustain such energetic surges, protection devices must be capable of handling the high energy level and long duration of surge. Most commonly selected components for this purpose are «Metal Oxide Varistor» (MOV), which offers the unique feature of being very good conductors of current if the applied voltage exceeds its breakdown threshold.

However MOV may not react quickly enough to a fast rise-time signal. MOV has to be used with faster avalanche devices such as Transzorbis or Zener diodes; this solution guarantees that the MOV will provide the high energy handling capability while the avalanche device suppresses the initial spike that the MOV cannot dampen.



- R1: Little fuse V150ZA8
- F1*: Please adjust fuse rating to power effectively used in the application.
- LMC1*: Common Mode Choke type Pulse P0502 value 470µH current 14A or equivalent
- C1, C4.....: Capacitor 2x220nF/200V Murata GRM32DR72E224K or other equivalent ceramic chip capacitor
- L1, L2*: Inductor with value higher than 4.7µH type Pulse PE53700 15,4A or equivalent
- C8: Capacitor 220nF/200V type Murata GRM32DR72E224K or equivalent
- C2, C3, C6, C7: Capacitor 10nF rated according isolation
- D1: Reverse polarity protection diode rated according maximum input current & reverse polarity voltage
- C9: Aluminium electrolytic capacitor 10µF/per converter rated 200V
- D2, D3: Transient voltage supressor diode type Little fuse 5KP64A

Notes* :

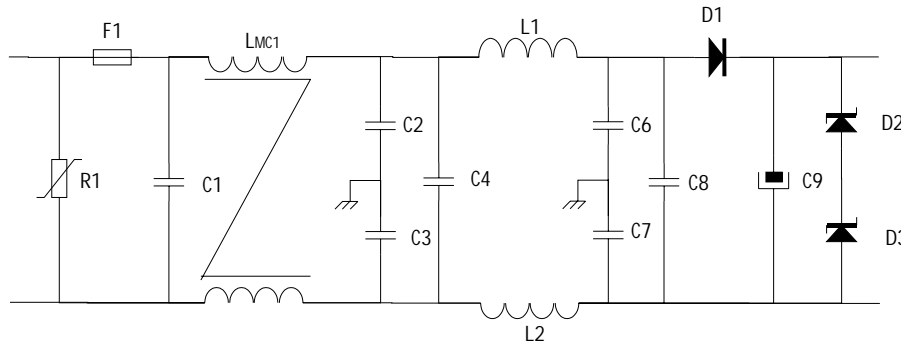
- **Note on fuse :** fuse may be not allowed depending on the application and by some authorities. In any case please adjust fuse rating to power effectively used in the application.
- **Note on inductors :** inductors LMC1, L1 and L2 can be rated according to input current required.
- **Note on D2, D3 :** the typical schematics include 2 transil diode components to sustain the energy level specified in the different standards. If your levels are higher you can use more than two components and add in parallel additionnal 2 diodes. The following table proposes some examples of achieved levels :

Number of diodes	Standards	Levels achieved	Impedance
2	EN61000-4-5	2 KV	12 Ohm
2	EN50155	1.8 KV	100 Ohm
2	HN-46-R01	5 KV	500 Ohm

4- Schematics Adapted for Nominal Bus of 24, 37.5 VDC

To sustain such energetic surges, protection devices must be capable of handling the high energy level and long duration of surge. Most commonly selected components for this purpose are «Metal Oxide Varistor» (MOV), which offers the unique feature of being very good conductors of current if the applied voltage exceeds its breakdown threshold.

However MOV may not react quickly enough to a fast rise-time signal. MOV has to be used with faster avalanche devices such as Transzorb or Zener diodes; this solution guarantees that the MOV will provide the high energy handling capability while the avalanche device suppresses the initial spike that the MOV cannot dampen.



- R1: Little fuse V56ZA8
- F1*: Please adjust fuse rating to power effectively used in the application.
- LMC1*: Common Mode Choke type Pulse P0502 value 470µH current 14A or equivalent
- C1, C4.....: Capacitor 2x1µF/100V Murata GRM32DR72E224K or other equivalent ceramic chip capacitor
- L1, L2*: Inductor with value higher than 4.7µH type Pulse PE53700 15,4A or equivalent
- C8: Capacitor 2x1µF/100V type Murata GRM32DR72E224K or equivalent
- C2, C3, C6, C7: Capacitor 10nF rated according isolation
- D1: Reverse polarity protection diode rated according maximum input current & reverse polarity voltage
- C9: Aluminium electrolytic capacitor 100µF/per converter rated 100V
- D2, D3: Transient voltage supressor diode type Little fuse 5KP33A
- Cc*: Common mode noise capacitance 10nF per converter

Notes* :

- **Note on fuse :** fuse may be not allowed depending on the application and by some authorities. In any case please adjust fuse rating to power effectively used in the application.
- **Note on inductors :** inductors LMC1, L1 and L2 can be rated according to input current required.
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2	HN-46-R01	5 KV	500 Ohm



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