

ENC50155 Railways Applications

Until recent years, railway systems have been protected national activities with protective standardization bodies. As a consequence a tremendous quantities of standards both for mobile and fixed equipment are existing among which the most popular are :

- The French NF F standards: NF-F 48 series, NF-F-01-510, NF-F67000, ...
- The UK BRB/RIA standards: RIA12, RIA13, RIA18, RIA20, BR1900, ..
- The German standards: VDE 0435, IEC571, 19 Pfl,
- The Italian FS standards: ST306158, ST304142,
- The American standards published by the Association of American Railroads : «Signal Manual», Specification 110, ... A major work has been done to harmonize railway standards in Europe. The introduction of European Norm EN's is being adopted slowly by railways electronics manufacturers among which :
- The EN 50155 standard: "Railways Applications Electronic Equipment Used on Rolling Stock",
- The EN50125 Standard: "Railway applications; Environmental Conditions for rolling stock"
- The EN50163 Standard: "Supply voltagages of Traction Systems"

This application note do not intend to describe each standard but to resume five most important requirements that apply for DC/DC converters when considered as component :

- Input requirements,
- Electromagnetic compatibility requirements,
- Mechanical requirements,
- Thermal (temperature, humidity) requirements,
- Isolation requirement.

Range of DC/DC Converters

EN50155 and IEC60571 specify a nominal input variation of $\pm 30\%$ including ripple but some other specifications define $\pm 40\%$.

Technical Standards

Modern trains achieve savings of weight and space by using battery voltage up to 110Vd.c. but most system equipments require input power at 12V and 24Vdc. The DC/DC Converter transforms the basic 110Vdc to 12 and 24Vdc, but can also perform the inverse if necessary. i.e. convert 12 and 24Vdc to 110Vdc.

Nominal input	EN50155 standard			NF F 01-510 standard			RIA12 standard			
	Permanent input range (0,7-1,25 Vin)	Brownout 100ms (0,6xVin)	Transient 1s (1,4xVin)	Permanent input range	Brownout 100ms (0,5xVin)	Transient 100ms	Permanent input range (0,7-1,25 Vin)	Brownout 100ms (0,6xVin)	Transient 1s (1,5xVin)	Transient 20ms (3,5xVin)
24 V	16,6 - 30 V	14,4 V	33,6 V	18 - 34 V	12 V	40 V	16,6 - 30 V	14,4 V	36 V	84 V
37,5 V	26 - 47 V	22,5 V	52,5 V	/	/	/	26 - 47 V	22,5 V	56,25 V	131,25 V
48 V	33,6 - 60 V	28,8 V	67,2 V	/	/	/	33,6 - 60 V	28,8 V	72 V	168 V
72 V	50,4 - 90 V	43,2 V	100,8 V	50 - 90 V	36 V	115 V	50,4 - 90 V	43,2 V	112,5 V	252 V
96 V	67,2 - 120 V	57,6 V	134,4 V	/	/	/	67,2 - 120 V	57,6 V	144 V	336 V
110 V	77 - 137,5 V	66 V	154 V	77 - 137	55 V	176 V	77 - 137,5 V	66 V	165 V	385 V

Environmental specification

Surge Requirements

Railway electronic equipment shall be protected from surges either directly induced or indirectly coupled such that no damage or failure occurs during operations. The magnitude, duration and source impedance of these surges for design purposes are defined in EN 50155, RIA 12 or the international standard IEC-801-5 renamed EN61000-4-5 as follow :

	EN50155 standard			BRB/RIA 12 standard			EN61000-4-5 standard		
	Level	Waveform	Source impedance	Level	Waveform	Source impedance	Level	Waveform	Source impedance
Direct spikes Line to line coupling	1.800 V	5/50 μ s	100 W	800 V	10/100 μ s	5 W	1 : 500 V	1,2/50 μ s	2 W
	1.800 V	5/50 μ s	5 W	1.500 V	5/50 μ s	5 W	2 : 1.000 V	1,2/50 μ s	2 W
				3.000 V	0,5/5 μ s	100 W	3 : 2.000 V	1,2/50 μ s	2 W
				4.000 V	0,1/1 μ s	100 W	4 : 4.000 V	1,2/50 μ s	2 W
	8.400 V	0,05/0,1 μ s	100 W	7.000 V	0,05/0,1 μ s	100 W			
Direct spikes Line to earth coupling	1.800 V	5/50 μ s	100 W	800 V	10/100 μ s	5 W	1 : 500 V	1,2/50 μ s	12 W
	1.800 V	5/50 μ s	5 W	1.500 V	5/50 μ s	5 W	2 : 1.000 V	1,2/50 μ s	12 W
				3.000 V	0,5/5 μ s	100 W	3 : 2.000 V	1,2/50 μ s	12 W
				4.000 V	0,1/1 μ s	100 W	4 : 4.000 V	1,2/50 μ s	12 W
	8.400 V	0,05/0,1 μ s	100 W	7.000 V	0,05/0,1 μ s	100 W			

Compliance with Electromagnetic Interference Requirements

Railway electronic systems are subjected to different level of electromagnetic interference requirements.

	Generic Standards	EN 50121-3 and -4	EN 50155	NF F 05-510	GAIA stand-alone module compliance unless otherwise specified
Radio electrical conducted emission <30MHz 0,15 - 0,5 MHz (quasi peak) 0,5 - 5 MHz (quasi peak) 5 - 30 MHz (quasi peak)	EN55022 EN55011	EN55011 level +20 dB : 79 dB/ μ V/m+20dB (quasi peak) 73 dB/ μ V/m+20dB (quasi peak) 73 dB/ μ V/m+20dB (quasi peak)	Level : 70 dB/ μ V/ qp 70 dB/ μ V/ qp 70 dB/ μ V/ qp	Level : < 46 dB/ μ A 26 dB/ μ A 26 dB/ μ A	with KG9503 or LGDS-50 filter < 70 dB/ μ V/m (quasi peak) < 70 dB/ μ V/m (quasi peak) < 70 dB/ μ V/m (quasi peak)
Radio magnetic emission qp at 10m >30MHz 30 - 80 MHz 80 - 230 MHz 230 - 1.000 MHz	EN55022 EN55011	EN55011 level class B : 40 dB/ μ V/m (quasi peak) 40 dB/ μ V/m (quasi peak) 47 dB/ μ V/m (quasi peak)	Level : 70 dB/ μ V/m < 70 dB/ μ V/m < 70 dB/ μ V/m	Level : 56 db/ μ V/m 56 dB/ μ V/m 63 dB/ μ V/m	with KG9503 or LGDS-50 filter 40 dB/ μ V/m (quasi peak) 40 dB/ μ V/m (quasi peak) 47 dB/ μ V/m (quasi peak)
Electrostatic discharge immunity (Internal)	EN61000-4-2 or IEC-801-2	Level : 6KV contact cond. B Level : 8KV air cond. B	/	/	Level 4KV contact cond. B Level 6KV contact cond. B Level 8KV air cond. B
Radio frequency electromagnetic fields immunity (80 - 1.000 MHz)	EN 61000-4-3 or IEC-801-3 EN50140	Level : 10V/m condition A Level : 20V/m condition A	Level : 10V/m Level : 20V/m	Level : 10V/m /	Level 10V/m condition A Level 20V/m condition A
Fast transient burst immunity (DC power port and I/O ports)	EN 61000-4-4 or IEC-801-4	Level : 0.5KV condition A Level : 2KV condition A	Level : 2 KV	Level : 2KV	Level : 0.5KV condition A Level : 2KV condition B
Surges immunity (see section 2)	EN 61000-4-5 or IEC-801-5	Level : 2KV condition B Impedance 42 Ohm	Level : 1,8 KV (see section 2)	/	Level : 4KV with additional filter KG9503
Conducted disturbances induced by radio frequency fields immunity (150KHz-80MHz) (DC power port and I/O port)	EN50141 or EN 61000-4-6 EN50121-4	Level : 3V condition A Modulation 80% AM Impedance 150 Ohm Level : 10V condition A	/	/	Level 3V condition A Level 10V condition A
Damped oscillatory magnetic field immunity	EN 61000-4-10	Level : 30 A/m condition B	/	/	Level : 30A/m condition B

Compliance with Mechanical Requirements

Railway electronic systems are subjected to high level of mechanical environmental constraints depending on their Implementation

- Ground equipment,
- Wayside equipment,
- Mobile equipment.

These constraints are defined in different standards among which the most commonly used are :

Equipment location	Parameter	EN50155	NF F 01-510 (Rolling stock) NF F 05-510 (Fixed equipment)	BRB/RIA20	GAIA Converter modules Qualification
Rolling equipment	Vibration Frequency range Acceleration	Category < 0,3 Kg 5 - 150 Hz 5g	Category «Bogies» 0 - 150 Hz ASD density : 0,1g ² /Hz	Category 2 «Bogies» 20 - 600 Hz ASD density : 0,1g ² /Hz	Compliant
	Shock (Half sinus) Peak acceleration Duration	Long. / Trans. / Vert. axis 5g / 2g / 1g 50 ms / 20ms / 20ms	Category «essieu» 50g 10 ms	Category 2 «Bogies» 50g 11 ms	Compliant
Ground equipment	Vibration Frequency range Acceleration	/	Category «traverses» 6-2.000 Hz 9 g	/	Compliant
	Shock (Half sinus) Peak acceleration Duration	/	Category «traverses» 80g 11 ms	/	Compliant

Compliance with Temperature/Humidity Requirements

The EN50155 standard specifies 4 grades of operating temperature requirements according to the severity of the environment as shown is the following table.

- An industrial grade with an operating temperature range of -40°C/+71°C ambient with no derating and a maximum case temperature of 91°C,

Category	Internal cabinet temperature range	Ambient board temperature range	GAIA Converter modules temperature range
T1	-25°C / +55°C	-25°C / +70°C	Industrial line : -40°C / +71°C ambient
T2	-40°C / +55°C	-40°C / +70°C	Industrial line : -40°C / +71°C ambient
T3	-25°C / +70°C	-25°C / +85°C	Hi-rel line : -40°C / +85°C ambient -40°C / +105°C case
TX	-40°C / +70°	-40°C / +85°C	Hi-rel line : -40°C / +85°C ambient -40°C / +105°C case

Humidity Requirements

Mobile or fixed railway equipments have also to comply with humidity requirements. GAIA Converter modules have been qualified with EN60068-2-3 standard and comply with the following requirement of EN50155, NF01-510 or BS2011 standards.

Standards	Requirements
EN50155	2 x 25 h 40°C
NF F 01-510	100% relative humidity
BS2011 / IEC-68-2-3	56 days 93% relative humidity

Compliance with Isolation Requirements

Railway electronic equipment shall be protected against dielectric strength through different isolation barriers. The levels are defined in different standards such as EN50155, NF F 670001 or NF 05-510 and are resumed in the following table.

Input Nominal	Rolling stock EN50155 requirements	Rolling stock NF F 670001 requirements	Ground equipment NF F 05-510 requirements	GAIA Converter modules performance
24 VDC	500Veff/50Hz/1min.	group A : 1.500Veff/1min.	2.000Veff/50Hz/1min.	Basic version : 500Veff/50Hz/1min. Y version : 2.000Veff/50Hz/1min.
48 VDC	500Veff/50Hz/1min.	group A : 1.500Veff/1min.	2.000Veff/50Hz/1min.	Basic version : 500Veff/50Hz/1min. Y version : 2.000Veff/50Hz/1min.
72 - 125 VDC	1.000Veff/50Hz/1min.	group A : 1.500Veff/1min.	2.000Veff/50Hz/1min.	Basic version : 500Veff/50Hz/1min. Y version : 2.000Veff/50Hz/1min.
125 - 315 V	1.500Veff/50Hz/1 min.	group A : 1.500Veff/1min.	2.000Veff/50Hz/1min.	Basic version : 500Veff/50Hz/1min. Y version : 2.000Veff/50Hz/1min.