

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 |
| Direct spikes Line to earth coupling | 8.400 V | 0,05/0,1 μ s | 100 W | 7.000 V | 0,05/0,1 μ s | 100 W | | | |
| | 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. |