Power for Railway Applications

- EN50121:2000
- EN50155:2000
- XP Products for the Railway Industry
  - SRX Series
  - DC Standby Systems
  - Base-plate Cooled
  - C & CI Series
  - High power

In Rail applications it is important that all equipment is able to withstand the harsh environments encountered; climatic, mechanical and electrical on traction vehicles and rolling stock.

In the past within Europe, many countries developed their own national rail standards. However, with the privatisation of many national rail companies and a general move to harmonisation of national standards within the European Union two new standards for electronic equipment on rolling stock and track side equipment (EN50121 & EN50155) have generally replaced the older national standards.

National Standards:

- ***BRB/RIA 12***
  General specification for Protection of Traction and Rolling Stock Equipment from Transients and Surges in DC control systems.
- ***BRB/RIA 13***
  General specification for Electronic Equipment used on Traction and Rolling stock.
- ***BRB/RIA 20***
  Requirement for Vibration and Shock testing of Equipment on Railway Vehicles.
- ***NF F 01-510***
  Railway Rolling Stock Environment Conditions sustained or produced by Devices in Vehicles.

EN50121:2000

EN50121:2000 is a set of standards that specifies the limits for electromagnetic emissions of the railways to the outside world and the electromagnetic emission and immunity for equipment working within the railways.

The five parts contained in the standard are as follows:

Part 1. General.
Provides a general introduction, defines the EMC management between infrastructure and rolling stock, as well as describing the rail environment.

Part 2. Emission of the railway system as a whole to the outside world.
Sets emission limits to the outside world at specific radio frequencies and defines measurement test methods.

Part 3. Rolling Stock 3-1 Train & Complete vehicle.
Defines traction stock, rolling stock and independent hauled stock emission and immunity requirements and measurement techniques.

3-2 Apparatus.
Defines train-borne equipment, emission and immunity levels and measurement techniques.

Part 4. Signalling & Telecom's Equipment.
Defines emission and immunity levels and measurement techniques for signalling and telecommunication equipment.

Part 5. Fixed power supply installations.
Defines emission and immunity levels and measurement techniques for fixed power supply installations.

Generally power products supplied by XP, would form part of the apparatus on board the train - thus EN50121-3-2 would apply.

Conducted Emissions from power supply ports is in the table below:

Conducted Emissions from PSU within Apparatus		
Port	Frequency Range	Limits
Battery Power DC	150KHz-500KHz 500KHz-30MHz	79dBµV quasi-peak 73dBµV quasi-peak

Immunity for input of power supply from the battery supply is in table below;

Immunity - Battery referenced ports.Voltage <400V (power supply input)			
Environmental phenonena	Basic Standard	Severity	Performance Criteria
Fast Transient burst	EN61000-4-4	2KV 5/50ns Tr/Th 5 KHz rep frequency	A
Surges	EN50155	1.8KV waveform 5/50us Source impedance 100Ohm	B
Conducted radio frequency	EN61000-4-6	3Vrms carrier voltage 150KHz to 80MHz 1KHz, 80%AM Source impedance 150Ohm	A

Immunity for equipment housing is in the table below;

Immunity - Battery referenced ports.Voltage <400V (power supply input)			
Environmental phenonena	Basic Standard	Severity	Performance Criteria
Radio frequency	EN61000-4-3	10V/m rms carrier voltage 80MHz to 1 GHz 1 KHz, 80%AM	A
Electrostatic discharge	EN61000-4-2	6KV contact discharge 8KV air discharge	B

Performance Criteria Definition

A. The apparatus shall continue to operate normally during and after the test. No degradation of performance.
B. The apparatus will continue to operate normally after the test. There may be a loss of performance during the test.

EN50155:2000

The most frequently cited design specification is the document IEC571 “Electronic Equipment on Rail Vehicles”. This is also known as European Norm EN50155 “Electronic Equipment used on Rolling Stock”. In the UK the standard is RIA12 “General Specification for Protection of Traction and Rolling Stock from Transients and Surges in DC Control Systems”. EN50155 and RIA12 are very similar but RIA12 also requires a specific surge withstand capability explained later.
The most important requirements of the specification can be broken down in to four basic sections.

- Input
- Mechanical (Shock & Vibration)
- Electromagnetic compatibility
- Environmental (Temperature & Humidity)

A. Input Requirements

Electronic systems used within the railway environment experience a wide variation in input supply with brownout operation, transience and spikes.

Table 1 below details for each nominal input voltage used within the industry, the input ranges, brownouts and transients that must be meet to comply with EN50155 and compares this with the RIA 12 & NF F 05-510 standards. Surges induced directly or indirectly on to the input supply must be filtered to ensure that equipment is not damaged .

110 V	96 V	72 V	48 V	24 V	Nominal Input
EN50155					
77-137.5V 66.0 V 154.0 V	67.2-120V 57.6 V 134.4 V	50.4-90.0V 43.2 V 100.8 V	33.6-60.0V 28.8 V 67.2 V	16.6-30.0V 14.4V 33.6V	Permanent input range (0.7 -1.25V Vin) Brownout 100ms (0.6 x Vin) Transient 1sec (1.4 x Vin)
RIA12					
77.0 - 137.5 V 66.0V 165.0 V 385.0 V	67.2 -120V 57.6V 144V 336.0 V	50.4 - 90.0 V 43.2 V 112.5 V 252.0 V	33.6 - 60.0V 28.8 V 72.0 V 168.0 V	16.6 - 30.0V 14.4 V 36.0 V 84.0 V	Permanent input range (0.7 -1.25V Vin) Brownout 100ms (0.6 x Vin) Transient 1sec (1.5 x Vin) Transient 1sec (3.5 x Vin)
NF F 05-510					
77.0 - 137.0 V 55.0V 176.0 V			50.0 - 90.0 V 36.0 V 115.0 V	18.0 - 34.0V 12.0 V 40.0 V	Permanent input range Brownout 100ms (0.5 x Vin) Transient (100 ms)

Table 2 below details the magnitude, duration and source impedance of surges for design purposes defined in EN50155 and compares this with the RIA 12 standard.

	EN50155			RIA12		
	Level	Time	Source Impedance	Level	Time	Source Impedance
Direct spikes line to line coupling	1.8 kV	5/50μS	100Ω	800 kV	10/100μS	5Ω
	1.8 kV	5/50μS	5Ω	1.5 kV	5/50μS	5Ω
				3.0 kV	0.5/5μS	100Ω
	8.4 kV	0.5/5μS	100Ω	4.0 kV	0.1/1μS	100Ω
				7.0 kV	0.05/0.1μS	100Ω
Indirect Spikes line to earth coupling	1.8 kV	5/50μS	100Ω	800 kV	10/100μS	5Ω
	1.8 kV	5/50μS	5Ω	1.5 kV	5/50μS	5Ω
				3.0 kV	0.5/5μS	100Ω
				4.0 kV	0.1/1μS	100Ω
	8.4 kV	0.05/0.1μS	100Ω	7.0 kV	0.05/0.1μS	100Ω

B. Electromagnetic Interference

The level of electromagnetic interference requirements for a particular piece of electronic equipment dependent on the location/application; EN50121 above defines these for each particular application.
However EN50155 defines basic levels - it must be noted that equipment generally supplied by XP can be considered as a component - the standards apply to the finished product intended for installation on the rolling stock.

Table 3 below compares the levels between EN50121-3 & 4, NF F 05-510 and EN50155 along with other standards, which are referred to within these standards.

	EN50121-3 & -4	EN50155	NF F 05-510
Radio electrical conducted emissions <30MHz	EN55011 level +20dB		
0.15 - 0.5MHz (quasi peak)	79 dB/μV/m+20dB (quasi peak)	70 dB/μV qp	<46 dB/μA
0.5 -5MHz (quasi peak)	73 dB/μV/m+20dB (quasi peak)	70 dB/μV qp	26 dB/μA
5 - 30MHz (quasi peak)	73 dB/μV/m+20dB (quasi peak)	70 dB/μV qp	26 dB/μA
Radio electrical emission qp at 10m >30MHz	EN55011 LEVEL class B	70 dB/μV/m	
30 - 80 MHz	40 dB/μV/m (quasi peak)	70 dB/μV/m	56 dB/μV/m
80 - 230 MHz	40 dB/μV/m (quasi peak)	70 dB/μV/m	56 dB/μV/m
230 - 1000 MHz	47 dB/μV/m (quasi peak	70 dB/μV/m	56 dB/μV/m
Electrostatic discharge immunity (internal)	6 kV contact cond. B 8 kV air cond.B		
Radio frequency electromagnetic fields immunity (80-1000MHz)	10 V/m condition A 20 V/m condition A	10 V/m 20 V/m	10 V/m
Fast transient burst immunity.	0.5 kV condition A 2.0 kV condition A	2.0 kV	2.0 kV
Surges immunity	2 Kv condition B impedance 42 Ohm	1.8 kV	-
Conducted disturbance induced by radio frequency	3 V condition A Mod 80% AM, Impedance 150 Ohm. 10 V condition A	-	-
Damped oscillatory magnetic field immunity	30 A/m condition B	-	-

C. Mechanical

Due to the nature of railways, any equipment used on or close to rolling stock will be subject to a constant vibration of varying frequency and magnitude.

EN50155 and formally RIA 20 specify the level electrical equipment must comply to depending on its location within the railway environment.

Rolling Stock Equipment	EN50155	RIA20	NF F 05-510
Vibration Freq. Range Acceleration	<0.3 Kg 5-150 Hz 5g	Cat. 2 Bogies 20-600 Hz ASD density 0.1 g^2/Hz 7g value	Cat. 2 Bogies 0-150 Hz ASD density 0.1 g^2/Hz
Shock (Half sinus) Peak Acceleration Duration	3 axis 5/2/1g 50/20/20 ms	Cat. 2 Bogies 50 g 11ms	Cat. 2 Bogies 50 g 10 ms

Note: Electronic Equipment mounted on boards and boxes fixed to the vehicle frame must be able to withstand vibration on all 3 axes at the levels detailed above. If points of resonance exist, the equipment shall be vibrated at those frequencies during a total of 1hr. But for a maximum of 15mins for each point of resonance. For the remaining time (1 to 1.75hrs per axis) the equipment shall be vibrated using a rise/fall frequency sweep of 1 octave/min).

D. Temperature/Humidity

Four grades of operating temperature are specified by EN50155, which are further sub-divided in to ambient PCB temperature and enclosure ambient temperature.

Grade	External Enclosure Ambient temperature	Internal Enclosure Ambient Temperature
T1	-25°C to 40°C	-25°C to 55°C
T2	-40°C to 35°C	-40°C to 55°C
T3	-25°C to 45°C	-25°C to 70°C
T4	-40°C to 50°C	-40°C to 70°C

Electrical equipment should be designed for relative humidity stress limits over the external enclosure temperature ranges defined above as follows:

- Yearly average ≤ 75% relative humidity.
- 30 days per year continuously = 90% relative humidity.

XP Products for the Railway Industry

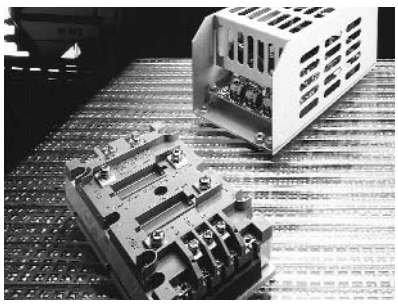
Approved to support over 60 UK rail companies through the Link-up qualification Scheme, XP over the years have supplied power systems in to the railway market sector in a variety of configurations depending on the application.

Both modular and complete systems based on standard and bespoke solutions are available.
When looking at any application with regard to the standards discussed it is important to remember that these specifications relate to the finished product, of which the power supply or DC/DC converter is classified as a component part only.

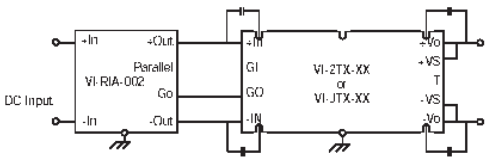
As can be seen from the comparisons between the new standards and the older RIA & NF standards, the RIA standards are generally more onerous

Detailed below are details of a number of projects completed to date.

Standard Solutions
VI-RIA-002

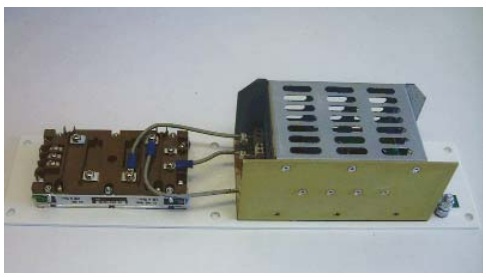


Designed to meet the requirements of RIA 12 and RIA 13 for Railway applications when used in conjuction with suitable Vicor Modules. Part No. VI-RIA-002 is for 110 VDC Bus modules when used in conjuction with the VI-2TX-XX or VI-JTX-XX Series.



VI-RIA-002 includes input Fusing, Filtering. Transient protection and hold up capacitors. For higher power, boosters can be added. For multi outputs, drivers can be added. Max Power at output = 600 W.
The standard product (above right) can be modified for use with a variety of DC/DC Converters.

Compliant DC/DC Converter



The plate assembly shown was designed to provide a transient protected DC o/p for attachment to overseas rolling stock using the Paxman range of diesel locomotive engines.

SRX DC/DC Converter

The SRX Series of DC/DC converters are available in a number of mechanical configurations & output ratings of up to 300W. These units are designed to accommodate a number of standard options designed to meets specific customer requirements.

Model Numbering - SRX Series

Style

SRA = Chassis Mount (Ears)
SRN = Narrow
SRX = Chassis Mount
SRB = Box
SRC = 3U Cassette
SRE = 6U Eurorack

Power (watts)

200
300

Inputs

24	=	24 VDC
35	=	36 VDC
48	=	48 VDC
72	=	72 VDC
95	=	96 VDC
C	=	110 VDC

No. of Outputs

S = Single
M = Multi[5]

Outputs

Single O/Ps

02	=	2 V
03	=	3.3 V
05	=	5 V
08	=	8 V
12	=	12 V
15	=	15 V
24	=	24 V
36	=	36 V
48	=	48 V
60	=	60 V
C1	=	100 V
C3	=	130 V
C7	=	170 V
D2	=	220 V
E3	=	300 V

Options

-C	=	Cover
-B	=	Signals (Batt)
-S	=	Signals (TTL)
-R	=	Signals (Relay)
-T	=	OTP
-N	=	Temp Comp
-D	=	'OR'diode
-E	=	Tropicalisation
-F	=	Relay I/P & O/P
-M	=	Ruggedised

EXAMPLE: SRX 200 C S 12 - C

SRX= Input Open Frame
200 = Power Output
C = 110 VDC Input
C = Safety Cover Fitted
12 = Output 12 VDC
S = Single Output

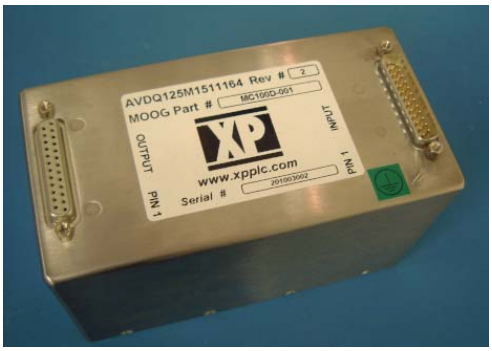
Compliant DC Standby System

The system shown was designed to meet "the general specification for protection of traction and rolling stock from transients & surges in control systems", RIA12

System comprised of IP54 protected enclosure, wired in PTFE cabling to meet fire legislation & vibration specification of rail rolling stock, for units attached to locomotive engines. The system is completed using a VI-RIA-002 filter, 2x 150W 110V/24V converters,12V 12Ah battery and voltage monitoring.

To comply with EMC requirements bronze breathers were applied to the enclosure to reduce EMC apertures & improve EMC capabilities, allowing airflow for the battery in case of gassing & compliance to IP54.

Base-plate cooled solutions for Railway Applications



Multiple-Output base-plate cooled enclosed DC/DC Converters designed to provide transient protected DC outputs, third party tested for:

- Conducted & Radiated EMC
- High & Low Temperature
- Vibration
- Reliability - HALT Test

C & CI Series

The C Series of converters, offer a complete range of individual power supplies, DC outputs, Inverters and Standard options can be configured to offer a total power solution.

The options include:
- Tropical protection
- Increased mechanical strength
- Operating temperature range from -40 ˚C to +75 ˚C
- Complete range of monitoring & control packages

The C Series converter shown opposite is installed onboard a tram. Designed to operate with input voltages of 900 VDC and housed within an IP54 cubicle, constructed to enable the unit to withstand high levels of shock and vibration.

Custom unit designed for Long Island Railroad-General Motors (USA)

24 kW switched mode battery charger for onboard application

Input: 3 phase 400 VAC
Output: 74 VDC @ 300 A (24 kW)

Unit designed to operate -40 °C to +80 °C by using natural convection and automatic derating of the output at high temperatures. The unit is hermatically encapsulated against the ingress of dust and designed for high levels of shock and vibration (unit tested with 2 g for 4 hrs at resonance frequency).

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