

# Application Note for Railway Product

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**This paper introduces components of rolling stock electronic equipment and different requirements for them, and puts forward key points complying with EN 50155 standards for selecting DC/DC Converter used in rolling stock electronic equipment, including isolation voltage, input voltage range, operating temperature range, EMC and so on.**



# > Introduction of rolling stock electronic equipment

The modern railway systems has a number of on-board control systems, they are almost all electrically powered. Since a train is virtually a self-contained unit, many different types exist. The electronic equipment is mainly powered by an auxiliary power supply system, which refers to all the load devices in addition to traction power network, including auxiliary power supply system and battery system, as shown in Figures 1 and 2.

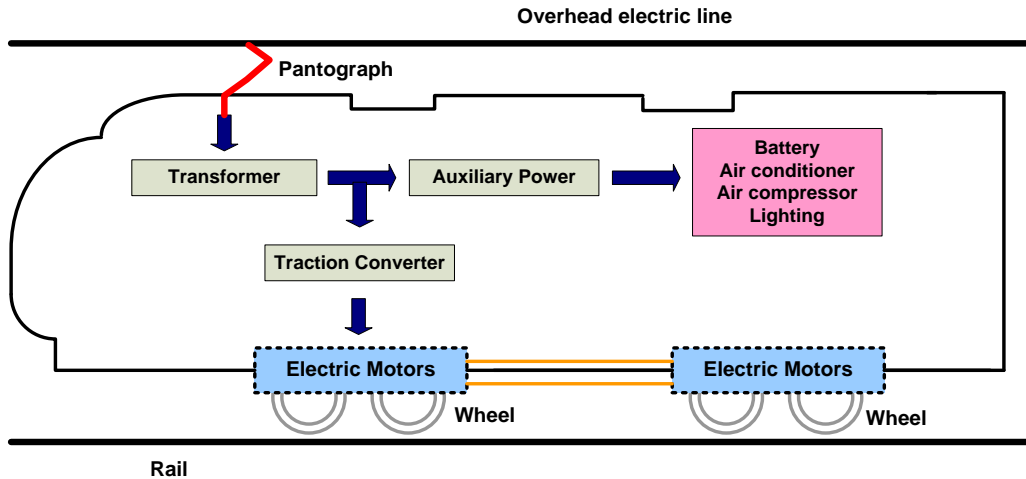


Figure 1: Block diagram of a rolling stock showing the basic arrangement of power source the equipment.

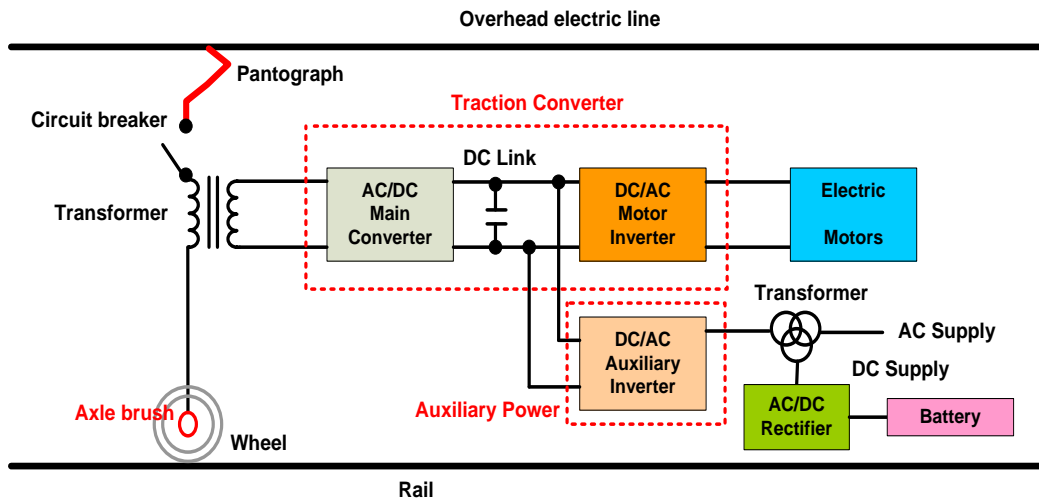


Figure 2: The output from the DC/AC auxiliary converter is 3-phase AC and is used for train lighting and the AC motors of air conditioning fans and compressors. The 3-phase is also converted to DC by the rectifier which provides current for battery charging and control circuits.



DC/DC converters are used in railway environments to convert DC battery voltages to a lower voltage for usage in a variety of control and energy circuits. This is because rolling stock uses a DC power distribution system so that batteries can be used to maintain electrical power in the event of a generator failure. Usually, this equipment takes power from a low-voltage bus power supply. And battery system at normal operation powers Train Control and Management System (TCMS), lighting system, Automatic Train Control (ATC) system, radio and other systems, as shown in Figure 3.

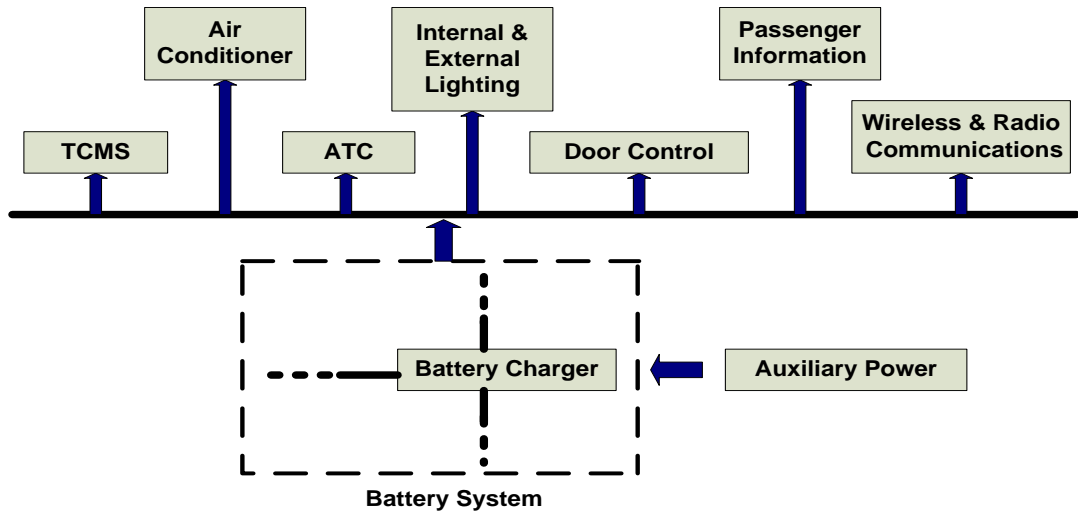


Figure 3: Block diagram of a railway rolling stock battery system.

The rolling stock electronics mainly consists of TCMS, lighting, communication, door control system, ATC and so on. These Systems are isolated powered by bus so as to ensure reliable operation of each subsystem, which helps isolate fault areas in case equipment failing. Owing to intelligent technology, the equipment are interconnected through the train communication bus with Remote Control function so as to drivers could control every electronic system through the on-board controller.

■ **Requirements of electronic equipment in railway application**

The one most frequently cited in design specifications is European Norm EN 50155, This standard is applicable to all electronic equipment installed in railway vehicles for control, adjustment, protection, and supply etc. EN 50155 relates to battery powered supply systems or low voltage power supplies that are directly connected to, or not connected to the contact system. DC/DC converters for in-vehicle electronic equipment must meet EN 50155, and must satisfy the Following requirements:

- Input voltage range;
- Interruptions of voltage supply and Supply change-over;
- Temperature and humidity;
- Shock and vibration;
- Insulation and voltage withstand;
- Electromagnetic compatibility;



## > EN50155 Railway Certification fundamental introduction

### ◆ Input voltage range:

EN 50155 covers nominal input voltage ranges for different vehicle batteries. The nominal battery voltages ( $U_n$ ) are 24V, 28V, 36V, 48V, 72V, 96V, and 110V depending on the class of vehicle. All electronic equipment should be designed to operate continuously in the range 0.7 ( $U_n$ ) to 1.25 ( $U_n$ ) and to also withstand temporary fluctuations in the range 0.6 ( $U_n$ ) to 1.4 ( $U_n$ ).

MOTIEN railway DC/DC converters, RW-8W, RW-20W series has an input voltage range of 13V~70V, 42V~176V and is compatible with 24V, 28V, 36V, 48V, 72V, 96V, 110V vehicle batteries. RW-25W series has an input voltage range is 16V~160V and is compatible with 24V, 28V, 36V, 48V, 72V, 96V, 110V vehicle batteries.

Nominal Input ( $U_n$ )	Input Range	Transients	
		Low ( 0.1 s ) 0.6 ( $U_n$ )	High ( 1 s ) 1.4 ( $U_n$ )
24V	16.8 - 30V	14.4V	33.6V
28V	19.6V - 35V	16.8V	39.2V
36V	25.2 - 45V	21.6V	50.4V
48V	33.6 - 60V	28.8V	67.2V
72V	50.4 - 90V	43.2V	100.8V
96V	67.2 - 120V	57.6V	134.4V
110V	77 - 137.5V	66V	154V

Table 1: Input Specifications for EN 50155

### ◆ Interruptions of voltage supply:

Due to a short circuit on DC supply distribution line and subsequent operation of fuse/circuit breakers, input voltage may reduce to 0V for a short period. During a short interruption, the DC distribution system presents a low impedance (short circuit) condition due to the clearing of an overload or fault condition on the supply bus. This condition can cause reverse current (negative peak inrush current) from the load. Equipment designed to meet the requirements of EN50155 required operating through short interruptions in the incoming supply.

Regarding interruptions on supply voltage, there are three classes of interruption:

- Class S1: no interruption
- Class S2: 10mS interruption
- Class S3: 20mS interruption

The choice of class should be defined by the system integrator; unless otherwise specified, the requirements of class S2 apply.



### ◆ Supply change-over:

In the case of equipment supplied by specified source, not directly connected to the vehicles power supply (e.g. stabilized DC/DC Converter, POE) the specification of this local source (e.g. voltages, current, tolerances) shall be met. Characteristics of the output voltage of the stabilized supply and input voltage of the equipment shall fit together. EN50155 standards define that an interruption may occur if the equipment supply is switched between different Input sources.

Regarding change-over on supply voltage, there are two classes of change-over:

- C1 100mS at  $0.6U_n$  no interruption
- C2 30mS interruption

Unless otherwise specified, the requirements for class C1 apply.

MOTIEN railway DC/DC converters are designed in fully compliant with all of Interruptions of voltage supply and Supply change-over standards above.

### ◆ Temperature/Humidity Requirements

All railway vehicles electronic equipment must be designed to operate to its full specification according to a range of different temperature classes, shown below in Table 2. The user of the railway vehicles electronic equipment shall respect the thermal integration constraints specified by the supplier and shall design the integration environment in order to ensure an operational temperature compliant with the operational temperature class of the integrated electronic equipment.

Electronic equipment and integration environment are generic designations applicable to several levels, some examples are listed below:

- - An enclosed or open frame complex component integrated on a PCB;
- - A single electronic board or a plug-in unit integrated into a sub-rack;
- - A single electronic board integrated into an enclosure;
- - A sub-rack integrated into a cubicle or an enclosure;
- - A rack or case integrated into a vehicle;

Class OT5 and OT6 cannot be used as a general specification for temperature in vehicle requirement (e.g. can used for semiconductor drive unit (SDU), combustion engine control unit).

Temperature classes OT1 and OT2 should be used for passenger compartments and driver's cab with a standard reference temperature of  $25^{\circ}\text{C}$ . OT3 and OT4 should be used for equivalent in technical cabinet with a standard reference temperature of  $45^{\circ}\text{C}$ . Unless otherwise specified, the requirements of category OT3 apply.

Class	Equipment operating temperature range
OT1	$-25^{\circ}\text{C} \sim +55^{\circ}\text{C}$
OT2	$-40^{\circ}\text{C} \sim +55^{\circ}\text{C}$
OT3	$-25^{\circ}\text{C} \sim +70^{\circ}\text{C}$
OT4	$-40^{\circ}\text{C} \sim +70^{\circ}\text{C}$
OT5	$-25^{\circ}\text{C} \sim +85^{\circ}\text{C}$
OT6	$-40^{\circ}\text{C} \sim +85^{\circ}\text{C}$

Table 2: Temperature Requirements for EN 50155



MOTIEN railway DC/DC converters are designed to operate in a convection cooled environment of -40°C to 85°C with many also able to operate in ambient temperatures up to 100°C.

In order to prove compliance with the thermal and humidity requirements of EN 50155 there are a number of type tests which must be met by the final equipment, shown below in Table 3.

Test item	Criterion
Low temperature test	EN 60068-2-1 test Ad
Dry heat test	EN 60068-2-2 test Be
Damp Heat Test	EN 60068-2-30 test Db
Low temp. storage test	EN 60068-2-1

Table 3: Environmental test Requirements

MOTIEN railway DC/DC converters are designed in fully compliant with all of Environmental standards above.

◆ **Shock and vibration:**

All Railway vehicles electronic equipment must be able to withstand, without deterioration, the levels of shock and vibration which would be seen by a train in regular service. The complete cubicle or rack together with its auxiliaries and mounting arrangements (including its shock-absorbing devices if the equipment is designed for mounting on such devices) shall be subjected to the tests indicated in EN 61373.

Unless otherwise stated shall meet the requirements of EN 61373 category 1, Class B. These are defined below:

Category	Orientation	RMS 10 mins/axis	Frequency range
1 Class B Body mounted	Vertical (Z-Axis)	0.103 Grms (1.01m/s <sup>2</sup> )	mass≤500 kg f = 5 ~ 150 Hz
	Transverse (Y-Axis)	0.046 Grms (0.450m/s <sup>2</sup> )	
	Longitudinal (X-Axis)	0.0714 Grms (0.700 m/s <sup>2</sup> )	

Table 4: Functional Random Vibration for EN 61373

Category	Orientation	RMS 5 hours/axis	Frequency range
1 Class B Body mounted	Vertical (Z-Axis)	0.584 Grms (5.72m/s <sup>2</sup> )	mass≤500 kg f = 5 ~ 150 Hz
	Transverse (Y-Axis)	0.260 Grms (2.55m/s <sup>2</sup> )	
	Longitudinal (X-Axis)	0.404 Grms (3.96 m/s <sup>2</sup> )	

Table 5: Increased Random Vibration for EN 61373



Category	Orientation	RMS 5 hours/axis	Nominal Duration D
1 Class B Body mounted	Vertical (Z-Axis)	3.0612 G (30m/s <sup>2</sup> )	30ms ( 3 times for each direction, 6 directions, 18 times in total.)
	Transverse (Y-Axis)	3.0612 G (30m/s <sup>2</sup> )	
	Longitudinal (X-Axis)	5.1020 G (50m/s <sup>2</sup> )	

Table 6: Shock for EN 61373

MOTIEN railway DC/DC converters are designed in fully compliant with all of Vibration and Shock standards above.

◆ **Insulation and voltage withstand:**

Isolation is one of effective methods to prevent fault diffusion and plays an important role in vehicle electronic equipment. Equipment's dielectric test is closely related to vehicle battery voltage. Relevant requirements are Table 7. It will also ensure that circuit's meet their galvanic insulation requirements. The test comprises 2 parts, the first of which is the insulation resistance measurement. This is made at 500V dc. The minimum level of insulation resistance shall be 20M ohms. The second part is a voltage withstand test which is performed in accordance with table 7 below. The test shall be performed with AC (50 Hz or 60 Hz) or DC test voltage according to Table 7. Voltages should be increased slowly (type 10 seconds) up to the maximum value and then held for 1 min in type tests and 10 seconds in routine tests.

Vehicle Battery	Isolation Requirement
24V	500V AC or 750V DC
48V	500V AC or 750V DC
72~125V	1000V AC or 1500V DC
125~315V	1500V AC or 2200V DC

Table 7: Insulation and voltage withstand for EN 50155

For battery referenced port, a higher impulse withstand voltage is applicable, in respect of EN 50121-3-2 surge requirements.

MOTIEN railway DC/DC converter, RW-8W, RW-20W, RW-25W series offer 3000VDC Isolation and 1000M ohms insulation resistance.

◆ **Electromagnetic compatibility:**

Electromagnetic compatibility (EMS) is another main category of the EN50155 certification. MOTIEN railway certified DC/DC converters are approved at the European EN 50121-3-2 standard "Railways Applications Electromagnetic Compatibility Part 3-2 Rolling Stock Apparatus". The EMC requirements of train-borne electrical equipment are defined by how in interfaces with the external Environment. These interfaces are known as ports:



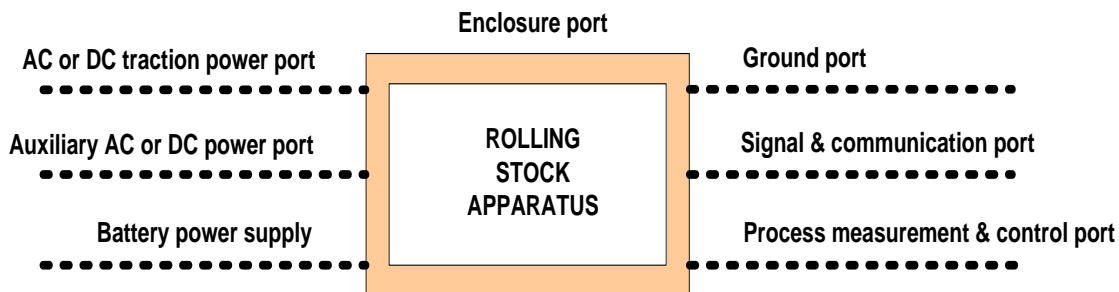


Table 8: Main categories of ports for EN 50121-3-2

Different ports have different EMC requirements. For battery ports, there are no conducted emissions limits in the Frequency of 9 kHz~150 kHz. Table 9 shows the EMC requirements for a battery referenced port in accordance with EN 50121-3-2, the same limits are also applicable to signal and communication ports as well as process measurement and control ports.

Test Items	Limits or test requirements
Conducted emissions 150KHz~500KHz 500KHz~30MHz	99dB $\mu$ V quasi-peak  93dB $\mu$ V quasi-peak
Radiated emissions 30MHz~230MHz 230MHz~1GHz	40dB $\mu$ V/m quasi-peak at 10m  47dB $\mu$ V/m quasi-peak at 10m
ESD IEC 61000-4-2	$\pm$ 6 kV, Contact discharge $\pm$ 8 kV, Air discharge Performance criteria B
Radio-frequency Electromagnetic field. Amplitude modulated IEC 61000-4-3	80 MHz ... 800 MHz 20 V/m(rms), 80 % AM, 1 kHz 800 MHz ... 1000 MHz 20 V/m(rms), 80 % AM, 1 kHz 1400 MHz ... 2000 MHz 10 V/m(rms), 80 % AM, 1 kHz 2000 MHz ... 2700 MHz 5 V/m(rms), 80 % AM, 1 kHz 5100 MHz ... 6000 MHz 3 V/m(rms), 80 % AM, 1 kHz Performance criteria A

Table 9: Electromagnetic compatibility for EN 50121-3-2





Test Items	Limits or test requirements
Fast transients IEC 61000-4-4	± 2KV , 5/50ns, 5 KHz Performance criteria A
Surge IEC 61000-4-5	1.2 / 50 μs ± 2KV /42Ω, 0.5μF, Open circuit test voltage, line to ground ± 1 kV /42 Ω, 0.5μF, Open circuit test voltage, line to line Performance criteria B
Conducted disturbance immunity IEC 61000-4-6	0.15 MHz~80 MHz 10 V(r.m.s) 80% AM, 1KHz Performance criteria A

Table 9: Electromagnetic compatibility for EN 50121-3-2

