EUROPEAN UNION AGENCY FOR RAILWAYS

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Requirements for Personnel Carriages ensuring compatibility with train detection systems.

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1.0	30/01/2025	First version of the document

Contents

1 General context

1.1 Introduction

This document applies to personnel carriage as defined in point 7.1.1.6 of TSI LOC&PAS

1.2 Reference documents

Acronym	Name	Reference
[1]	TSI LOC&PAS	Commission regulation (EU) No 1302/2014; 18.11.2014 with amendment M5 commission implementing regulation (EU) 2023/1694;
[2]	ERA/ERTMS/033281 v5.0	Interfaces between control-command and signalling trackside and other subsystems
[3]	EN 50592:2016	Railway applications - Testing of rolling stock for electromagnetic compatibility with axle counters
[4]	EN 50728:2024	Railway applications - Rolling stock - Testing for electromagnetic compatibility with track circuits
[5]	EN 50163:2004/A3:2022	Railway applications - Supply voltages of traction systems
[6]	EN 50343:2014/A1:2017	Railway applications - Rolling stock - Rules for installation of cabling

1.3 Abbreviations

Abbreviation	**Description**
EMC	Electromagnetic compatibility
TSI	Technical Specification for Interoperability
ERA	European Union Agency for Railways
TDS	Train Detection Systems

2 Train detection systems compatibility requirements

The following requirements shall be fulfilled for all “single pole” power supply line voltages (1,5kV DC, 3kV DC, 1kV AC 16,7 Hz / 22 Hz / 50 Hz and 1,5kV AC 50 Hz). If the unit is equipped with a power generator for onboard auxiliaries the requirements in point 2.1 are not of relevance.

2.1 Compatibility with train detection systems – track circuits

For the limit levels (AC and DC) a budget allocation between locomotives and personnel carriages of 20% is taken into account. Considering a quadratic summation for the emissions of locomotive(s) and personnel carriages and assume 100% limit utilization for an influencing unit by the locomotive(s), for the whole influencing unit (locomotive(s) + personnel carriages) a still tolerable exceedance of 2% will occur.

The locomotive(s) used in combination with the personnel carriages is authorized for the country in which the train operates.

The following requirements relate on a single personnel carriage.

(1) Compliance with the limit levels defined for the respective feeding systems shall be shown in accordance with [4]. The corresponding limit values and evaluation parameters (FFT) are listed in Table 1 and illustrated in Figure 1 and Figure 2.

Frequency range [Hz]B3:E26	**Interference current limit A [rms value]**		**Evaluation parameters**
	Feeding 1500 V/DC 3000 V/DC	**Feeding** 1000 V/AC 50 Hz 1500 V/AC 50 Hz 1000 V/AC 16,7 Hz 1000 V/AC 22 Hz	
10 - 20	0,7	10,5 [1)]	FFT Time window 1s, Hanning window min. 80% overlap
20 - 30	0,1	1,5 [1)]	
30 - 40	0,07	1,05	
40 - 68	0,025	0,375 [2)]	
68 - 130	0,01	0,15	
130 - 260	0,1	1,5	
260 - 650	0,01	0,15	
650 - 1300	0,088	1,32	
1300 - 1500	0,004	0,06	
1500 - 1980	0,002	0,03	
1980 - 3010	0,0015	0,022	
3010 - 6600	0,016	0,24	
6600 - 6650	0,004	0,06	
6650 - 8730	0,0015	0,022	
8730 - 9000	0,0021	0,031	
9000 - 17590	0,0021	0,031	FFT Time window 40 ms, Hanning window min. 80% overlap
17590 - 24600	0,0023	0,034	
24600 - 32700	0,0034	0,051	
32700 - 55000	0,0049	0,0735	
55000 - 63220	0,033	0,459	
63220 - 71240	0,014	0,21	
71240 - 100000	0,033	0,495	
	1) not relevant for 1000 V/AC 16,7 Hz and 1000 V/AC 22 Hz 2) not relevant for 1000 V/AC 50 Hz and 1500 V/AC 50 Hz		

Table 1. Interference current limits (rms), DC-feeding (1500 V, 3000 V) and AC-feeding (1000 V/50 Hz, 1500 V/50 Hz, 1000 V/16,7 Hz, 1000V/22 Hz)

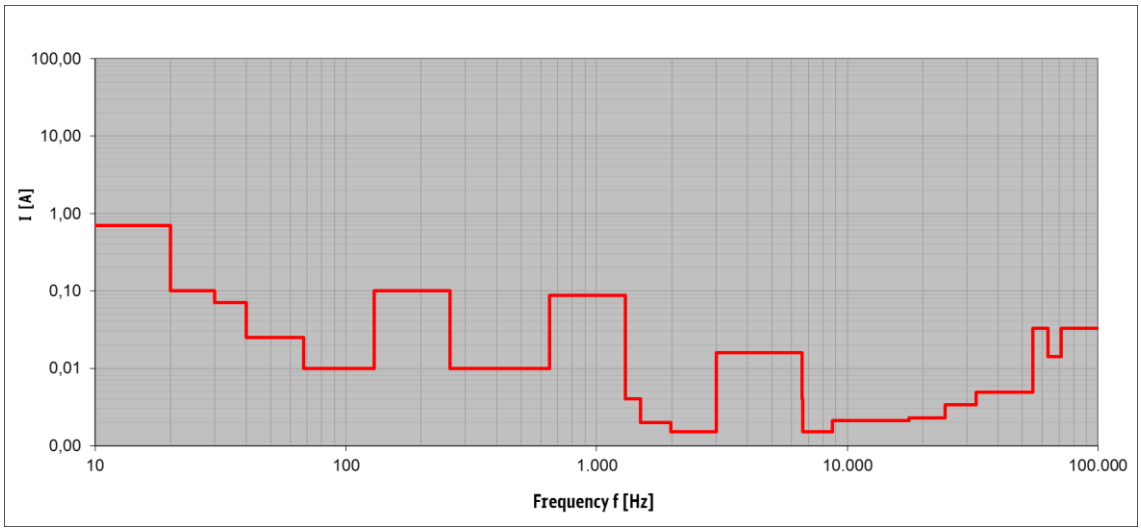

Figure 1. Feeding 1500 Vdc, 3000 Vdc

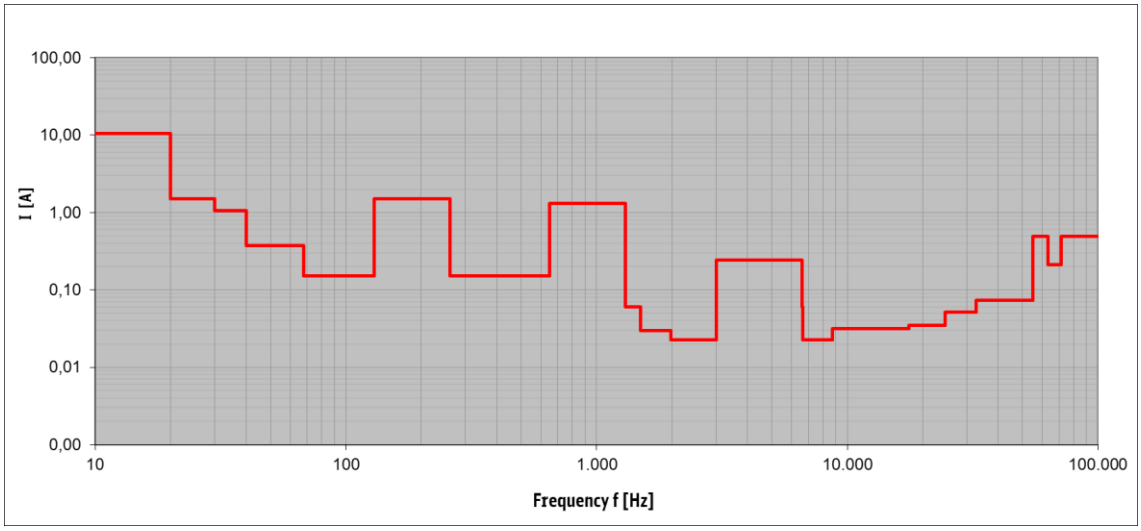

Figure 2. Feeding 1000 Vac/50 Hz; 1500 Vac/50 Hz; 1000 Vac/16,7 Hz; 1000 Vac/22 Hz

(2) If individual limit values according to Table 1 (simplified interference current limit values) are exceeded, the corresponding limit values listed in Table 2 (detailed interference current limit values) and illustrated in Figure 3 and Figure 4 can be used in the affected frequency range and for the affected feeding system.

Frequency range [Hz]	Interference current limit A [rms value]		Evaluation parameters
	Feeding 1500 V/DC 3000 V/DC	**Feeding** 1000 V/AC 50 Hz 1500 V/AC 50 Hz 1000 V/AC 16,7 Hz 1000 V/AC 22 Hz	
10-11	1,5	22,5	FFT Time window 1s, Hanning window min. 80% overlap
11-15	1	15 [1)]	
15-19	0,7	10,5 [1)]	
19-21	0,25	3,75 [1)]	
21-30	0,1	1,5 [1)]	
30-32	0,16	2,4	
32-37	0,09	1,35	
37-42	0,07	1,05	
42-54	0,026	0,39 [2)]	
54-67	0,04	0,6	
67-80	0,011	0,165	
80-97	0,04	0,6	
97-109	0,1	1,5	
109-119	0,25	3,75	
119-122	0,07	1,05	
122-127	0,025	0,375	
127-130	0,07	1,05	
130-162	0,25	3,75	
162-177	0,2	3	
177-261	0,25	3,75	
261-280	0,013	0,195	
280-354	0,25	3,75	
354-395	0,0154	0,231	
395-397	0,25	3,75	
397-545	0,0154	0,231	
545-548	0,25	3,75	
548-551	0,1565	2,348	
551-554	0,25	3,75	
554-595	0,0154	0,237	
595-598	0,25	3,75	
598-601	0,125	1,875	
601-664	0,25	3,75	

Frequency range [Hz]	Interference current limit A [rms value]		Evaluation parameters
	Feeding 1500 V/DC 3000 V/DC	**Feeding** 1000 V/AC 50 Hz 1500 V/AC 50 Hz 1000 V/AC 16,7 Hz 1000 V/AC 22 Hz	
604-645	0,0154	0,231	FFT Time window 1 s, Hanning window min. 80% overlap
645-648	0,25	3,75	
648-651	0,1	1,5	
651-661	0,25	3,75	
661-664	0,088	1,32	
664-764	0,25	3,75	
764-768	0,088	1,32	
768-769	0,25	3,75	
769-772	0,088	1,32	
772-814	0,25	3,75	
814-818	0,088	1,32	
818-1298	0,25	3,75	
1298-1498	0,0045	0,068	
1498-1500	0,0028	0,042	
1500 - 1648	0,0028	0,042	
1648-1696	0,003	0,045	
1696-1702	0,0045	0,068	
1702-1750	0,003	0,045	
1750-1778	0,0045	0,068	
1778-1984	0,003	0,045	
1984-3000	0,0015	0,023	
3000-3600	0,0015	1,5	
3600-3950	0,1	1,5	
3950-3990	0,0525	0,788	
3990-4430	0,045	0,675	
4430-4690	0,039	0,585	
4690-4900	0,05	0,75	
4900-5640	0,027	0,405	
5640-5970	0,05	0,75	
5970-6120	0,026	0,39	
6120-6190	0,05	0,75	
6190-6710	0,016	0,24	
6710-7210	0,0015	0,0225	
7210-7600	0,0041	0,062	
7600-8730	0,0015	0,0225	
8730-9000	0,016	0,24	

Frequency range [Hz]	Interference current limit A [rms value]		Evaluation parameters
	Feeding 1500 V/DC 3000 V/DC	**Feeding** 1000 V/AC 50 Hz 1500 V/AC 50 Hz 1000 V/AC 16,7 Hz 1000 V/AC 22 Hz	
9000-9200	0,016	0,24	FFT Time window 40ms, Hanning window min. 80% overlap
9200-9600	0,0113	0,17	
9600-10600	0,0022	0,033	
10600-10800	0,0104	0,156	
10800-11200	0,016	0,24	
11200-11650	0,009	0,136	
11650-12700	0,0034	0,051	
12700-12900	0,0086	0,129	
12900-13200	0,016	0,24	
13200-13800	0,0071	0,107	
13800-14050	0,016	0,24	
14050-15290	0,0036	0,054	
15290-16110	0,016	0,24	
16110-17600	0,0021	0,0315	
17600-19700	0,0035	0,0525	
19700-20300	0,033	0,495	
20300-21800	0,0039	0,0585	
21800-22500	0,033	0,495	
22500-24600	0,0023	0,0345	
24600-25200	0,012	0,495	
25200-27140	0,0035	0,0525	
27140-30000	0,0038	0,057	
30000-30400	0,012	0,495	
30400-32700	0,0038	0,057	
32700-33900	0,012	0,495	
33900-35000	0,005	0,075	
35000-36500	0,012	0,495	
36500-40200	0,0049	0,0735	
40200-45000	0,033	0,495	
45000-54000	0,0053	0,0795	
54000-63220	0,033	0,495	
63220-71240	0,014	0,21	
71240-100000	0,033	0,495	
	1) not relevant for 1000 V/AC 16,7 Hz and 1000 V/AC 22 Hz 2) not relevant for 1000 V/AC 50 Hz and 1500 V/AC 50 Hz		

Table 2. Detailed interference current limits (rms), DC-feeding (1500 V, 3000 V) and AC-feeding (1000 V/AC 50 Hz, 1500 V/AC 50 Hz, 1000 V/AC 16,7 Hz, 1000V/AC 22 Hz)

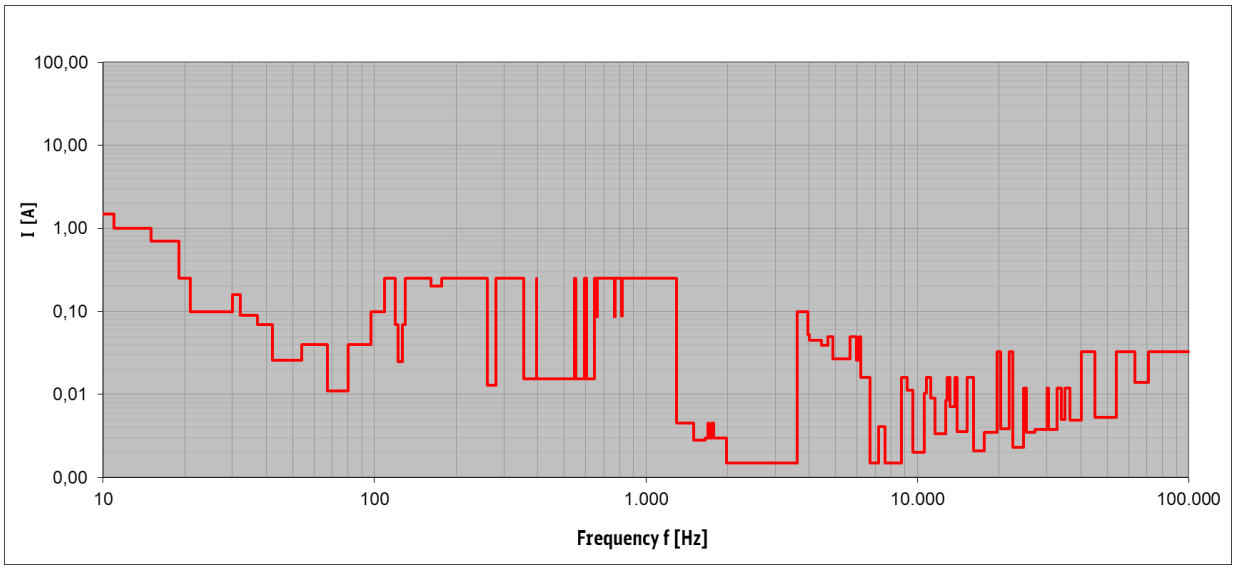

Figure 3. Detailed interference current limit curve (rms), DC-feeding (1500 V, 3000 V)

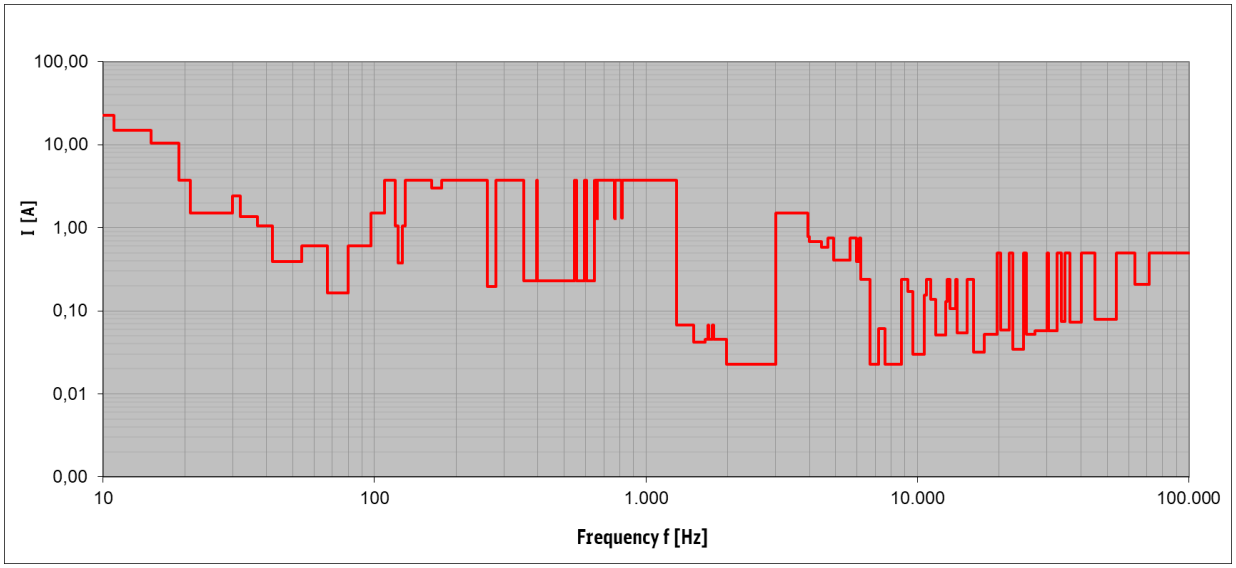

Figure 4. Detailed interference current limit curve (rms), AC-feeding (1000 V/AC 50 Hz, 1500 V/AC 50 Hz, 1000 V/AC 16,7 Hz, 1000V/AC 22 Hz)

(3) No limit values are defined in the frequency range up to 10 Hz and for the fundamental frequencies of the feeding systems (DC, 16,7 Hz, 22 Hz, 50 Hz).

(4) For AC systems there shall be no steady state DC current (maximum 200 mA).

(5) For AC systems interference current harmonics that occur at odd harmonics of the fundamental frequencies do not have to be considered in the frequency range up to up to 30th harmonic.

(6) For DC systems, interference current harmonics that occur at multiples of 300 Hz do not have to be considered in the frequency range up to 1500 Hz.

2.2 Compatibility with train detection systems - axle counter

The following requirements relate on a single personnel carriage.

(1) The personnel carriages shall be compliant with [2] – Chapter 3.2.1

(2) Based on measurements according [3] compliance shall be shown for the following frequency management. The corresponding limit values and evaluation parameters are illustrated in Figure 5, Figure 6, Figure 7 and listed in Table 3.

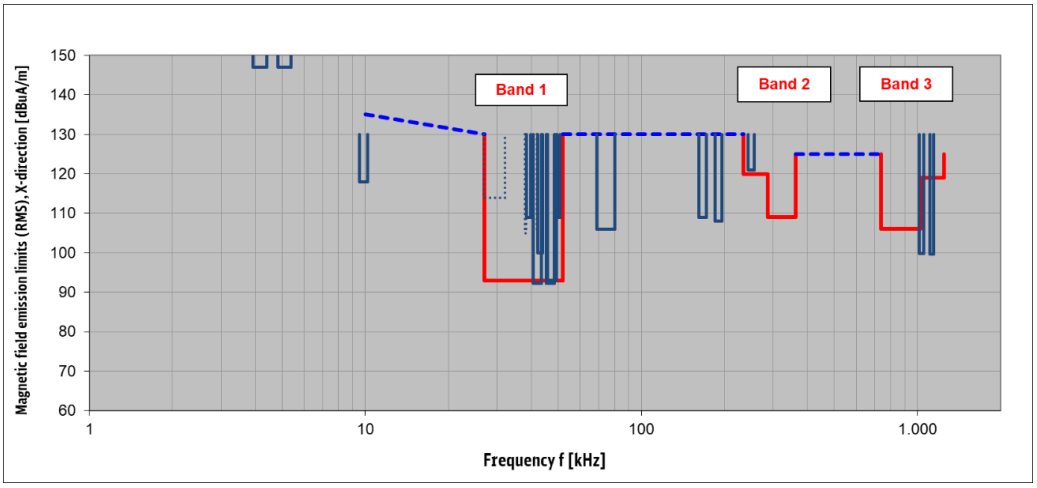

Figure 5. Magnetic field emission limits, X-direction (red, dashed blue curve from [2])

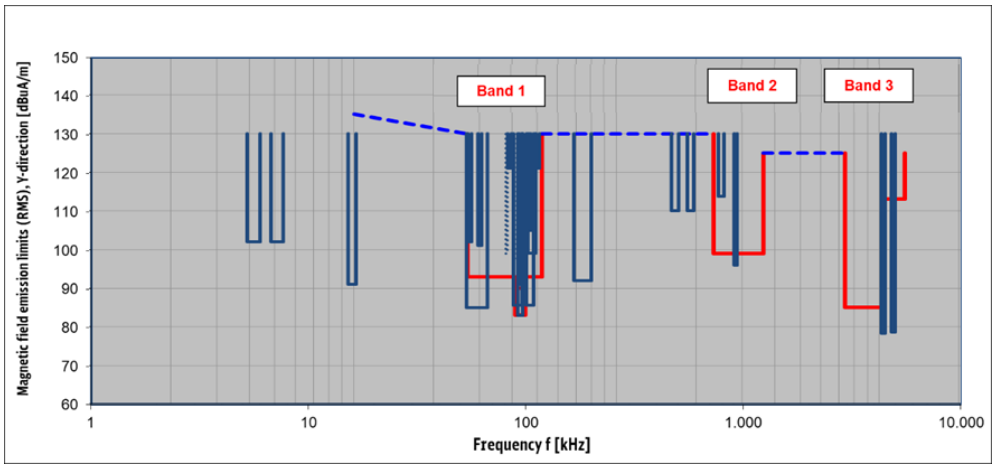

Figure 6. Magnetic field emission limits, Y-direction (red, dashed blue curve from [2])

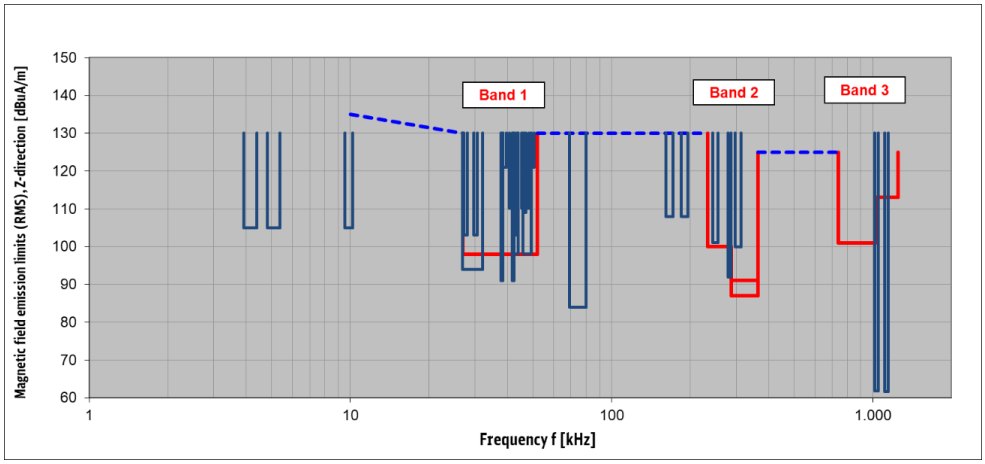

Figure 7. Magnetic field emission limits, Z-direction (red, dashed blue curve from [2])

Type	Frequency range defined by the centre frequency [kHz]	Emission limit X Axis [dBµA/m] (RMS)	Emission limit Y Axis [dBµA/m] (RMS)	Emission limit Z Axis [dBµA/m] (RMS)	Filter order (Butterworth) and 3 dB- bandwidth	Evaluation parameters
Sk11	4,0 - 4,3 and 4,9 - 5,3	147	102	105	4th order, 170 Hz	20% overlap (3dB points) integration time: 4ms
ZP 70 M	9,6 – 10,1	118	91	105	2nd order, 160 Hz	20% overlap (3dB points) integration time: 4 ms
ZP30	27,0 - 32,0	114	85	94	4th order, 250 Hz	20% overlap (3dB points) integration time: 4 ms
Poland A	27,2 – 28,1		102	103	4th order, 840 Hz	20% overlap (3dB points) integration time: 2 ms
Poland B	29,7 – 30,7		101	103	4th order, 960 Hz	20% overlap (3dB points) integration time: 2 ms
DSS200-45	37,8 - 38,2 and 41,8 - 42,2			91 91	4th order, 100 Hz 4th order, 120 Hz	integration time: 5 ms 20% overlap (3dB points) integration time: 5 ms
WDD39	38,85 – 39,15	109	121	121	4th order; 1000 Hz	20% overlap (3dB-points) integration time: 1 ms
ELS 93	42 - 42,02 and 46,8 - 46,82	92	85	110	4th order; 3000 Hz	20% overlap (3dB-points) integration time: 2 ms
Poland C	42,6 – 43,7		91	103	4th order, 970 Hz	20% overlap (3dB points) integration time: 2 ms
ZP43 M/E	42,9 – 43,1	100	83*/90*	98	4th order; 1600 Hz	20% overlap (3dB-points) integration time 1 ms
Poland D	46,5 – 47,1		105	109	4th order, 440 Hz	20% overlap (3dB points) integration time: 2 ms
ELS 95	46,79 – 46,83 and 48,17 – 48,21	93	99	98	4th order; 2000 Hz	20% overlap (3dB-points) integration time: 2 ms
WDD50	49,85 – 50,15	109	121	121	4th order; 1000 Hz	20% overlap (3dB-points) integration time: 1 ms
RSE 45	69 – 80	106	92	84	2nd order, 50 Hz	20% overlap (3dB-points) integration time: 6 ms
ZK24-2 (ch-L)	161,9 – 171,9	109	110	108	2nd order, 480 Hz	20% overlap (3dB-points) integration time: 2,2 ms
ZK24-2 (ch-H)	185,7 – 195,7	108	110	108	2nd order, 420 Hz	20% overlap (3dB-points) integration time: 2,2 ms
RSR 180	249 – 251	121	113	101	4th order, 10 kHz	20% overlap (3dB-points) integration time: 1.5 ms
Poland E	280 – 287		96	92	4th order, 6600 Hz	20% overlap (3dB points) integration time: 1,5 ms
Poland F	298 – 314			100	4th order, 15000 Hz	20% overlap (3dB points) integration time: 1,5 ms
RSR 122	1020 – 1050 and 1115 – 1145	99	78	61	4th order, 6 kHz	20% overlap (3dB-points) integration time 2 ms

Table 3. Magnetic field emission limits, evaluation method: bandpass filtering

* 90dBµA/m for emissions under the train, defined by the distance between the middle of the first and the last axle of the train + 0.5m on both sides, independently of the radius of the wheels. 83dBµA/m for emissions measured before the first axle and after the last axle of the train has passed over the measurement sensor, see Figure below.

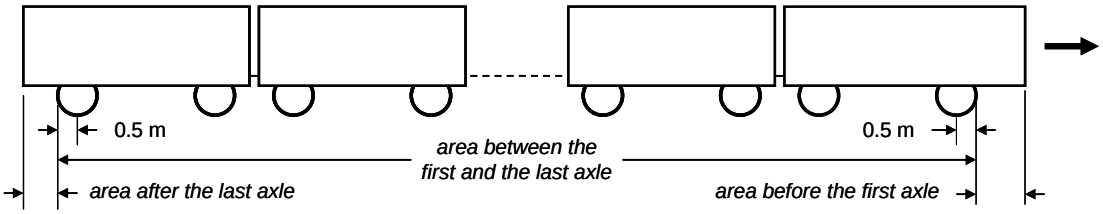

Figure 8. Emissions under the train

Evaluation of exceedances of limits defined in Table 3:

In case the limits specified in Table 3 are exceeded and the minimum time interval between two successive exceedances is bigger than the integration time T_{int} defined, further evaluation for short duration interference shall be conducted for reduced integration times as defined in Table 4.

Type	Increasing of magnetic field limits for a reduced integration time of 0,5 x T_{int} [dB]	Increasing of magnetic field limits for a reduced integration time of 0,25 x T_{int} [dB]
Sk11	6	12
ZP 70 M	3	6
ZP30	3	6
DSS 200-45	6	12
ELS 93	-	-
ZP43 M	3	6
ELS 95	-	-
RSE 45	3	6
RSR 122	6	12

Table 4. Shorter integration time for evaluation of exceedances

(3) In the frequency range from 3,9 kHz to 52 kHz, limit values reduced by 3 dB in the y- and z-directions shall be complied with before the first and after last axis of the carriage (see Figure 8). This limit reduction shall be considered for the corresponding limit levels defined in Table 3 and in document [2] - Chapter 3.2.1, Band 1.

Note: Below the carriage (after the first axle and before the last axle, see Figure 8) no limit reduction has to be considered. The reduction of the limit levels before the first and after the last axle considers the summation of the magnetic field emissions resulting from rail current.

3 Requirement on the power supply converter

Compliance with the requirements shall be demonstrated by evidence for design and type tests:

(1) The input inductance of one carriage shall be at least 40 mH for 1500 Vdc and 80 mH for 3000 Vdc (up to 3 kHz). This impedance shall be met by passive components.

(2) The phase of the input impedance versus the frequency shall be between +90 and -90 degrees.

(3) Converter shall switch off if voltage is out of range (see [5]).

4 Recommendations on design and layout on electrical equipment's including cabling.

The following provisions are recommendations for the design and layout supporting the compliance with the requirements in chapter 2 and 3. They are not in the scope of the assessment of a Notified Body.

4.1 Mounting positions

The electrical equipment should be installed on the carriage in a way, that no disturbance of axle counter and other infrastructure side components, placed on rail level will occur.

(1) The main electrical components (power supply converter, power components for air conditioning / heating, ...) should be placed as far away as reasonably possible from the rail.

(2) The electrical components/systems should be placed in electromagnetically shielded housings.

4.2 Cabling

(1) The cabling should meet the requirements of [6].

(2) The supply and return conductors of the onboard power supplies (e. g. converters) should be arranged as close to each other as possible. The individual conductors of a cable should be twisted together, and the cable should be shielded and earthed on both sides to ground.

(3) Cables should be laid as close as possible to the vehicle ground (use metal cable canals/ducts or metal tubes that are electrically connected to the vehicle ground).

(4) Cables for sensors, data bus as well as control and signal cables should be designed as shielded cables.