

Railway applications — Interference limits of existing track circuits used on European railways

ICS 45.060.01

National foreword

This Published Document was published by BSI. It is the UK implementation of CLC/TR 50507:2007.

The UK participation in its preparation was entrusted by Technical Committee GEL/9, Railway electrotechnical applications, to Subcommittee GEL/9/1, Signalling and communications.

A list of organizations represented on this committee can be obtained on request to its secretary.

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This Published Document was published under the authority of the Standards Policy and Strategy Committee on 29 June 2007

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ISBN 978 0 580 55327 1

Amendments issued since publication

Amd. No.	Date	Comments

**Railway applications –
Interference limits of existing track circuits used on European railways**

Applications ferroviaires -
Limites des interférences des circuits
de voie existants sur les réseaux
ferroviaires européens

Bahnanwendungen -
Störgrenzwerte von Gleiskreisen
der europäischen Bahnen

This Technical Report was approved by CENELEC on 2007-01-16.

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

This Technical Report was prepared by SC 9XA, Communication, signalling and processing systems, of Technical Committee CENELEC TC 9X, Electrical and electronic applications for railways.

The draft, which was based on information supplied by some European railway infrastructure authorities for track circuits currently in use in the individual countries, was submitted to vote and was approved by CENELEC as CLC/TR 50507 on 2007-01-16.

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1 Scope

This Technical Report has been written to define the interference limits of existing track circuits used on European railways. The purpose of this Technical Report is to provide an overview, a reference and a source of information for other specifications and specifications that are presently in preparation. As required by the CENELEC rules, it will be updated as needed and will be finally replaced by a future specification or standard.

According to CENELEC rules, the existing national specifications are not required to be replaced by this Technical Report. They will remain in use as the basis for approval of vehicles in the respective countries. Where available, the national specifications are referenced in Annex A of this Technical Report.

The two main parts of this Technical Report are:

- 1) the List of European track circuit equipment;
- 2) the National Annex.

The contents of these two parts have been provided by railway infrastructure representatives. Not all EU countries have provided information and in some cases the information may be incomplete.

In 4.5, the track circuits are classified into preferred and non-preferred types ¹⁾ with regard to their future use on interoperable lines. This definition provides an indication which types of track circuits are preferred for new signalling projects.

In Annex A the interference limits and test specifications are defined within a template prepared by CENELEC, which is intended to ensure a large degree of common content and to facilitate comparisons between national specifications. The content of Annex A is based on existing national specifications.

This Technical Report will remain informative until it is replaced by a specification. It may, however, be used as a basis for defining requirements, for example in improved national specifications. If the content is used in the TSI, the TSI document shall clearly define the consequences of the requirements. The vehicles have only to be made compatible with the track circuits used on the lines where they run, as defined in EN 50238. Normally an approval certificate will be restricted to these lines or countries.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 50238, *Railway applications - Compatibility between rolling stock and train detection systems*

UIC leaflet 512, *Rolling stock – Conditions to be fulfilled in order to avoid difficulties in the operation of track circuits and treadles*

TSI CCS AAA1; *Train detection systems characteristics necessary to be compatible with rolling stock.*

¹⁾ Previously Class A and Class B as defined in TSI CCS.

3 Definitions

For the purposes of this document, the following terms and definitions apply.

3.1

accepting body

body that is responsible for evaluating the compatibility case and issuing the certificate of acceptance

3.2

certificate of acceptance

written authorisation from the Accepting Body that the compatibility case is acceptable to allow the new or modified systems to enter service

NOTE This may be qualified.

3.3

compatibility case

suite of documents which records the evidence demonstrating the degree of compatibility between rolling stock, traction power supplies and train detection systems for a specific route or specific railway network

3.4

coupled vehicles (CV)

part of the influencing unit except the traction subsystem

3.5

degraded modes

modes of operation in the presence of faults which have been anticipated in the design of the rolling stock

NOTE Degraded modes will normally allow the rolling stock to complete its journey.

3.6

gabarit

maximum permissible levels of interference signal, with respect to frequencies and duration, to which a train detection system may be exposed

3.7

influencing unit (IU)

rolling stock influencing the infrastructure

NOTE This comprises all coupled/connected vehicles, e.g. complete train with single or multiple traction, single vehicle, multiple connected/coupled vehicles.

3.8

right side failure

failure of a signalling system, which results in a more restrictive condition for the movement of traffic than is appropriate

3.9

traction subsystem (TS)

subset of the traction unit which produces traction force or electric brake force

3.10

traction unit (TU)

subset of the influencing unit

NOTE Comprises all traction subsystems including auxiliary supplies and other power supplies, which can be collectively switched off by one collector/pantograph.

3.11

wrong side failure

failure of a signalling system, which results in a less restrictive condition for the movement of traffic than is appropriate

4 Summary of specifications

4.1 General

The essential characteristics of the track circuits are listed in tabular form. The annexes contain the specified interference limits (gabarits) of the track circuits and the test specifications for the vehicles.

4.2 Gabarits

The set of gabarits and their associated test specifications are grouped according to the following traction parameters:

- traction frequency;
- traction voltage.

The traction systems are:

- 25 kV, 50 Hz;
- 15 kV, 16,7 Hz;
- 3 kV, DC;
- 1 500 V, DC;
- 750 V, DC;
- non-electrified.

This differentiation is necessary to avoid unnecessarily pessimistic interference levels, and take account of harmonic content as a function of the traction frequency and voltage.

Each gabarit consists of a graph of the maximum interference current as a function of frequency. Time constraints are defined for each case or frequency range.

The gabarits define the maximum interference current permitted for the track circuit operating frequency bandwidth. Formulas for calculating the effect of multiple trains/locomotives are defined. This will enable the vehicle manufacturer or tester to establish the maximum interference current of a single locomotive, power converter on a passenger coach, or a complete train.

The gabarits take account of the requirements in the existing national specifications as they stand.

4.3 Test specifications

The test specifications are intended to ensure that the test results are consistent and may be assumed to apply in other locations. In particular the following aspects are considered:

- a) how to measure on the vehicle:
 - cumulative current flowing via the current collectors to the vehicle, to be measured as close as possible to the current collectors via a suitable filter (e.g. 100 Hz in the case of a 100 Hz track circuit test);
 - frequency and bandwidth parameters/bandpass filter characteristics (see 4.4);

- b) vehicle test conditions:
 - velocity: full range from standstill to maximum speed;
 - traction modes: variation of acceleration, stationary and coasting modes, constant velocity, brake mode, start-up against the brakes;
 - normal mode and failure modes;
 - auxiliary supplies – from no load to full load;
 - compliance with TSI CCS AAA1 (electrical impedance between the wheels);
 - configuration management of hardware and software of the unit being approval tested;
- c) test location:
 - description of power supply arrangement;
 - definition of reference test track or route, if applicable;
- d) number of measurements:
 - a minimum of several measurements per vehicle mode is required to identify critical areas which require more lengthy test series;
- e) analysis and evaluation of test results:
 - the final analysis is usually given in the time domain. Some Rail Administrations may require an analysis in the frequency domain;
 - the integration time (length of time window) or smoothing time constant takes the required maximum allowable interference duration into account to avoid misleading results.

It is to be expected that deviations in test results may occur if tests are performed on different infrastructures due to differing traction supply characteristics such as resonant frequencies of supply networks, ripple on DC supplies or harmonics of AC supplies. The difficulties of finding a worst-case test site, which is representative of different countries with the same basic traction voltage and frequency are not trivial and may require that testing takes place on specific test tracks or routes in the different countries.

4.4 Example of filter

Figure 1 shows an example of the filter characteristics for a 100 Hz track circuit compatibility test with f_K is equal to 100 Hz and B is equal to 4 Hz.

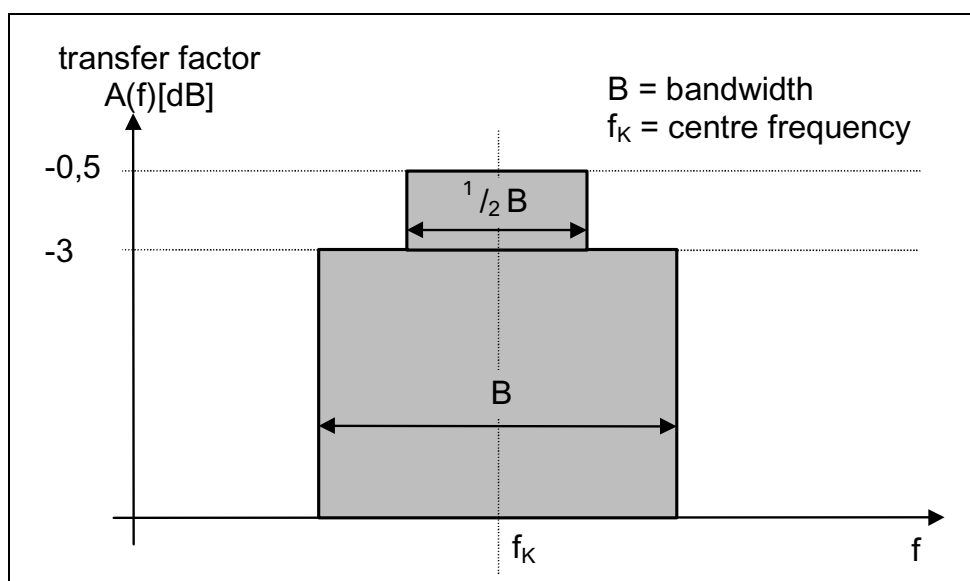


Figure 1 – Example of filter characteristics

4.5 List of European track circuit equipment

Table 1 gives a list that defines the types of track circuit equipment currently being used by European railways. Types classified as “preferred” are designated to be used on future re-signalling projects.

Table 1 – Types of track circuit equipment

Country	Information source	Type	Manufacturer	Operating frequency	Interference limits	Traction voltage	Application	Classification
AT	ÖBB GB-ST	2-Lagen Motorgleisrelais BsSk 1722/8	Siemens	100 Hz	See A.1		Interoperable	Preferred
		3-Lagen Motorgleisrelais BsSk 1722/4	Siemens					
		Transistorgleisrelais S 50108914	Alcatel	100 Hz; 106,7 Hz				Preferred
	ÖBB GB-ST	Gleichstromgleisrelais 960 90760	Alcatel / Zelisko		No		Interoperable	
		Gleichstromgleisrelais V25427	Siemens					
		Gleichstromgleisrelais Z70	Siemens	DC				
		Gleichstromgleisrelais 001183	SBW					
		Gleichstromgleisrelais 590040202	Zelisko					
		Tonfrequenzgleisstromkreise uncodiert	Siemens	~ 10 kHz				
BE	INFRABEL, I.I.3 Signalling DPT	Jointless Track Circuit	Alstom	$f_0 = 1\ 600, 1\ 900, 2\ 200, 2\ 500\ \text{Hz}$	See A.2	3 kV, 25 kV	Interoperable	Preferred
		HF Jointless Track Circuit ER428	Acec	15 kHz	No			
	INFRABEL	50 Hz Track Circuit Birail	Acec, Area, Automation,...	50 Hz	See A.2	3 kV		
		50 Hz Track Circuit Monorail	Acec, Area, Automation,...	50 Hz				
		High Voltage Track Circuit	Acec	4 Hz pulse rate	Not applicable	3 kV, 25 kV		Preferred
	INFRABEL	DC Track Circuits	Acec	DC	No	Diesel	No	
	INFRABEL	UM 71 C TVM 430	CSEE Transport	1 700, 2 000, 2 300, 2 600 Hz	See A.2 (Cf Gabarits)	25 kV	Interoperable (HSL 1)	
SZ	SZDC	KO-1583/KO-1599		25 Hz	See A.3		no	
		KO-2491/KO-2796		50 Hz				
	SZDC	KO-3595/KO-3599			See A.3	3 kV, 25 kV	Interoperable	
		KO-31/KO-32	AZD	75 Hz				
		KO-34/KO-35/KO-36	AZD					
		KO-3102/KO-3103	AZD					
		KO-43	AZD	275 Hz				

Table 1 – Types of track circuit equipment (continued)

Country	Information source	Type	Manufacturer	Operating frequency	Interference limits	Traction voltage	Application	Classification
DK	Denmark Railway Network	DC track circuit	Bombardier	DC	See A.4	25 kV	Interoperable	Preferred
		77 Hz track circuit	Bombardier	77 Hz				Preferred
		FTGS 46, FTGS 917	Siemens	4 750-6 250 Hz, 9 500-16 500 Hz				Preferred
FI	RHK	JZE 53500	Adtranz	DC	< 20 A/s (DC)			
		JZE 53100	Adtranz	DC	< 20 A/s (DC)			
		DC	VR	DC				
		DC	Ganz	DC				
		DC, diode	VR	DC				
		125 Hz Single Rail, Motor Relay	Siemens	125 Hz				
		126 Hz Double Rail, Motor Relay	Siemens	125 Hz				
		FTGS46	Siemens	4,75 - 6,25 kHz				
		FTGS917	Siemens	9,6 - 16 kHz				
		?	Russia	25 Hz				

Table 1 – Types of track circuit equipment (continued)

Country	Information source	Type	Manufacturer	Operating frequency	Interference limits	Traction voltage	Application	Classification
FR	SNCF/IG.SF	50 Hz	CSEE/Transport- Alstom - C.F.S.W - Mors - Saxby	50 Hz	See A.6 (Cf Gabarits)	1,5 kV DC	Interoperable (conv & detour)	
		83 Hz	CSEE/Transport- Alstom - Aster - C.F.S.W - Mors -Saxby	83 Hz		25 kV AC		
		UM71C	CSEE/Transport	1 700, 2 000, 2 300, 2 600 Hz		1,5 kV DC, 25 kV AC		
		UM71 CB	CSEE/Transport	1 700, 2 000, 2 300, 2 600 Hz		25 kV AC		Preferred
	SNCF/IG.SF	UM 71 C TVM PSE	CSEE/Transport	1 700, 2 000, 2 300, 2 600 Hz		1,5 kV DC, 25 kV AC	Interoperable (HS)	
		UM71 C TVM 300	CSEE/Transport	1 700, 2 000, 2 300, 2 600 Hz		25 kV AC		
		UM 71 C TVM 430	CSEE/Transport	1 700, 2 000, 2 300, 2 600 Hz		25 kV AC		
		UM71 C TVM SEI	CSEE/Transport	1 700, 2 000, 2 300, 2 600 Hz		25 kV AC		Preferred
	SNCF/IG.SF	HVI Track Circuit	Alstom	3 Hz pulse rate	No	1,5 kV DC, 25 kV AC	Interoperable (conv & detour)	Preferred
		300/850 Hz	CSEE/Transport	300, 850 Hz		25 kV AC		
	SNCF/IG.SF	DC	CSEE/Transport	DC, pulsed at 175 Hz	No		no	
		DC	CSEE/Transport- Silec Thomson - C.F.S.W -	DC				
	RATP	CVC/M	Alstom	8 200, 8 600, 9 200, 10 000, 10 600, 11 000, 12 300 Hz - FSK ± 75 Hz	No		Suburban railway	



Table 1 – Types of track circuit equipment (continued)

Country	Information source	Type	Manufacturer	Operating frequency	Interference limits	Traction voltage	Application	Classification
DE	DB Netz	DC Track Circuit	WSSB, Siemens	DC	No	Diesel	Interoperable (conv)	
		42 Hz	WSSB, Siemens	42 Hz	See A.7	15 kV	Interoperable (HS detour & conv.)	
		50 Hz	WSSB, Siemens	50 Hz		Diesel	Interoperable (conv.)	
		100 Hz	WSSB, Siemens	100 Hz		15 kV	Interoperable (HS detour & conv.)	
		100 Hz	Alcatel SEL	100 Hz				
		TF-Gsk	Siemens	10 kHz	No			
		TF-Gsk	WSSB, Siemens	16 kHz				
		EON 1 and 3	WSSB, Siemens	7, 8, 10, 12, 15 kHz	See A.7	15 kV	Interoperable (conv.)	
		EON 7	ZWUS, Bombardier-ZWUS	14,6; 16,8 kHz				
		GLS 9/15	Siemens	9-15 KHz				
		FTGS	Siemens	4 750...6 250 Hz, 9 500...16 500 Hz		Interoperable (HS & conv.)	(Proposed to be preferred)	

Table 1 – Types of track circuit equipment (continued)

Country	Information source	Type	Manufacturer	Operating frequency	Interference limits	Traction voltage	Application	Classification	
IT	RFI	ATIS Track Circuit	Ansaldo		No	25 kV 50 Hz	Interoperable	Preferred	
		CGSD	Alstom	50 Hz Track Circuit Birail		3 kV DC		Preferred	
		BACCUS	GE Transportation Systems	50 Hz Track Circuit Birail	See A.8			Preferred	
		Staticode 85	Ansaldo	50 Hz Track Circuit Birail					
		Staticode 85	Ansaldo	83,3 Hz Track Circuit Birail					
		JZB121-801-802-803-804	Fatme - ADTRANZ	50 Hz/83,3 Hz Track Circuit Birail					
		S.1 - S.2 - S.3 - S.4	Sasib - ALSTOM	50 Hz/83,3 Hz Track Circuit Birail					
		W1 -W.2- W.3 - W.4 - W.5 - W.6	Westinghouse - ANSALDO	50 Hz/83,3 Hz Track Circuit Birail					
		Cdb FS con relè a disco	Alstom, Site, Bombardier, Ansaldo	50-83,3 Hz Track Circuit Mono and Birail					
		Digicode DTC24-1 track circuit	Sasib - ALSTOM	1 900...4 300 Hz	No	25 kV 50 Hz		Preferred	
		Overlay SASIB AM 85	Sasib	Track Circuit Birail (Amplitude Modulation)	See A.8	3 kV DC			
		Overlay SASIB FSK	Sasib	Track Circuit Birail FSK Modulation					
		Overlay SASIB FSK ISOLA 93	Sasib	Track Circuit Birail FSKModulation					
		SILAFO FSK	SILIANI - GETS	Track Circuit Birail FSKModulation					
		Short circuit joint control	Alstom, Site, Bombardier, Westinghouse-Ansaldo	8, 10, 12, 18 kHz	No				
		High Frequency Track Circuit HF 01	Westinghouse-Ansaldo	12, 15, 21 kHz	See A.8				

Table 1 – Types of track circuit equipment (continued)

Country	Information source	Type	Manufacturer	Operating frequency	Interference limits	Traction voltage	Application	Classification
NL	ProRail BV		GRS	50 Hz	Yes	No		
		Overlay OTC45 10kHz		10 kHz	Not applicable	Diesel, 1,5 kV DC		
		Low frequency track circuit 50 Hz	GRS	5 Hz	See A.9	Diesel		
		Low frequency track circuit 75 Hz with ATP codes	GRS	75 Hz	See A.9 (Regards Train Detection as well as ATP)	Diesel; 1,5 kV DC		Preferred
		HVI Impulse Track Circuit	Alstom	10 Hz pulse rate	No	Diesel; 1,5 kV DC; 15 kV 16,7 Hz		Preferred
		FTGS 46	Siemens	4,75 - 6,25 kHz	See A.9	1,5 kV DC; 15 kV 16,7 Hz	Interoperable	Preferred
		FTGS 917	Siemens	9,5 - 16,5 kHz				Preferred
		Jade AF – Havenspoorlijn (Jointless Track Circuit)	Alstom	2 206, 2 500, 2 841, 3 157 Hz FSK f0 ± 40 Hz				Preferred
		Jade HF – Havenspoorlijn (Jointless Track Circuit)	Alstom	49 082, 67 232 Hz f0 ± 500 Hz	See A.9	Diesel; 25 kV 50 Hz		Preferred
		Jade LF – A15 Tracé Havenspoorlijn (Jointless Track Circuit)	Alstom	f0 = 1 600, 1 900, 2 200, 2 500 Hz				Preferred
		FTGS	Siemens	4 750...6 250 Hz, 9 500...16 500 Hz	See A.10	15 kV	Interoperable	Preferred
		TI 21	Bombardier	1 532 - 2 610 Hz				Preferred
NO	Jernbaneverket	Motor relay VT1	Westinghouse	95, 105 Hz				
		Motor relay JRV	Bombardier	95, 105 Hz				
		DC JRK	Bombardier	DC		Diesel		



Table 1 – Types of track circuit equipment (continued)

Country	Information source	Type	Manufacturer	Operating frequency	Interference limits	Traction voltage	Application	Classification
PL	PKP PLK S.A.	OTZ	Bombardier-ZWUS	50 Hz	See A.11		Interoperable	
		OTS	Bombardier-ZWUS	50 Hz				
		OTL	Bombardier-ZWUS	50 Hz				
		SOT-1	Bombardier-ZWUS	1 580, 1 860, 2 170, 2 470, 2 800 Hz				
		SOT-2	Bombardier-ZWUS	7 000, 8 000, 10 000, 12 150, 14 600, 16 700 Hz				
		EOC	Bombardier-ZWUS	26 150, 28 700, 31 500 Hz				
ES	ADIF	50 Hz	Alcatel	50 Hz	See A.12	3 kV DC	Interoperable (conv.)	
		Short SJ-24S	Alstom	800 Hz				
		50 Hz	Alstom (GRS)	50 Hz				
		HVI (High Voltage Impulse)	Alstom (Jeumont & Schneider)	10 Hz				
		TI 21 I / M	Bombardier	1,5-2,6 / 5-9 kHz		3 kV DC 25 kV 50 Hz	Interoperable (HS & conv.)	
		50 Hz	Bombardier	50 Hz		3 kV DC	Interoperable (conv.)	
		UM 71/2000	CSEE/Transport	1 700 - 2 600 Hz		25 kV 50 Hz	Interoperable (HS)	
		50 Hz	Dimetronic	50 Hz		3 kV DC	Interoperable (conv.)	
		FS 2000/3000/5000	Dimetronic	1 700-2 600 / 4 000 -7 500 / 4 080 - 6 000 Hz		3 kV DC 25 kV 50 Hz	Interoperable (HS & conv.)	
		Short ME 3015 / 3047 / 3091	Electrans	15 / 14,5 / 11-19 kHz		3 kV DC	Interoperable (conv.)	
		50 Hz	Enysee (SICE)	50 Hz		3 kV DC		
		50 Hz	Siemens	50 Hz		3 kV DC		
		FTGS 46 / 917	Siemens	4-6 / 9-17 kHz		3 kV DC 25 kV 50 Hz	Interoperable (HS & conv.)	



Table 1 – Types of track circuit equipment (continued)

Country	Information source	Type	Manufacturer	Operating frequency	Interference limits	Traction voltage	Application	Classification
SE	Banverket	JRK 10470	Bombardier Sweden	DC	See A.13	15 kV	Interoperable	Preferred
		JZE 54500/1, JZE 54100	Banverket	DC	Yes			
CH	Siemens CH (HTZ-79/567)	12V=	Siemens Schweiz AG	DC	See A.14 55 Aeff (0 Hz)			
	Siemens CH (HTZ-79/567)	QC1008-9	Siemens Schweiz AG	DC	See A.14 18 Aeff (0 Hz)			
	Siemens CH (HTZ-79/567)	QL57-2	Siemens Schweiz AG	80 kHz	No			
	Siemens CH (HTZ-79/567)	GLS42-125	Siemens Schweiz AG	42 Hz, 100 Hz, 125 Hz	See A.14 2 Aeff (100 Hz)	15 kV	Interoperable	
	Siemens CH (HTZ-79/567)	FTGS46	Siemens Schweiz AG	5,5 kHz	See A.14 1 Aeff (5,5 KHz)			
	Siemens CH (HTZ-79/567)	FTGS917	Siemens Schweiz AG	13 kHz	See A.14 0,5 Aeff (13 KHz)			
	Siemens CH (HTA-494/111)	UGSK-95	Siemens Schweiz AG	137 Hz to 225 Hz	See A.14 5 Aeff (137 Hz, 175 Hz, 225 Hz)			Preferred
	Alcatel CH (3EF 00003 0004)	A6231	Alcatel Schweiz AG	100 Hz	No	15 kV	Interoperable	
	SBB	NS1-RUTA	Alstom	3 Hz	No			
	SBB	TMn726/TMn701	Siemens Schweiz AG	125 Hz	See A.14 5 Aeff (125 Hz)			

Table 1 – Types of track circuit equipment (continued)

Country	Information source	Type	Manufacturer	Operating frequency	Interference limits	Traction voltage	Application	Classification
UK	Network Rail	50 Hz Double Rail	Various	50 Hz	See A.15	750 V	Interoperable	Preferred
		50 Hz Single Rail	Various	50 Hz				
		Reed on the AC Railway	GEC (Alstom)	363 Hz - 423 Hz	See A.15 (Single Rail only)			
		Reed on the DC Railway	GEC (Alstom)	363 - 423 Hz	See A.15 (Double Rail only)	750 V		
		TI 21	Bombardier	1 532 - 2 610 Hz	See A.15 (TI 21-1 Only)	25 kV, 750 V		Preferred
		HVI Track Circuit	Alstom	3 Hz pulse rate	See A.15 (NCO.RTV.600/UK only)	25 kV, 750 V		
		FS 2600	Westinghouse	371,8 - 525,8 Hz	See A.15 (Double Rail only)	750 V		
		DC (non AC immune)	Various	DC	No	Diesel		
		DC (AC immune)	Various	DC	See A.15	25 kV		
		Aster		1 700, 2 000, 2 300, 2 600 Hz				
		WR Quick Release	Various	50 Hz	No	Diesel		
		Lucas Pulsing	Girling Ltd	14 pulses/sec, 0,5 ms				
		UM71 CTVM430	CSEE/Transport	1 700, 2 000, 2 300, 2 600 Hz	See A.15 (Cf Gabaritis)	25 kV AC	Interoperable (channel tunnel)	Preferred

Annex A (informative)

National specifications

A.1 Austria, ÖBB specification

A.1.1 Scope of the specification

This specification is to be applied together with EN 50238 whereby EN 50238 covers largely the preparation of a safety/compatibility case.

The scope of this specification is limited to defining electromagnetic interference limits and test specifications for electric traction and other electrical equipment on trains.

The national regulation "Anforderungskatalog an Triebfahrzeuge für die Zulassung im Netz der ÖBB" (Requirements for Approval of Rolling Stock for the Austrian National Railway Network) , 11th July 2003 applies in Austria.

A.1.2 Gabarits

A set of gabarits and their associated test specifications are required, grouped according to the following traction parameters:

- traction frequency: 16,7 Hz;
- traction voltage: 15 kV.

The gabarits will define the maximum interference current permitted for the track circuit operating frequency bandwidth. A formula for calculating the effect of multiple trains/locomotives will be defined. This will enable the vehicle manufacturer or tester to establish the maximum interference current of a single locomotive, power converter on a passenger coach, or a complete train.

The gabarits will take account of the requirements in the existing railway specifications. The existing specifications are not expected to be changed. The values of interference in the existing specifications will only be modified for the future specification if the rule stated in the previous paragraph was not applied by the railway when the interference values were originally defined.

Interference limits for 100 Hz and 106,7 Hz track circuits (on ÖBB lines):

a) maximum current for an influencing unit:

- $I_{\max 100IU} = 2,8 \text{ A}$;
- r.m.s. integration time 0,5 s;

b) maximum current for a traction unit:

- $I_{\max 100TU} = 2,0 \text{ A}$;
- r.m.s. integration time 0,5 s;

c) calculation rule for multiple traction units:

$$I_{n100TU} = \frac{2,8 \text{ A}}{\sqrt{n}} \text{ for } 1 \leq n \leq 3 \quad n : \text{Number of Traction Units}$$

If the addition of the measured influencing currents does not meet the above mentioned calculation rule, the maximum current has to be reduced to fulfil the limit for the total influencing unit;

d) characterisation of filter:

- B bandwidth = 4 Hz;
- f_K centre frequency = 100 Hz or 106,7 Hz.

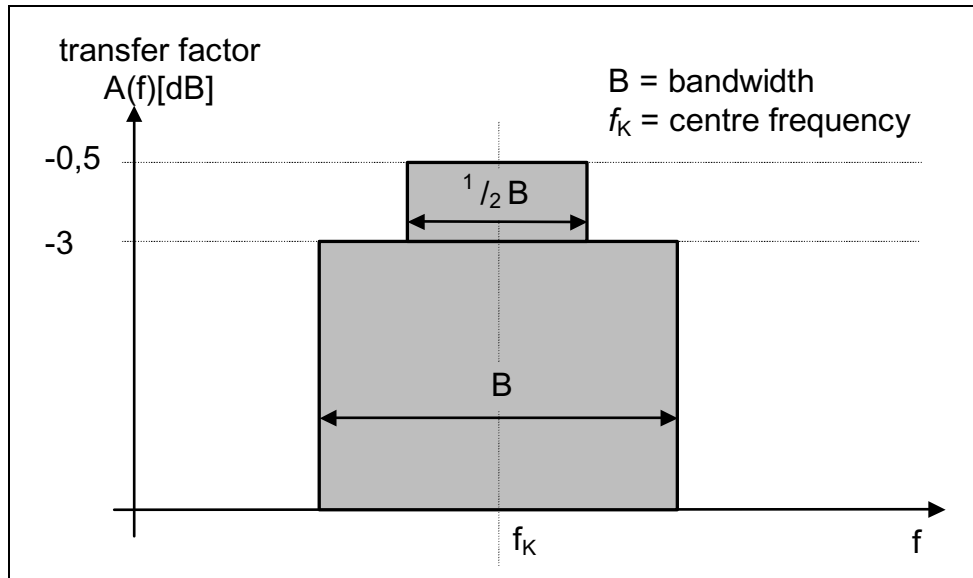


Figure A.1 – Filter characteristics for track circuit compatibility test

A.1.3 Test specifications

The test specifications are intended to ensure that the test results are consistent and may be assumed to apply in other locations. In particular the following aspects shall be covered:

- how to measure on the vehicle:
 - cumulative current flowing from the catenary to the vehicle, to be measured as close as possible to the overhead line/catenary via a suitable filter (e.g. 100 Hz in the case of a 100 Hz track circuit test). If the rails are used for the transmission of the return current of the heating train line, an additional measurement at the V_o connection of the traction-transformer has to be made. In both cases the gabarits shall be fulfilled;
- vehicle test conditions:
 - velocity: full range from standstill to maximum speed;
 - traction modes: variation of acceleration, idle mode, constant velocity, brake mode;
 - normal mode and failure modes;
 - unloaded heating train line, when testing locomotives;
 - loading on heating train line when testing coaches shall be defined. UIC 550 can provide a basis for this;
- test location and test conditions:
 - standstill testing in a station near the Austrian border;
 - for an approval for the whole network of the ÖBB several measurements covering all critical areas of the ÖBB-network and traction modes the vehicle are necessary (usually the lines Vienna-Salzburg-Villach-Vienna and Vienna-Hohenau);
 - if the approval is only wanted for a specific line, the measurements may be limited to this line;

- due to the operation of different (partly older) types of vehicles in the ÖBB-network it has to be considered, that the voltage in overhead line has a very high level of harmonics to the 16,7 Hz traction frequency. The above-mentioned gabarits shall also be fulfilled under these bad case conditions of the traction voltage;
- analysis and evaluation of test results:
 - an initial analysis during the test series is required to ensure, for example, that the test equipment is providing a suitable signal/noise ratio with respect to the gabarit values (10 % of the gabarit or 5 mA, whatever is larger) and that no overloading occurs;
 - the final analysis is required in the time domain. Analysis in the frequency domain is not recommended due to the difficulty of achieving a time reference;
 - the bandpass filtered harmonic current has to be displayed as floating r.m.s.;
 - the integration time (length of time window) or smoothing time constant shall take the required maximum allowable interference duration into account to avoid misleading results;
- the r.m.s. values may be calculated as follows:
 - true r.m.s. (integration);
 - mean rectified value multiplied by 1,11;
- note that if the r.m.s. value is calculated by mean time windows, the overlapping of sequential time windows shall be at least 50 %.

It is to be expected that deviations in test results may occur if tests are performed on different infrastructures due to differing traction supply characteristics such as resonant frequencies of supply networks, ripple on DC supplies or harmonics of AC supplies. It is realised that the difficulties of finding a worst-case test site that is representative of different countries with the same basic traction voltage and frequency is not trivial.

A.2 Belgium, INFRABEL specification

A.2.1 Scope of the specification

This specification is to be applied together with EN 50238 whereby EN 50238 covers largely the preparation of a safety/compatibility case.

The scope of this specification is limited to defining electromagnetic interference limits and test specifications for electric traction and other electrical equipment on trains.

A.2.2 Gabarits

A set of gabarits and their associated test specifications are required, grouped according to the following traction parameters:

- traction frequency;
- traction voltage.

For INFRABEL the following sets of gabarits are taken into account:

- set 1 of gabarits for 3 kV, DC;
- set 2 of gabarits for 25 kV, 50 Hz;

A.2.2.1 Definitions

A Freight Train (FT) can have a maximum of 2 traction units.

A Passenger Train (PT) can have a maximum of 16 UIC coaches and 1 traction unit.

Since one influencing unit may consist of multiple sources of influence, it shall be ensured that the resulting interference current emitted by the influencing unit into the power supply network does not exceed the gabarit value.

A.2.2.2 Gabarit for 3 kV, DC

- a) maximum current for an influencing unit (calculation rule according to e):
- $I_{AC} = 20 \text{ A}$ (35 Hz < f < 60 Hz);
 - $I_{AC} = 50 \text{ A}$ (35 Hz < f);
 - $I_{AC,TS,MINIMUM} > 0,5 \text{ A}$ (otherwise not taken into account for the calculation rule);
 - $I_{AC,CV,MINIMUM} > 0,5 \text{ A}$ (otherwise not taken into account for the calculation rule);
- b) maximum 50 Hz current for an influencing unit (calculation rule: summation):
- $I_{50} \leq 4 \text{ A}$ (48,5 Hz < f < 51,5 Hz) for DC and AC traction;
 - $I_{50} \geq 4 \text{ A}$ (48,5 Hz < f < 51,5 Hz) for AC traction during max 1 000 ms;
- c) maximum transient currents for a traction unit:
- $|\Delta I / \Delta t| < 2 500 \text{ A/s}$ (f < 35 Hz);
- d) maximum current (1 500 Hz < f < 3 000 Hz) for an influencing unit (calculation rule according to e):
- $I_f < 500 \text{ mA}$ (1 500 Hz < f < 3 000 Hz);
 - $I_f < 3 \text{ A}$ (f = 6 n x 50 Hz ± 55 Hz, n = 5, 6, 7, 8, 9, 10) (calculation rule: summation);
- e) calculation rules are given in Table A.1.

Table A.1 – Calculation rules for 3 kV DC

Frequency	Possibility of synchronisation between the perturbation sources	Calculation rule
< 1 000 Hz	-	Summation for the same f
$\geq 1 000 \text{ Hz}$	Yes	Summation for the same f
$\geq 1 000 \text{ Hz}$	No	Quadratic summation for same f
f	-	Quadratic summation for different f

A.2.2.3 Gabarit for 25 kV, 50 Hz

- a) maximum current (1 500 Hz < f < 3 000 Hz) for an influencing unit (calculation rule according to c):
- $I_f < 500 \text{ mA}$ (1 500 Hz < f < 3 000 Hz);
 - $I_f < 3 \text{ A}$ ($f = (2n+1) \times 50 \text{ Hz} \pm 10 \text{ Hz}$, n = 15, 16, 17, 18, 19, 20, 21, 22, 23)
(calculation rule: summation);
 - $I_f < 2,2 \text{ A}$ ($f = (2n+1) \times 50 \text{ Hz} \pm 10 \text{ Hz}$, n = 24, 25, 26, 27, 28, 29)
(calculation rule: summation);
- b) calculation rules are given in Table A.2.

Table A.2 – Calculation rules for 25 kV 50 Hz

Frequency	Possibility of synchronisation between the perturbation sources	Calculation rule
< 1 000 Hz	-	Summation for the same f
$\geq 1\,000$ Hz	Yes	Summation for the same f
$\geq 1\,000$ Hz	No	Quadratic summation for same f
f	-	Quadratic summation for different f

A.2.3 Test specifications

The specifications of the rolling stock and the interference produced have to be analysed:

- on the vehicle with adequate measurement and logging tools to analyse the injected currents in the return circuit;
- in the track with measurement coils and train detection systems adequately adapted.

A.2.3.1 Injected currents in the track

For the coupled vehicles, the verification of the above-mentioned limits is done by analysing the injected currents in the power distribution system (measured at the catenary). The vehicles have to conform with UIC 550.

For the influencing units or for the traction units, the verification of the above-mentioned limits is done by analysing the currents from the catenary. Cumulative current flowing from the catenary to the TU, to be measured as close as possible to the overhead line/catenary via a suitable filter (see A.2.3.2 for characteristics).

The measurements have to be performed in the following conditions:

- vehicle test conditions:
 - velocity: full range from standstill to maximum speed, at full power and at reduced power in steps of 10 %;
 - traction modes: variation of acceleration especially, for “difficult” speeds, stationary or coasting mode, constant velocity, brake mode;
 - behaviour during the fluctuation of the catenary voltage;
 - behaviour during slipping;
 - closing the power switch of the traction unit or of the traction unit at a certain distance.

These measurements have to be performed in different typical configurations of the traction equipment and of the distribution system of electrical energy:

- configuration with all the systems in service;
- configuration with some systems out of service (degraded mode).

The measurements are realised with the aid of non-saturable coils, associated with filters and equipment on board of the train.

The complete measurement equipment (measurement-sensors and equipment, data-storage equipment, etc.) necessary for the control of the above mentioned limits have to be described in detail. Before the beginning of the measurements, the complete measurement equipment has to be inspected by the authorised staff of INFRABEL.

- test location:
 - description of power supply arrangement, 3 kV DC,
 - definition of reference test line, line 94, location “Bois du Coucou” at distance mark 46,400;
- number of measurements:
 - a minimum of several measurements per vehicle test condition is required to identify critical areas which require more elaborate test series;
- analysis and evaluation of test results:
 - the electromagnetic traction compatibility with the track circuits is evaluated on the test site itself. The track circuits are adapted and regulated in the way they are most sensitive to outside perturbations and tested in the presence of rolling stock that is used in its most aggressive way,
 - the evaluation of the injected currents in the track are measured as close as possible to the catenary via suitable filters (see A.2.3.2).

A.2.3.2 Example of the filter(s) used for the evaluation of the injected currents

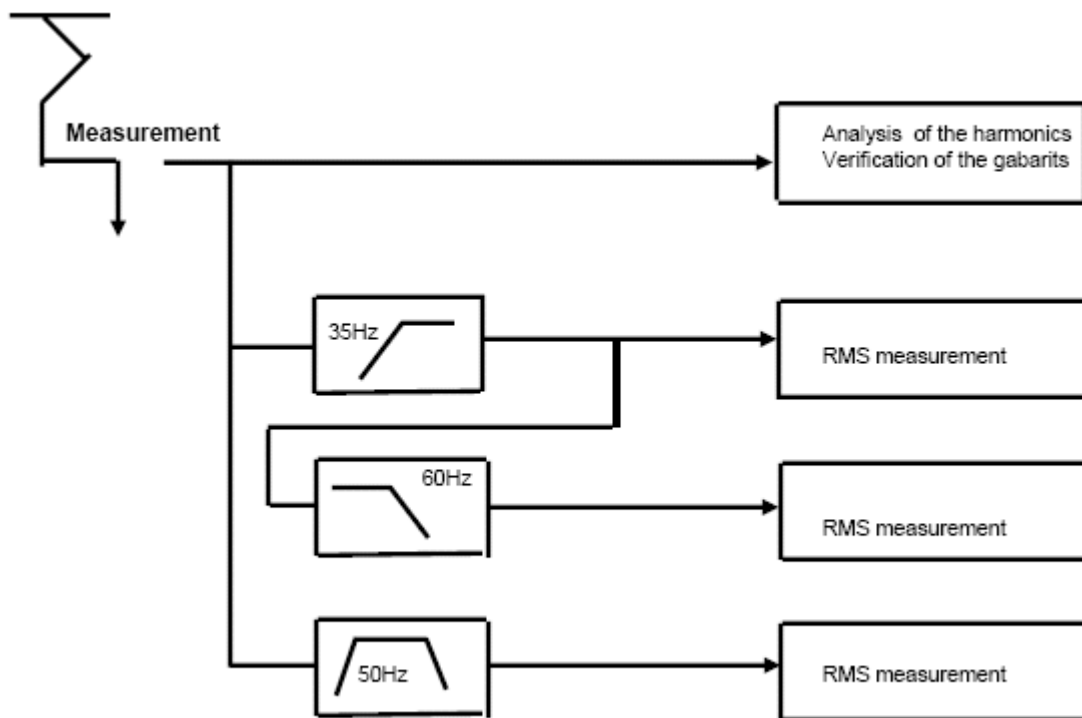


Figure A.2 – Example of the filter(s) used for the evaluation of the injected currents

- place of measurement:
 - the injected currents in the track are measured as close as possible to the catenary;
 - the current measurement has to have a precision of at least 2,5 % on the whole frequency range of 30 Hz up to 3 000 Hz;
- 35 Hz and 60 Hz filters:
 - the filters are 8th order Butterworth;
 - the 35 Hz high frequency bandpass filter needs an attenuation of minimum 20 dB at the frequency of 25 Hz;
 - the 60 Hz low frequency bandpass filter needs an attenuation of minimum 20 dB at the frequency of 85 Hz;

- the filters are not allowed to be saturated by the expected traction currents;
- 50 Hz filter:
 - the filters are 8th order Butterworth or elliptical;
 - the 50 Hz bandpass filter needs an attenuation of minimum 80 dB at the frequencies of 30 Hz and 83 Hz;
- the filters are not allowed to be saturated by the expected traction currents.

A.2.4 References

[1] Compatibilité électromagnétique du matériel roulant avec les systèmes de détection des trains et les transmissions par circuits galvaniques, Ref MI.01-EMC-75.2.0 Version 1.1, 4.03.2002.

A.3 Czech Republic, SZDC specification

A.3.1 Scope of specification

The following national standards apply to compatibility:

- **ČSN 34 2613** Železniční zabezpečovací zařízení - Kolejové obvody a vnější podmínky pro jejich funkci (Railway Signalling Equipment – Track circuits and external conditions for their function).

The specifications and their application methods in the Czech Republic, described in the following sections, are based on currently out-dated specifications ČSN 34 2613:1998. These specifications are going to be replaced with new ones (ČSN 34 2613:2007).

A.3.2 Gabarits

The gabarits are the inference limits of the track circuits. Frequency and bandwidth shall be considered.

The gabarits define the maximum interference current in the rails permitted for the track circuit operating frequency bandwidth. A formula for calculating the effect of multiple trains/locomotives is required. This will enable the vehicle manufacturer or tester to establish the maximum interference current of a single locomotive, power converter on a passenger coach, or a complete train.

UIC leaflet 512 (especially wheel-to-wheel-resistance) has to apply.

A.3.2.1 Definitions

A traction unit is a vehicle (a locomotive or a trainset) with electric traction or bearing an electric power supply for heating.

A coach is a vehicle without traction but with electric equipment fed by a heating cable where return current may be led through the running rails.

A.3.2.2 Traction voltage and frequency - Interference limits

The gabarits listed below are valid for both traction systems used in the Czech Republic (3 kV and 25 kV 50 Hz) unless specified otherwise.

All types of track circuits are within the specification given in this subclause.

The traction unit shall not be emitting a disturbing current I_d to the traction system (to rails) in the given frequency bands for a time longer than 0,1 s if its value is higher than the values given in Table A.3.

Table A.3 – Values of gabarit (Czech Republic)

Frequency band Hz	I_d A
44 - 56 ^a	0,1
68 - 82	0,1
118 - 132	0,1
168 - 182	0,1
268 - 282	0,1
^a The limitation in this band does not apply for vehicles on lines electrified with the 25 kV 50 Hz system.	

The coach shall not emit a disturbing current I_d to the traction system (to rails) in the above frequency bands for a time longer than 0,1 s if its value is higher than 0,1 A.

The total current summed at above frequency bands in the return traction current running through a track circuit shall not exceed 0,167 A.

Considering the current distribution among tracks and between tracks and earth it assumed the total summed disturbing current running through one track within one power section composes from at most two sources of uncorrelated disturbance, i.e. from two trains 16 coaches each.

The above assumption is fixed; there are therefore no individual calculations based on number of vehicles in a section.

The disturbing current can affect any track circuit located in a path of return traction current running from a source of disturbance to the power substation.

All mentioned limits are effective values.

A.3.3 Test specifications

This subclause contains the test specification for verifying that vehicles are compatible with the track circuits. It contains a description of the procedure and a definition of measurement parameters.

A.3.3.1 Test arrangement

A.3.3.1.1 Traction units

The disturbing current is preferably measured at the return traction current conductor in the location that is nearest to the place of current partition and where there are no alternate current routes (see Figure A.3). The current is measured ahead of its partition to individual bogies (axles) and ahead of its connection with a vehicle frame where alternate routes may constitute.

If, from technical reasons, the measurement is not doable at the return traction current conductor it is allowed to carry out the measurement in the incoming conductor (location A). In this case however necessary measures have to be taken to determine an influence rate of the field generated by voltage difference, as well as the measures for the health protection of the personnel and for the protection of the measuring chain.

Both approaches are considered equal.

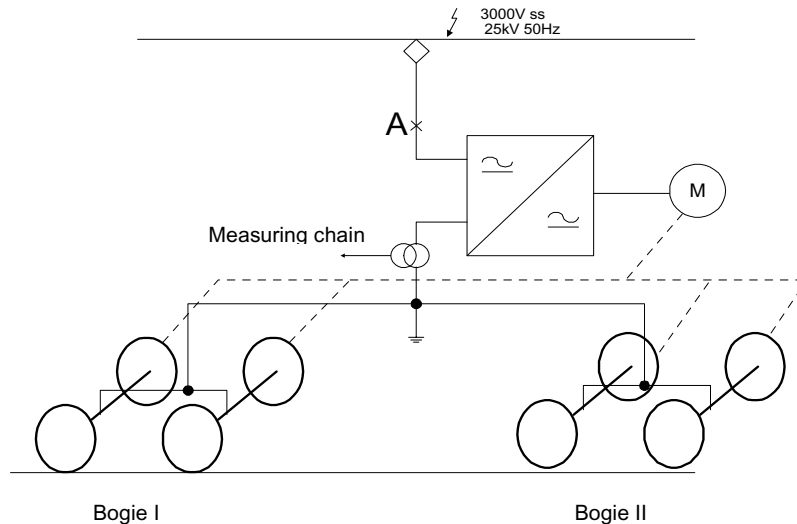


Figure A.3 – Placement of measuring converter

The noise ratio of the own measuring chain (including background offset) shall exceed neither 10 % of limit value nor 0,005 A (whatever is larger).

A.3.3.1.2 Coaches

The measurement is to be carried out on the heating conductor using the similar arrangement.

A.3.3.2 Test conditions

The measurement is to be carried out in normal and degraded modes of operation, when all propulsions (traction, auxiliary) are connected and active, in all the area of operational characteristic of the tested vehicle.

To document a position of the operational event of the tested vehicle a registration of suitable variables characterising the operational situation is made, e.g.:

- vehicle speed;
- traction current;
- relative force;
- auxiliary electric consumption (vehicle heating, etc.).

A.3.3.3 Test location

The VÚŽ test ring serves as the reference track for measurements of vehicles to be operated in the Czech Republic. The test ring guarantees specification power supply conditions with negligible influence of another energy consumer. There is therefore no dependency of measurement results on the daytime of measurement.

A.3.3.4 Number of measurements

To guarantee independency of test results on random effects several measurements of each kind are required.

A.3.3.5 Analysis and evaluation of test results

The analysis is made in two stages:

- first during the measurement process to search for critical conditions;
- second as detail analysis of the record after the completion of tests.

The evaluation of disturbing current amplitude is exclusively based on the evaluation in the time domain using the narrow-band filtration (analogue or digital one).

The evaluation in frequency domain has secondary meaning and serves to localise extremities.

The methods working in frequency domain but using time scale are used to evaluate duration of disturbing current.

A.3.3.6 Filter definition

The transfer characteristic of filter for evaluation of measured data is being selected according to the tolerance scheme shown on Figure A.4, with the tuneable mean frequency f_0 where $\Delta f = 3$ Hz. The mean frequency is selected according to the frequency bands given in Table A.3 in such a way that permeable filter band is completely within the given frequency band.

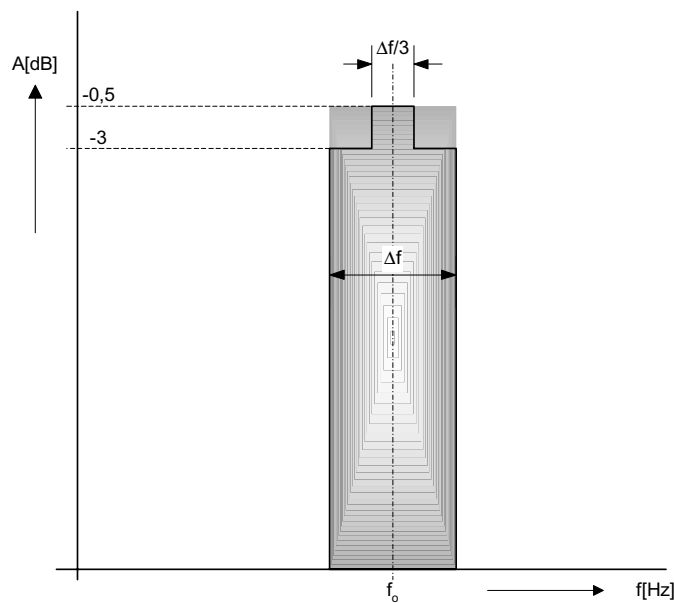


Figure A.4 – Filter characteristic

The measuring chain uses r.m.s. value detector; for the integration a filter with start-up time 0,1 s, if a method of sliding window is used then the minimum overlap shall be 50 %.

A.4 Denmark, BS specification

A.4.1 Scope of the specification

This specification is to be applied together with EN 50238 whereby EN 50238 covers largely the preparation of a safety/compatibility case.

The scope of this specification is limited to defining electromagnetic interference limits and test specifications for electric traction and other electrical equipment on trains.

A.4.2 Gabarits

A set of gabarits and their associated test specifications are required, grouped according to the following traction parameters:

- traction frequency 50 Hz;
- traction voltage 25 kV.

Each gabarit consists of a graph of the maximum interference current as a function of frequency. Time constraints shall be defined for each case or frequency range.

The gabarits will define the maximum interference current permitted for the track circuit operating frequency bandwidth. A formula for calculating the effect of multiple trains/locomotives will be defined. This will enable the vehicle manufacturer or tester to establish the maximum interference current of a single locomotive, power converter on a passenger coach, or a complete train.

The gabarits will take account of the requirements in the existing railway specifications. The existing specifications are not expected to be changed. The values of interference in the existing specifications will only be modified for the future specification if the rule stated in the previous paragraph was not applied by the railway when the interference values were originally defined.

A.4.2.1 Definitions

Since one influencing unit may consist of multiple sources of influence, it shall be ensured that the resulting interference current emitted by the influencing unit into the power supply network does not exceed the gabarit value.

A.4.2.2 Calculation of multiple traction

Calculation rule for currents from traction units that produce interference currents below 1 kHz (track circuits):

$$I_{nTU/f_g} = \frac{I_{gabarit}}{n} \leq I_{TU/f_g} \quad 1 < n \leq 6 \quad n : \text{Number of traction units}$$

f_g is the frequency defined in the gabarit.

Calculation rule for currents from traction units that produce interference currents above 1 kHz (track circuits):

$$I_{nTU/f_g} = \frac{I_{gabarit}}{\sqrt{n}} \leq I_{TU/f_g} \quad 1 < n \leq 6 \quad n : \text{Number of traction units}$$

f_g is the frequency defined in the gabarit.

A.4.2.3 Gabarit for 25 kV, 50 Hz

A.4.2.3.1 Interference limits for DC track circuits

Direct currents, continuous > 1,5 s < 4 A.

Maximum inrush currents DC-component after 1,5 s < 15 A.

A.4.2.3.2 Interference limits for 77 Hz track circuits

77 Hz continuous > 1 s < 4 A, 3 dB bandwidth 70 Hz to 85 Hz.

A.4.2.3.3 Interference limits and rules for multiple traction for FTGS 46 track circuits on DK lines

Table A.4 – FTGS 46

Channel centre frequency f_k	Measured interval	Maximum current for an influencing unit for 3 dB real channel bandwidth
Hz	Hz	A
4 750	300	1,4
5 250	300	1,4
5 750	300	1,4
6 250	300	1,4

The limit for the calculated level is 1,40 A.

A.4.2.3.4 Interference limits and rules for multiple traction for FTGS 917 track circuits on DK lines

Table A.5 – FTGS 917

Channel centre frequency f_k	Measured interval	Maximum current for an influencing unit for 3 dB real channel bandwidth
Hz	Hz	A
9 500	500	0,700
10 500	500	0,700
11 500	500	0,700
12 500	500	0,700
13 500	500	0,700
14 500	500	0,700
15 500	500	0,700
16 500	500	0,700

The limit for the calculated level is 0,70 A.

A.4.2.3.5 100 kHz track circuits

High frequency track circuit equipment 100 kHz $\pm$ 40 kHz 28 mA.

A.4.3 Test specifications

The test specifications are intended to ensure that the test results are consistent and may be assumed to apply in other locations. In particular the following aspects shall be covered:

- how to measure on the vehicle:
 - cumulative current flowing from the catenary to the vehicle, to be measured as close as possible to the overhead line/catenary via a suitable filter (e.g. 100 Hz in the case of a 100 Hz track circuit test);
 - frequency and bandwidth parameters/bandpass filter characteristics (see A.2.3.2);

- vehicle test conditions:
 - velocity: full range from standstill to maximum speed;
 - traction modes: variation of acceleration, idle mode, constant velocity, brake mode;
 - normal mode and failure modes in according to EN 50388, 10.3;
 - unloaded heating train line when testing locomotives;
 - loading on heating train line when testing coaches shall be defined. UIC 550 can provide a basis for this;
 - compliance with UIC leaflet 512 (electrical resistance between the wheels of a wheel set);
- power supply:
 - test shall be made at different distances from the feeder stations on a single and a double-fed line;
 - filters in rolling stock including possible resonances shall be taken into account;
 - test location;
 - description of power supply arrangement, 25 kV 50 Hz;
 - definition of reference test line, line 26. Vojens-Tinglev maximum 180 km/h;
- number of measurements:
 - a minimum of several measurements per vehicle mode is required to identify critical areas which require more lengthy test series;
- analysis and evaluation of test results:
 - an initial analysis during the test series is required to ensure, for example, that the test equipment is providing a suitable signal/noise ratio with respect to the gabarit values (10 % of the gabarit or 5 mA, whatever is larger) and that no overloading occurs;
 - the final analysis is required in the time domain. Analysis in the frequency domain is not recommended due to the difficulty of achieving a time reference;
 - the bandpass filtered harmonic current has to be displayed as floating r.m.s.;
 - the integration time (length of time window) or smoothing time constant shall take the required maximum allowable interference duration into account to avoid misleading results;
 - the r.m.s. values may be calculated as follows:
 - true r.m.s. (integration);
 - mean rectified value multiplied by 1,11;
 - note that if the r.m.s. value is calculated by mean time windows, the overlapping of sequential time windows shall be at least 50 %.

It is to be expected that deviations in test results may occur if tests are performed on different infrastructures due to differing traction supply characteristics such as resonant frequencies of supply networks, ripple on DC supplies or harmonics of AC supplies. It is realised that the difficulties of finding a worst-case test site that is representative of different countries with the same basic traction voltage and frequency is not trivial.

A.4.4 Example of filter, signal processing and measurements

A.4.4.1 DC-track circuits

Band-pass filtering, 3rd order high-pass filter, - 3 dB by 0,1 Hz and 5th order high-pass filter with - 3 dB by 2,5 Hz, r.m.s. of the measured signal, integration time 1 s.

A.4.4.2 77 Hz – track circuits

Band-pass filter, 8th Order (2 x 4) elliptic filter, - 3 dB by 70 Hz and 85 Hz, r.m.s. of the measured signal, integration time 1 s.

A.4.4.3 FTGS 46 track circuits

Spectrum analysis and complementary comments for processing measurements.

Spectrum analysis.

The recorded signal is spectrally analysed as follows:

- frequency range: 0 – 20 kHz;
- frequency resolution 25 Hz (distance between bins);
- FFT-window: Hanning, 40 ms;
- overlapping of following windows: $\geq 80\%$;
- output: r.m.s.-value of the “Peak-Hold” with in the measurement duration (typically a couple of minutes).

R.M.S.-calculation 4,5 kHz to 6,5 kHz.

Root-Sum-Square of the 13 bins in each of the interval 4,6 kHz to 4,9 kHz (inclusive), 5,1 kHz to 5,4 kHz (inclusive), 5,6 kHz to 5,9 kHz (inclusive), and 6,1 kHz to 6,4 kHz (inclusive).

The limit for the calculated level is 1,40 A.

A.4.4.4 FTGS 917 track circuits

Spectrum analysis and complementary comments for processing measurements.

Spectrum analysis.

The recorded signal is spectrally analysed as follows:

- frequency range: 0 – 20 kHz;
- frequency resolution 25 Hz (distance between bins);
- FFT-window: Hanning, 40 ms;
- overlapping of following windows: $\geq 80\%$;
- output: r.m.s.-value of the “Peak-Hold” with in the measurement duration (typically a couple of minutes).

R.M.S.-calculation 9 kHz to 17 kHz.

Root-Sum-Square of the 13 bins in each of the interval 9,25 kHz to 9,75 kHz (inclusive), 10,25 kHz to 10,75 kHz (inclusive), 11,25 kHz to 11,75 kHz (inclusive), 12,25 kHz to 12,75 kHz (inclusive), 13,25 kHz to 13,75 kHz (inclusive), 14,25 kHz to 14,75 kHz (inclusive), 15,25 kHz to 15,75 kHz (inclusive) and 16,25 kHz to 16,75 kHz (inclusive).

The limit for the calculated level is 0,70 A.

A.5 Finland, RHK specification

A.5.1 Scope of the specification

This specification is to be applied together with EN 50238 whereby EN 50238 covers largely the preparation of a safety/compatibility case.

This document is based on document LISO 1.8 given by Finnish Railway Administration.