Irish Railway Standard IRS-302-B

Requirements for ATP and CAWS Class B Systems in Republic of Ireland:

Requirements for CCT and CCO

Issue	Published by	Issue Date
B	CRR on behalf of the Irish Railway Industry	09/04/2026

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1 Foreword

1.1 Irish Railway Standards:

i. cannot replace any Technical Standard for Interoperability (TSI) or other legal requirements which may be applicable to a given project;
ii. are recommended to be chosen as an Alternative Solution in conjunction with a TSI Parameter to demonstrate conformity with the Essential Requirements;
iii. may be called up as a code of practice in conjunction with CSM 402/2013;
iv. may be called up as good industry practice in conjunction with Railway Safety Act 2005;
v. may be called up as a code of practice in conjunction with the safe integration of projects within the Railway System in the Republic of Ireland as defined under 2016/797/EU Art 18 as transposed by S.I. 477 of 2020 ;
vi. may in parts or in full be called up as a National Rule (NR) for the Republic of Ireland in conjunction with 2016/797/EU as transposed by S.I. 477 of 2020, and 2016/798/EU as transposed by S.I. 476 of 2020.

1.2 Where Irish Railway Standards are called up as a NR, in line with 2016/797/EU Art 13(2) as transposed by S.I. 477 of 2020 the reason for its application shall be identified, based on one or more of the following justifications:

i. where the TSIs do not cover, or do not fully cover, certain aspects corresponding to the Essential Requirements, including open points as referred to in 2016/797 Article 4(6);
ii. where non-application of one or more TSIs or parts of them has been notified
iii. under 2016/797 Article 7 as transposed by S.I. 477 of 2020 ;
iv. where a specific case requires the application of technical rules not included in the relevant TSI;
v. National Rules used to specify existing systems, limited to the aim of assessing technical compatibility of the vehicle with the network;
vi. networks and vehicles not covered by TSIs;
vii. as an urgent temporary preventive measure, in particular following an accident.

2 Scope and Application

2.1 Scope

The focus of this IRS is the specification of the continuous signal transmission interface for the Class B train control command and signalling systems in the Republic of Ireland, in accordance with [TSI-CCS], which indicates that the definition of the requirements for a Class B system is the responsibility of the relevant Member State.

This IRS provides high level functional requirements for both CCO and CCT.

2.2 Editing rules

- The document is divided into sections and sub-sections in which requirements are defined.
- Each requirement is identified with a unique identification number, and with an attribute, that makes the requirement Mandatory or Optional, where these requirements contain options or contain a range of configuration parameters to select from.
    - Mandatory Requirements shall be implemented in all CCO or CCT installations.
    - Optional Requirements may be implemented or not.
- Each requirement is labelled with an 'Onboard', 'Trackside' or 'Application Condition' "Allocation".
- Each requirement is labelled with an "Owner". The "Owner" label is an informative element which is intended to support the allocation of requirements between the industry stakeholders;
    - IM: the requirement is allocated to the IM which operates, or intends to operate, the network on which the CCT is installed
    - RU: the requirement is allocated to the RU which operates, or intends to operate in Ireland, a Unit on which the CCO is installed. This is expected to be implemented through a mandatory IM requirement (e.g. network access requirement).
    - CLASS B CCO Supplier: the requirement is allocated to the RU which operates, or intends to operate in Ireland, the Unit on which the CCO is installed. Its implementation may typically be carried out by a supplier which has been contracted by the RU to supply an element of the CCO. Such requirements can originate from a mandatory IM requirement to the RU (e.g. through network access requirement).
    - CLASS B CCT Supplier: the requirement is allocated to the IM which operates, or intends to operate, the network on which the CCT is installed. Its implementation may typically be carried out by a supplier which has been contracted by the IM to supply an element of the CCT.

The above allocation is independent of which entity is defined as the "Applicant" according to 2016/797 (EU).

- The unique identifiers are intended to support the development, verification & validation activities for the Class B equipment. The requirement identifiers are not intended to change in the next version of the document. For new requirements new identifiers would be generated in sequence and introduced between the existing ones.
- Notes, Justifications and Examples are only informative and shall be regarded as supporting information for the understanding of the requirements. They are shown in blue italics as follows: *Notes in the text.*

- The use of terms her, his, signalman, driver, etc. in this standard is not intended to be gender specific.

2.3 General Compliance Date

This Irish Railway Standard comes into force on the date of its publication

2.4 NR Provisions

- Table 1 identifies all sections of this IRS which are proposed as Irish NRs. The rationale is identified in line with section 1.2.
- Throughout this document NRs are identified by unique numbering with rules for Fixed Installations Control-Command and Signalling Trackside containing the coding CCT and rules for Vehicle Control-Command and Signalling Onboard containing the coding CCO. For example, the format of this coding for CCT is generically as follows: ***[REQ:IRS_CLASSB_CCT_xxxxx]*** with xxxxx being replaced by numerical counter. Likewise, for CCO it's: ***[REQ:IRS_CLASSB_CCO_xxxxx].***
- In each case where DeBo assessment is required for conformity assessment of a NR it shall be performed by a DeBo recognised for the Republic of Ireland, and employing the Modules stated. The assessment Modules are defined in 2010/713/EC (In this regard, the term NoBo (as used in 2010/713/EC) shall be understood to mean DeBo and references to TSIs shall be understood to mean references to Irish NRs). Note, all NRs to be employed as part of an authorisation require DeBo assessment. As exceptions NRs originating from the [TSI-OPE] do not require DeBo assessment.
- When a requirement of this IRS refers to the [IRS-EMC], the conformity assessment of this requirement shall be made in accordance with the assessment requirements specified in that [IRS-EMC] document.

Section	Rationale (see section 1,2)		Module(s)
6	where the TSIs do not cover, or do not fully cover, certain aspects corresponding to the Essential Requirements, including open points as referred to in 2016/797 Article 4(6); National Rules used to specify existing systems, limited to the aim of assessing technical compatibility of the vehicle with the network;	i v	For CCT: (SG) or (SH1)
7	where the TSIs do not cover, or do not fully cover, certain aspects corresponding to the Essential Requirements, including open points as referred to in 2016/797 Article 4(6); National Rules used to specify existing systems, limited to the aim of assessing technical compatibility of the vehicle with the network;	i v	For CCO: (SB+SD) or (SB+SF) or (SH1)

Table 1 - National Rule Provisions

2.5 Safety Requirements

Requirements specified in section 8 shall be implemented for safety reasons during operation and maintenance of Class B CCO and CCT.

Any IM or RU, through application of their Safety Management System and of the requirements of [IOD] in combination with applicable TSIs and applicable NRs, shall ensure compliance with the requirements of this IRS.

When a requirement of this IRS refers to the [IRS-EMC], the conformity assessment of this requirement shall be made in accordance with the assessment requirements specified in that [IRS-EMC] document.

The assessment against the Application Conditions (SRACS) of this document shall be performed by the IM or RU responsible for their definition and implementation (self-assessment), under the control of an Assessment Body (AsBo).

3 Normative References

In the development, operation and management of the CCO and CCT systems the application of the following standards shall be required. Subsequent revisions may be used instead of the quoted revisions.

[50126]	EN50126:2017 Railway applications - The specification and demonstration of reliability, availability, maintainability and safety (RAMS) Part 1 and Part 2
[50716]	Railway Applications - Requirements for software development (superseding EN50128:2020)
[50129]	EN50129:2018 Railway applications - Communication, signalling and processing systems - Safety related electronic systems for signalling
[50159]	EN50159:2010 Railway applications - Communication, signalling and processing systems - Safety-related communication in transmission systems
[IOD]	Interoperability Directive, (EU) 2016/797 (as transposed in the Republic of Ireland)
[CSM402]	CSM-RA 402/2009 Commission Implementing Regulation (EU) No 402/2013 of 30 April 2013 on the common safety method for risk evaluation and assessment and repealing Regulation (EC) No 352/2009 including any related amendments, e.g. (EU) 2015/1136
[IRS-EMC]	IRS 203 Irish Railway Standard – EMC coordination, version as valid on the date of application for authorisation
[IRS-305]	IRS 305 Irish Railway Standard - Requirements for Class A ETCS CCT Systems and for IM Operating Rules in the Republic of Ireland (trackside)
[TSI-CCS]	Technical Specification for Interoperability relating to the ‘control-command and signalling’ subsystems of the rail system in the European Union COMMISSION REGULATION (EU) 2016/919 including any related amendments.
[TSI-OPE]	Up to 16.05.2021: Technical Specification for Interoperability relating to the operation and traffic management subsystem of the rail system in the European Union - 2012/757/EU

including any related amendments (e.g. (EU) 2015/995).
From 16.05.2021: Commission Implementing Regulation (EU) 2019/773 on the Technical Specification for Interoperability relating to the operation and traffic management subsystem of the rail system within the European Union including any related amendments.

4 Terms and Definitions

Where a Term contained in this section is used in this IRS, it shall have the associated Definition contained in this section.

50 Hz CCT Area	An area that is fitted with track code using the 50 Hz carrier designed to transmit information to trains fitted with CCO CAWS
83.3 Hz CCT Area	An area that is fitted with track code using the 83.3 Hz carrier designed to transmit information to both trains fitted with CCO ATP and trains fitted with CCO CAWS.
Actual Train Consist	The current train composition including all its physical properties (e.g. length, load, brake performance). These properties shall reflect the true current values including any set up of equipment or presence of failed equipment or degraded performance of equipment.
Airgap	The continuous signal transmission interface between CCT and CCO
Berth Track	The track coding section (or combination of track coding sections), immediately on the approach to a lineside signal, which transmits a code reflecting the aspect of that signal. *Note: the Berth Track length corresponds to:* - *In 50Hz CCT Area: the greater of either the minimum sighting distance for the signal at Civil Line Speed or 300m.* - *In 83.3 Hz CCT Area where ATP fitted trains are allowed to operate: At least the braking distance from the ATP Speed of the previous track coding section to Standstill of the trains permitted to operate on that section of line.*
Pre-Berth Track	The track coding section (or combination of track coding sections all of which transmit the same code), immediately on the approach to the Berth Track.
Fixed Installations	Installations and equipment of the railway network infrastructure in the Republic of Ireland, which comprises the infrastructure (INF), electric traction energy supply systems (ENE) and trackside control command and signalling systems (CCT).
Operating Rule	Any Operating Rule required by this standard shall be established in accordance with [TSI OPE].*Note: An Operating Rule which becomes required through the application of this IRS will constitute a national Operating Rule relating to the operation of a class B CCT or CCO system according to [TSI OPE].*

	In accordance with [TSI-OPE] the required national rules shall be contained in the Route Book elements provided from an IM to the RUs for integration into their Rule Books for drivers. In accordance with [TSI-OPE] the required national rules shall be contained in the driver's Rule Book provided from the RUs to the drivers. In accordance with [TSI-OPE] and the IM's SMS established under the requirements of the Railway Safety Directive the Operating Rules for IM stall shall be contained in the Documentation for Infrastructure Managers' staff.
Speed	See definitions below
Current Train **Speed**	Current speed of the Train with respect to the track over which it is running
Civil Line **Speed**	The maximum speed authorised by an IM for a section of track, derived from its design (e.g. track alignment, transition curves, maximum permitted cant deficiency, axle load), and a tolerance for maintenance and operation.
Turnout **Speed**	The maximum speed authorised by an IM for a turnout, derived from its design, and a tolerance for maintenance and operation
ATP **Speed**	The maximum speed, applicable with ATP active, and transmitted by an 83.3 Hz CCT Area where ATP fitted Train are allowed to operate, within a track coding section length. It must be generated based on: - The Civil Line Speed in that Track Coding Section. - The Turnout speeds, if present following that Track Coding Section. - The previous and next signal aspects. - The location of the Track Coding section with respect to the overlap of the next signal - The braking deceleration rates and response times of all Actual Train Consists permitted to operate with ATP on that section of track. - System reaction time. - Applicable gradients. This speed can be set to the following values: 0, 30, 50, 75 or 100 km/h.
ATP Running Release **Speed**	The maximum speed limit under which the train is permitted to operate under defined conditions in the vicinity of a red signal.
Track Coding Section	A section of track over which a single code rate is transmitted. A track coding section may correspond with all or part of a train detection section, or with multiple train detection sections.

Train	An operational formation consisting of one or more Units. Operational means, in this context, that the Train is equipped with a traction system, with at least one cab from which the Train can be operated, and with all other equipment as required for its operation on the rail network.
Unit	The smallest operational vehicle element which may be integrated in a Train or taken out of a Train by operating staff without the need to use specific workshop equipment. A Unit may be composed of one or multiple individual vehicles. Examples: • An IE-Class201 locomotive, as an individual vehicle, is a Unit • A fixed formation of one IE-Class8100 EMU motorised vehicle with one IE-Class8300 EMU trailer vehicle is a Unit *Note: In some fixed formations, two vehicles may share a joint element of running gear.*
Vehicle	Composed of Rolling Stock and CCO (definition by EU legislation and guidance)

5 Symbols and Abbreviated Terms

ATP	Automatic Train Protection (name given to the Class B functions which are based on 83.3 Hz code airgap)
CAWS	Continuous Automatic Warning System (name given to the Class B functions which are based on 50Hz and 83.3 Hz code airgap)
CCO	Command Control & signalling On-board sub-system. Unless otherwise stated, 'CCO' shall be read in this document as meaning 'Class B CCO'.
CCT	Command Control & signalling Trackside sub-system. Unless otherwise stated, 'CCT' shall be read in this document as meaning 'Class B CCT'.
EB	Emergency Brake
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EMU	Electric Multiple Unit
IM	Infrastructure Manager
NR	National Rule
PPM	Pulses Per Minute
RU	Railway Undertaking
RST	Rolling Stock
SIL	Safety Integrity Level
SRAC	Safety Related Application Condition(s)
TSI	Technical Specification for Interoperability

6 CCT Requirements

[REQ:IRS_CLASSB_CCT_00001];[Allocation:Trackside] ;[Type:Mandatory];[Owner:CLASS B CCT Supplier]
The requirements defining the CCT signal characteristics in this section including all subsections must be met in all infrastructure configurations, including e.g. points, crossings, jointed rail, embedded track, impedance bonds, etc.
CCT Equipment to which this IRS applies, and which was installed prior to the date of issue of this IRS shall be evaluated and be brought into compliance with this IRS within 18 months after its date of issue.
[END_REQ]

6.1 General Requirements for CCT

Note: As indicated in Section 4 - Terms and Definitions, 50 Hz CCT Areas can transmit information to trains fitted with CCO CAWS, and 83.3 Hz CCT Areas can transmit information to trains fitted with CCO CAWS and trains fitted with CCO ATP, subject to the IM network access requirements..

Note: CCO CAWS is designed to repeat signal information in the driver's cab from a distance correlated to the signal sighing distance. Whilst CCO CAWS triggers the brakes if the driver does not acknowledge an aspect downgrade, it is not designed to stop the trains before signals displaying a stop aspect or within their associated overlap. For that reason, no minimum braking performances are specified in this IRS for trains operating with CCO CAWS active.

Note: The core function of CCO ATP is to stop a train within a safe distance. Therefore, minimum braking performances are specified in this IRS for trains operating with ATP active (Refer to APPENDIX B)

Note: Independently from the minimum braking performance required for operating with CCO CLASS A or ATP CCO CLASS B active, any IM is responsible for limiting access to the network to trains whose braking performance meet the minimum braking performance required to operate safely with the underlying signalling system.

[REQ:IRS_CLASSB_CCT_00003];[Allocation:Trackside];[Type:Mandatory];[Owner:CLASS B CCT Supplier]
The CCT requirements indicated in this section shall be read in conjunction with the CCO requirements indicated in section 7 of this document.
[END_REQ]

[REQ:IRS_CLASSB_CCT_00004];[Allocation:Trackside];[Type:Mandatory];[Owner:CLASS B CCT Supplier]
The CCT shall not interfere adversely with any other Class A or Class B CCO or CCT systems, which are operated in the Republic of Ireland at the time of placing CCT in service. This shall be demonstrated based on the relevant requirements of [TSI-OPE], [TSI-CCS], [IRS-EMC], [50126], [50128], [50129] and [CSM402] and consider the actual application of these systems.
[END_REQ]

[REQ:IRS_CLASSB_CCT_00005];[Allocation:Trackside];[Type:Mandatory];[Owner:CLASS B CCT Supplier]
The electromagnetic characteristics for the CCT (EMC and EMI requirements) shall be according to [IRS-EMC].
[END_REQ]

[REQ:IRS_CLASSB_CCT_00006];[Allocation: Trackside];[Type:Mandatory];[Owner:CLASS B CCT Supplier]
The process of design, data preparation, configuration, programming, and installation of new, upgraded or renewed Class B CCT equipment, including the necessary interfacing with Non-Class B CCT, shall be commensurate with a SIL4 application. This shall follow the relevant requirements of [50126], [50128], [50129] and [CSM402].
[END_REQ]

6.2 Airgap Continuous Signal Transmission Requirements for CCT

Note: This section specifies the characteristics of the continuous signal, generated by the CCT and sent through the rail or cable loop circuits, and received by the CCO through the pickup coils.

The information signal between the rail and the on-board sub system is inductively coupled, allowing the transfer of information from CCT to CCO in 50 Hz (Carrier 1 – C1) and 83.3 Hz (Carrier 2 – C2) CCT Areas.

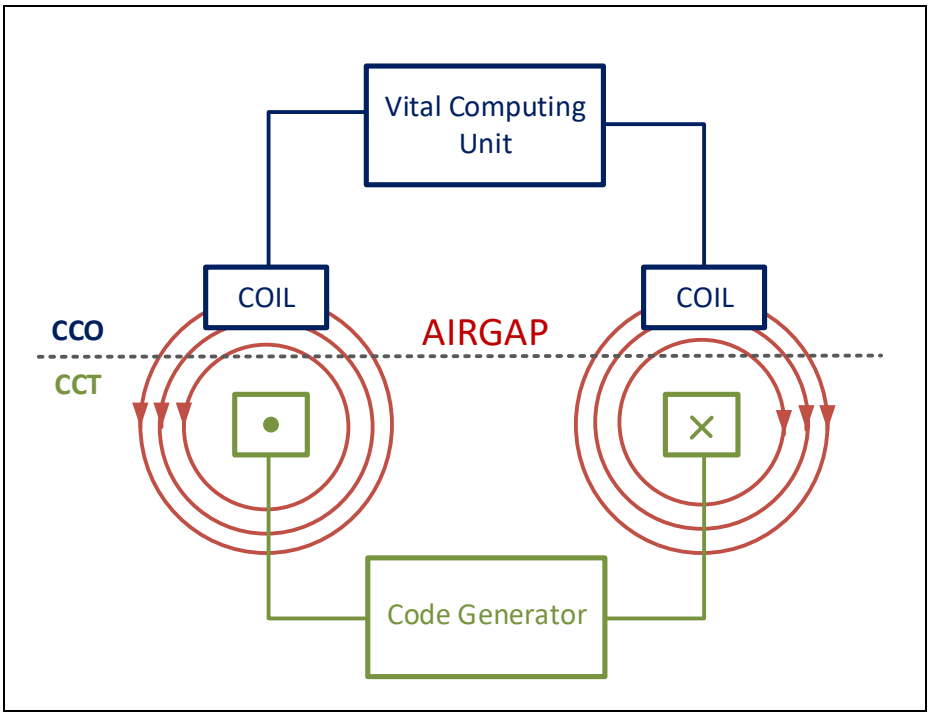

Figure 1 – Continuous signal transmission principle (Airgap)

The modulation of these carriers results in a set of codes expressed in Pulses Per Minute (ppm). This section of the document specifies the characteristics and performances of the two carriers and associated codes.

6.2.1 Code Transmission Circuit

[REQ:IRS_CLASSB_CCT_00009];[Allocation:Trackside];[Type:Mandatory];[Owner:CLASS B CCT Supplier]
The CCT code transmission circuit shall be formed either by the rails themselves – a rail circuit - or by a separate cable loop fitted to the rails.
[END_REQ]

[REQ:IRS_CLASSB_CCT_00010];[Allocation:Trackside];[Type:Mandatory];[Owner:CLASS B CCT Supplier]
Where a cable loop is used it shall be fitted onto the foot of the rail, as close as practicable to the web. A cable loop may consist of a single turn or multiple turns.
[END_REQ]

6.2.2 Code Signal Characteristics

[REQ:IRS_CLASSB_CCT_00011];[Allocation:Trackside];[Type:Mandatory];[Owner:CLASS B CCT Supplier]
The CCT signal shall be defined by the following signal characteristics:

- Carrier
  - Signal wave-form
  - Total harmonic distortion
  - Carrier frequency
  - Signal amplitude
  - Rail circuit or cable loop voltage
- Modulation
  - Signal wave-form
  - Modulating frequency
  - Duty Cycle of modulating signal
  - Modulation depth.

[END_REQ]

6.2.2.1 Signal wave-form for carrier and modulation

[REQ:IRS_CLASSB_CCT_00012];[Allocation:Trackside];[Type:Mandatory];[Owner:CLASS B CCT Supplier]
CCT shall generate a signal that consists in the modulation of the carrier amplitude, in accordance with an OOK (On-Off Keying) principle. The electrical shape of the signal is illustrated in
Figure 2 and shall consist of:

- A sinusoidal wave-form of Carrier
- A square wave-form of Modulation

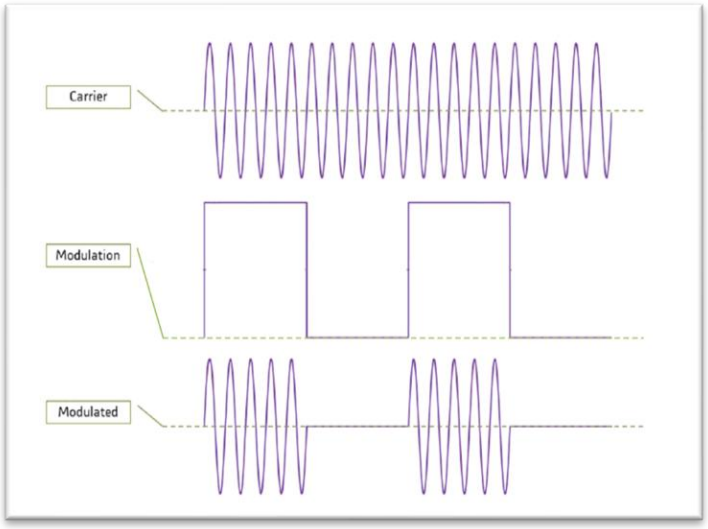

Figure 2 – Signal Modulation Principle
[END_REQ]

Note: The mathematical model defining the carrier and the modulating signal follows the following principles:

- *Sinusoidal carrier frequency:*
  - $v_{c(t)} = V_c \sin \omega_c t$

- *Square wave modulating signal with cycle T, frequency* $f_m = \frac{1}{T}$ *and amplitude* A
  - $v_{m(t)} = A$ *for* $0 < t < \frac{T}{2}$
  - $v_{m(t)} = 0$ *for* $\frac{T}{2} < t < T$

The modulated signal is the product of both signals: $v(t) = v_m(t).v_c(t) = v_m(t).V_c \sin \omega_c t$

[REQ:IRS_CLASSB_CCT_00013];[Allocation:Trackside];[Type:Mandatory];[Owner:CLASS B CCT Supplier]
The equipment modulating the CCT carrier shall do so with a rise time and fall time no greater than 3 ms.
[END_REQ]

6.2.2.1.1 Total Harmonic Distortion

[REQ:IRS_CLASSB_CCT_00014];[Allocation:Trackside];[Type:Mandatory];[Owner:CLASS B CCT Supplier]
The equipment supplying the CCT carrier shall operate with a value of Total Harmonic Distortion less than a maximum value of 8%.
[END_REQ]

6.2.2.2 Carrier frequency

[REQ:IRS_CLASSB_CCT_00015];[Allocation:Trackside];[Type:Mandatory];[Owner:CLASS B CCT Supplier]
CCT shall deliver carrier frequencies between the values specified in the table below:

Carrier Frequency	CCT_Min [CFreq]	Nominal	CCT_Max [CFreq]
C1 – 50 Hz	49Hz	50Hz	51Hz
C2 – 83.3 Hz	82.8Hz	83.3 Hz	83.8Hz

[END_REQ]

6.2.2.3 Signal amplitude

[REQ:IRS_CLASSB_CCT_00016];[Allocation:Trackside];[Type:Mandatory];[Owner:CLASS B CCT Supplier]
CCT shall deliver the following minimum code transmission circuit signal amplitude values, for unmodulated carrier and for the ON-half-cycle of the modulated carrier, according to the type of installed trackside circuit:

Carrier Frequency	Transmission circuit formed by a rail circuit	Transmission circuit formed by a single turn cable loop
C1 – 50 Hz	1.5 A_{rms}	3.0 A_{rms}
C2 – 83.3 Hz	3.0 A_{rms}	3.0 A_{rms}
A_{rms} = Ampere root mean square		

This minimum value is referred to as $CCT\_Min_{[Amp]}$
[END_REQ]]

[REQ:IRS_CLASSB_CCT_00017];[Allocation:Trackside];[Type:Mandatory];[Owner:CLASS B CCT Supplier]
CCT shall not deliver

- a rail circuit current or
- in case of a single cable loop, a cable-loop current

of greater than 20 A_{rms}, for the unmodulated carrier and for the ON-half-cycle of the modulated carrier, for both carrier frequencies (50 Hz [C1] or 83.3 Hz [C2]).
This maximum value is referred to as $CCT\_Max_{[Amp]}$

CCT shall not deliver

- in case of a multi-turn cable loop, a single cable-loop current

of greater than 20 A_{rms} divided by the number of turns, for the unmodulated carrier and for the ON-half-cycle of the modulated carrier, for both carrier frequencies (50 Hz [C1] or 83.3 Hz [C2]).
This maximum value is referred to as $CCT\_Max_{[Amp]}$
[END_REQ]

Note: Current values above 20 A_{rms} could cause the pickup coils to saturate and shall therefore be avoided.

6.2.2.3.1 Rail circuit or cable loop voltage

[REQ:IRS_CLASSB_CCT_00018];[Allocation:Trackside];[Type:Mandatory];[Owner:CLASS B CCT Supplier]
CCT shall not deliver a voltage across the two rails of the code transmission circuit of more than 30 V_{rms} unmodulated.
[END_REQ]

[REQ:IRS_CLASSB_CCT_000019];[Allocation:Trackside];[Type:Mandatory];[Owner:CLASS B CCT Supplier]
CCT shall not deliver a voltage across the terminals of a cable loop transmission circuit of more than 110 V_{rms} unmodulated.
[END_REQ]

Note: It is considered that 110 V_{rms} is acceptably safe based on the following arguments:

- *There are no exposed terminals or conductors in normal operation.*
- *The cables used in loops shall be double-insulated, so that the likelihood of exposure of a conductor due to damage is minimised.*
- *In the event of exposure of a conductor, the risk of shock to persons is minimised by the use of a supply, feeding the loop, which shall be isolated from earth.*
- *In the event of exposure of a conductor, the risk of imposing code voltage on other circuits through contact with the rail is minimised by the use of a supply which shall be isolated from earth and the fact that code loops are predominantly used in areas where train detection is by means of axle counters and not track circuits.*
- *RU and IM staff that may be present in the vicinity of a cable loop are required to be trained for appropriate behaviour related to these electric hazards (refer IRS_CLASSB_CCT_00021).*
- *The railway network is protected from access by members of the public.*

[REQ:IRS_CLASSB_CCT_00021];[Allocation:Trackside];[Type:Mandatory];[Owner:CLASS B CCT Supplier]
Cable loop transmission circuits shall be galvanically isolated from any other conductors and from earth. The cables used in loops shall be double-insulated.
[END_REQ]

Note: This is for protection against electrical hazards.

6.2.2.4 Modulation frequency

[REQ:IRS_CLASSB_CCT_00022];[Allocation:Trackside];[Type:Mandatory];[Owner:CLASS B CCT Supplier]

CCT shall deliver modulation frequencies between the values specified in the table below:

Code Name	CCT_Min[MFreq]	Nominal	CCT_Max[Mod Freq]
50 Code	45.6 ppm	48 ppm	51 ppm
75 Code	68.4 ppm	72 ppm	77 ppm
120 Code	117 ppm	123 ppm	129 ppm
180 Code	175.4 ppm	184 ppm	193.2 ppm
270 Code	268.8 ppm	276 ppm	283.2 ppm
420 Code	411 ppm	420 ppm	426 ppm

[END_REQ]

6.2.2.5 Duty Cycle of the modulating signal

[REQ:IRS_CLASSB_CCT_00023];[Allocation:Trackside];[Type:Mandatory];[Owner:CLASS B CCT Supplier]
CCT shall deliver a modulating signal duty cycle, for the modulation frequencies shown, between the values specified in the table below:

Code Name	Min[Mod Dut]	Nominal	Max[Mod Dut]
50 Code	46% ON	50% ON	52% ON
75 Code	45% ON	50% ON	52% ON
120 Code	44% ON	50% ON	52% ON
180 Code	42% ON	50% ON	52% ON
270 Code	40% ON	50% ON	52% ON
420 Code	38% ON	50% ON	52% ON

[END_REQ]

6.2.2.6 Modulation depth

Note: The modulation depth of the code transmission circuit signal is defined as $M_{dph} = \frac{(A_{mod} - A_{res})}{A_{mod}} * 100\ \%$, *where* A_{mod} *represents the maximum value of the modulating signal amplitude assumed during the ON half cycle, and* A_{res} *represents the maximum value of the modulating signal amplitude assumed during the OFF half cycle. Figure 3 shows an example of modulation depth different from 100%.*

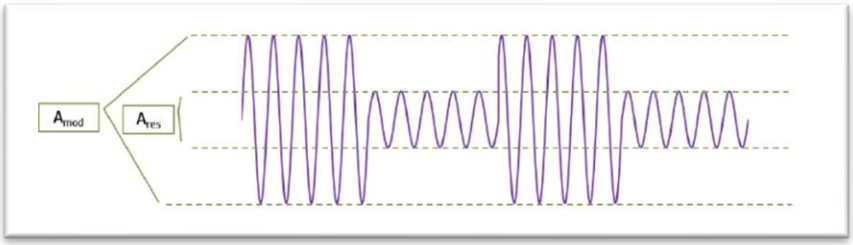

Figure 3 – Signal Modulation depth example

[REQ:IRS_CLASSB_CCT_00024];[Allocation:Trackside];[Type:Mandatory];[Owner:CLASS B CCT Supplier]
CCT shall deliver a signal with a modulation depth between 80% and 100%.
[END_REQ]

6.2.3 Performance Test for CCT signal transmission

[REQ:IRS_CLASSB_CCT_00025];[Allocation:Trackside];[Type:Mandatory];[Owner:CLASS B CCT Supplier]
The CCT signal characteristics shall be demonstrated as follows:

- Signal wave-form for carrier and modulation: By test at end of production or as commissioning test after installation on track (as Evidence Test)
- Total harmonic distortion: By test at the end of production of a representative sample for the type of product (as Evidence Test).
- Carrier frequency: By test at the end of production of a representative sample for the type of product (as Evidence Test).
- Signal amplitude: By commissioning test after installation on track (as Evidence Test)
- Rail circuit or cable loop voltage: By commissioning test after installation on track (as Evidence Test)
- Modulating frequency: By test at the end of production of a representative sample for the type of product (as Evidence Test).
- Duty Cycle of modulating signal: By test at the end of production of a representative sample for the type of product (as Evidence Test).
- Modulation depth: By test at the end of production of a representative sample for the type of product (as Evidence Test) or by commissioning test after installation on track (as Evidence Test)

[END_REQ]

Note: Tests at the end of production of a representative sample for the type of product are typically performed and documented under the responsibility of the product suppliers. The commissioning tests after installation on track are typically performed and documented under the responsibility of an Infrastructure Manager.

[REQ:IRS_CLASSB_CCT_00026];[Allocation:Trackside];[Type:Mandatory];[Owner:CLASS B CCT Supplier]
Tests at end of production, and commissioning tests for CCT signal transmission shall also include all activities which are required by the application specific safety cases.
[END_REQ]

6.2.4 83.3 Hz CCT Area Requirements

[REQ:IRS_CLASSB_CCT_00027];[Allocation:Trackside];[Type:Mandatory];[Owner:CLASS B CCT Supplier]
In an 83.3 Hz area, the CCT shall send to the CCO the code associated with:

- A signal aspect as defined in other requirements of this sub section.
- A stop demand (No Code) caused by
    - a technical fault,
    - a revocation of a movement authority.

This information shall be sent through track coding sections.
[END_REQ]

[REQ:IRS_CLASSB_CCT_00028];[Allocation:Trackside];[Type:Mandatory];[Owner:CLASS B CCT Supplier]
In an 83.3 Hz area where ATP fitted trains are allowed to operate, the code sent by the CCT shall be associated with the ATP Speed, in addition to the signal aspect, as defined in other requirements of this sub section.
[END_REQ]

[REQ:IRS_CLASSB_CCT_00029];[Allocation:Trackside];[Type:Mandatory];[Owner:CLASS B CCT Supplier]
Where a route has been set from a first signal to a second signal and a Train has passed the first signal with a "proceed" aspect, the code on the track coding section beyond that first signal, and up to the beginning of the Berth Track of the second signal, shall be associated with both:

- The most restrictive applicable ATP Speed over each track coding section transmitting a code.
- The signal aspect that was displayed in the first signal when the front of Train passed it.

Where the aspect of the second signal changes after the Train has passed the first signal, the code on the track coding sections beyond that first signal, and up to the beginning of the Berth Track of the second signal, shall be changed to reflect both:

- The most restrictive applicable ATP Speed over each track coding section transmitting a code.
- The signal aspect that would have been displayed in the first signal if the Train had not already passed it.

[END_REQ]

Note: the term "Berth Track" is defined in section 4.

[REQ:IRS_CLASSB_CCT_00030];[Allocation:Trackside];[Type:Mandatory];[Owner:CLASS B CCT Supplier]
Where a signal is displaying a stop aspect, No Code shall be sent on the Berth Track associated with that signal.
[END_REQ]

[REQ:IRS_CLASSB_CCT_00031];[Allocation:Trackside];[Type:Mandatory];[Owner:CLASS B CCT Supplier]
Where a signal is displaying a "proceed" aspect, the code on the Berth Track of that signal shall be associated with both:

- The most restrictive applicable ATP Speed over each track coding section of that Berth Track transmitting the code.
- The signal aspect that is displayed by that signal.

[END_REQ]

[REQ:IRS_CLASSB_CCT_00032];[Allocation:Trackside];[Type:Mandatory];[Owner:CLASS B CCT Supplier]
Where a signal is displaying a stop aspect, the code on the Pre-Berth Track of that signal shall be associated with both following conditions:

- The most restrictive applicable ATP Speed (50km/h or 30km/h) over each track coding section of that pre-berth track transmitting the code.
- A yellow signal aspect.

[END_REQ]

Note: the term "pre-berth" track is defined in section 4.

[REQ:IRS_CLASSB_CCT_00033];[Allocation:Trackside];[Type:Mandatory];[Owner:CLASS B CCT Supplier]
Where 83.3 Hz CCT is fitted for ATP and CAWS operation, the following elements shall be defined in accordance with the requirements of [CSM402], [50126], [50716], and [50129]:

- The signal positions
- The aspect sequences
- The distance from each code downgrade location to the associated red signal.
- The ATP speed at each code downgrade location.

The calculation shall take into consideration the Braking Performances specified in APPENDIX B corrected for the applicable track gradient.
[END_REQ]

Note: Inside 83.3 Hz CCT Area where ATP fitted trains are allowed to operate, the positioning of the signals and the aspects of these signals should be defined such that CAWS warnings are provided with sufficient anticipation to the drivers of trains operating any Actual Train Consist which is fitted with the Class B CAWS system. This intends to reduce the likelihood of such Trains overrunning the point protected by the signalling system if the driver does not acknowledge an aspect downgrade.

[REQ:IRS_CLASSB_CCT_00034];[Allocation:Trackside];[Type:Mandatory];[Owner:CLASS B CCT Supplier]
The CCT shall send the applicable ATP Speed and/or signal aspect information to the CCO, through 83.3 Hz C2 carrier. The modulation of the C2 carrier shall respect the following table.

C2 – 83.3 Hz Carrier		
Code Name	**ATP Speed [km/h]**	**Signal Aspect**
No Code (with or without carrier)	0	Red
50 Code	30	Yellow
75 Code	30	Green
120 Code	50	Yellow
180 Code	50	Green
270 Code	75	Double Yellow
420 Code	100	Green

Table 2 - 83.3 Hz code interpretation

[END_REQ]

[REQ:IRS_CLASSB_CCT_00035];[Allocation:Trackside];[Type:Mandatory];[Owner:CLASS B CCT Supplier]
At locations in 83.3 Hz CCT Areas where a Train fitted with CCO ATP passes a point at which there is an increase in ATP Speed because of an increase in the Civil Line Speed, including a speed increase on exiting a turnout, the trackside design shall ensure that the higher ATP Speed is not transmitted to the Train until the rear of the Train has passed the point at which the Civil Line Speed increases.
This shall be done by defining an appropriate track coding section, beyond the actual Civil Line Speed increase point, at which the increase is transmitted to the Train, following assurance that the rear of the train has passed clear of the speed increase location.
[END_REQ]

6.2.5 50Hz CCT Area Requirements

[REQ:IRS_CLASSB_CCT_00036];[Allocation:Trackside];[Type:Mandatory];[Owner:CLASS B CCT Supplier]
In a 50Hz area, the CCT shall send to the CCO the code associated with:

- A signal aspect as defined in other requirements of this sub section.
- A stop demand (No Code) caused by
    - a technical fault,
    - a revocation of a movement authority.

This information shall be sent through track coding sections.
[END_REQ]

[REQ:IRS_CLASSB_CCT_00037];[Allocation:Trackside];[Type:Mandatory];[Owner:CLASS B CCT Supplier]
Where a route has been set from a first signal to a second signal and a Train has passed the first signal with a "proceed" aspect, the code on the track coding sections beyond that first signal, and up to the beginning of the Berth Track of the second signal, shall be associated with the signal aspect that was displayed in the first signal when the front of the Train passed it.
Where the aspect of the second signal changes after the Train has passed the first signal, the code on the track coding sections beyond that first signal, and up to the beginning of the Berth Track of the second signal, shall be changed to reflect the signal aspect that would have been displayed in the first signal if the Train had not already passed it.
[END_REQ]

Note: the term "Berth Track" is defined in section 4

[REQ:IRS_CLASSB_CCT_00038];[Allocation:Trackside];[Type:Mandatory];[Owner:CLASS B CCT Supplier]
Where a signal is displaying a stop aspect, No Code shall be sent on the Berth Track associated with that signal.
[END_REQ]

[REQ:IRS_CLASSB_CCT_00039];[Allocation:Trackside];[Type:Mandatory];[Owner:CLASS B CCT Supplier]
Where a signal is displaying a "proceed" aspect, the code on the Berth Track of that signal shall be associated with the signal aspect that is displayed by that signal.
[END_REQ]

[REQ:IRS_CLASSB_CCT_00040];[Allocation:Trackside];[Type:Mandatory];[Owner:CLASS B CCT Supplier]
The CCT shall send the applicable signal aspect information to the CCO, in accordance with Section 6.2 of this document, through the 50 Hz C1 carrier. The modulation of the carrier C1 shall respect the following table.

C1 – 50 Hz Carrier	
Code Name	**Signal Aspect**
No Code (with or without carrier)	Red
50 Code	Yellow
120 Code	Double Yellow
180 Code	Green

Table 3 - 50Hz code interpretation

[END_REQ]

6.2.6 Transitions between 83.3 Hz Area and 50Hz Area

[REQ:IRS_CLASSB_CCT_00041;[Allocation:Trackside];[Type:Mandatory];[Owner:CLASS B CCT Supplier]
Lineside signs shall be designed and installed in accordance with [IRS-305] to advise drivers when entering or leaving a CCT Area or changing between CCT Areas, e.g. Carrier 1 to Carrier 2.
[END_REQ]

7 CCO Requirements

7.1 General Requirements for CCO

[REQ:IRS_CLASSB_CCO_00001];[Allocation:Onboard];[Type:Mandatory];[Owner:CLASS B CCO Supplier]
The CCO requirements indicated in this section shall be read in conjunction with the CCT requirements indicated in section 6 of this document.
[END_REQ]

[REQ:IRS_CLASSB_CCO_00002];[Allocation:Onboard];[Type:Mandatory];[Owner:CLASS B CCO Supplier]
The CCO shall not interfere adversely with any other Class A or Class B CCO or CCT systems, which are operated in the Republic of Ireland at the time of placing CCO in service. This shall be demonstrated based on the relevant requirement of [TSI-OPE], [TSI-CCS], [IRS-EMC], and consider the actual application of these systems.
[END_REQ]

[REQ:IRS_CLASSB_CCO_00003];[Allocation: Onboard];[Type:Mandatory];[Owner:CLASS B CCO Supplier]
The electromagnetic characteristics for the CCO (EMC and EMI requirements) shall be according to [IRS-EMC].
[END_REQ]

7.2 Airgap Continuous Signal Transmission Requirements for CCO

[REQ:IRS_CLASSB_CCO_00004];[Allocation:Onboard];[Type:Mandatory];[Owner:CLASS B CCO Supplier]
The CCO shall read code only from the two pickup coils associated with the active cab of the Train.
[END_REQ]

[REQ:IRS_CLASSB_CCO_00005];[Allocation:Onboard];[Type:Mandatory];[Owner:CLASS B CCO Supplier]
In an 83.3 Hz CCT Area, the CCO ATP or CCO CAWS shall, at any moment in time, determine as Current CCO Code one of the following code names, as defined in section 6.2.2.4:

- 50 Code
- 75 Code
- 120 Code
- 180 Code
- 270 Code
- 420 Code
- No Code (absence of valid code, including unmodulated carrier, or absence of valid carrier)

[END_REQ]

Note: For each code name the nominal code rate and associated tolerances can be found in Section 6.2.

[REQ:IRS_CLASSB_CCO_00006];[Allocation:Onboard];[Type:Mandatory];[Owner:CLASS B CCO Supplier]
In a 50 Hz CCT Area, the CCO CAWS shall, at any moment in time, determine as Current CCO Code one of the following code names, as defined in section 6.2:

- 50 Code

- 120 Code
- 180 Code
- No Code (absence of valid code, including unmodulated carrier, or absence of valid carrier)

[END_REQ]

Note: For each code name the nominal code rate and associated tolerances can be found in Section 6.2.

[REQ:IRS_CLASSB_CCO_00007];[Allocation:Onboard];[Type:Mandatory];[Owner:CLASS B CCO Supplier]
CCO signal reception compatibility with trackside codes as specified in section 6.2.1 shall be demonstrated, through generic product type testing, in a static environment, to ensure conformity with the required threshold values.
[END_REQ]

[REQ:IRS_CLASSB_CCO_00008];[Allocation:Onboard];[Type:Mandatory];[Owner:CLASS B CCO Supplier]
CCO signal reception shall be demonstrated, through commissioning testing, in a static environment on straight track, representing nominal CCO installation conditions, and the nominal values of all signal characteristics where such nominal values are defined, with the minimum signal amplitude specified in 6.2.2.3, for all code names.
[END_REQ]

[REQ:IRS_CLASSB_CCO_00009];[Allocation:Onboard];[Type:Mandatory];[Owner:CLASS B CCO Supplier]
Application specific Type tests and commissioning tests for CCO signal reception shall also include all activities required by the application specific safety cases.
[END_REQ]

7.3 Functional Requirements for CCO

7.3.1 ATP Requirements

[REQ:IRS_CLASSB_CCO_00010];[Allocation:Onboard];[Type:Mandatory];[Owner:CLASS B CCO Supplier]
The CCO ATP shall determine the ATP Speed on the basis of CCT codes received with 83.3 Hz carrier only.
[END_REQ]

[REQ:IRS_CLASSB_CCO_00011];[Allocation:Onboard];[Type:Mandatory];[Owner:CLASS B CCO Supplier]
The CCO ATP system shall evaluate ATP Speed based on code names detected in the following way:

- When no code is detected (with or without presence of carrier):
    - ATP Speed = 0 km/h while the driver has not activated the Running Release function
    - ATP Speed = ATP Running Release Speed = 15 km/h if the driver has activated the Running Release function
- When code 50 is detected: ATP Speed = 30 km/h
- When code 75 is detected: ATP Speed = 30 km/h
- When code 120 is detected: ATP Speed = 50 km/h
- When code 180 is detected: ATP Speed = 50 km/h
- When code 270 is detected: ATP Speed = 75 km/h
- When code 420 is detected: ATP Speed = 100 km/h

100 km/h is the maximum ATP speed permitted for operating trains with CCO ATP active.
[END_REQ]

[REQ:IRS_CLASSB_CCO_00012];[Allocation:Onboard];[Type:Mandatory];[Owner:CLASS B CCO Supplier]
The CCO ATP shall display to the driver on the DMI both the Current Train Speed and the ATP Speed.
[END_REQ]

[REQ:IRS_CLASSB_CCO_00013];[Allocation:Onboard];[Type:Mandatory];[Owner:CLASS B CCO Supplier]
If the Current Train Speed exceeds the ATP Speed (either because of an increase in Current Train Speed or a downward change in ATP Speed), an audible and visual alarm shall be sent by CCO ATP to alert the driver.

- If the driver responds to an alarm by moving the master controller to either the coast or brake position, the CCO ATP shall make a full service brake application and reduce the Current Train Speed until the new ATP Speed is reached, at which point the brakes shall release.
- If, however, the driver does not respond and is still attempting to motor the train, a full service brake application shall be initiated and maintained by the CCO ATP until the driver does respond.

[END_REQ]

[REQ:IRS_CLASSB_CCO_00014];[Allocation:Onboard];[Type:Mandatory];[Owner:CLASS B CCO Supplier]
When making an ATP-initiated service-brake application, the CCO ATP shall sense the train's rate of retardation. If this is found to be below 0.667m/s², the CCO ATP shall initiate an emergency brake application in order to reduce the train's actual speed to the ATP Speed. The period during which the CCO ATP senses the service brake application shall be defined in accordance with the requirements of [CSM402], [50126], [50716], and [50129].
[END_REQ]

[REQ:IRS_CLASSB_CCO_00016];[Allocation:Onboard];[Type:Mandatory];[Owner:CLASS B CCO Supplier]
The CCO ATP shall provide a Running Release button in the driving cab to permit the train to be driven at low speed even though no code is being received by the ATP system.
[END_REQ]

[REQ:IRS_CLASSB_CCO_00017];[Allocation:Onboard];[Type:Mandatory];[Owner:CLASS B CCO Supplier]
To cater for train-borne equipment failures, a sealed isolation switch shall be provided by CCO ATP. The operation of the isolation switch should be recorded in the train juridical recording unit.
[END_REQ]

7.3.2 CAWS Requirements

[REQ:IRS_CLASSB_CCO_00018];[Allocation:Onboard];[Type:Mandatory];[Owner:CLASS B CCO Supplier]
The CCO CAWS shall evaluate CAWS Aspects based on code names detected in the following way:

- When the carrier is 50 Hz:
  - No Code is detected: Red
  - Code 50 is detected: Yellow
  - Code 120 is detected: Double Yellow
  - Code 180 is detected: Green
- When the carrier is 83.3 Hz:
  - No Code is detected: Red
  - Code 50 is detected: Yellow
  - Code 75 is detected: Green
  - Code 120 is detected: Yellow
  - Code 180 is detected: Green
  - Code 270 is detected: Double Yellow
  - Code 420 is detected: Green

[END_REQ]

[REQ:IRS_CLASSB_CCO_00019];[Allocation:Onboard];[Type:Mandatory];[Owner:CLASS B CCO Supplier]
The CCO shall classify the CAWS Aspects with the following order of restrictiveness:

- Red (most restrictive)
- Yellow
- Double Yellow
- Green (least restrictive)

[END_REQ]

[REQ:IRS_CLASSB_CCO_00020];[Allocation:Onboard];[Type:Mandatory];[Owner:CLASS B CCO Supplier]
The CCO CAWS shall display the Current CAWS aspect to a driver in the form of a miniature signal display in the cab.
[END_REQ]

[REQ:IRS_CLASSB_CCO_00021];[Allocation:Onboard];[Type:Mandatory];[Owner:CLASS B CCO Supplier]
The CCO CAWS shall announce audibly any change in aspect from that previously displayed.
[END_REQ]

[REQ:IRS_CLASSB_CCO_00022];[Allocation:Onboard];[Type:Mandatory];[Owner:CLASS B CCO Supplier]
The CCO CAWS shall require a driver acknowledgement in the event of a change to a more restrictive aspect (a downgrade). Failure to acknowledge within 7 seconds shall result in a full service brake application together with disabling of the acknowledgement mechanism. The acknowledgement mechanism shall be re-enabled after a period of 60 seconds, but the brake application shall be maintained until the driver subsequently operates the acknowledgement mechanism.
[END_REQ]

Note: A change to a less restrictive aspect (an upgrade) does not require acknowledgement.

Note: The period of 60 seconds for disabling the acknowledgement is based on historical analysis which determined that the train would be travelling sufficiently slowly after this length of time to allow the driver to regain control of the brakes.

[REQ:IRS_CLASSB_CCO_00023];[Allocation:Onboard];[Type:Mandatory];[Owner:CLASS B CCO Supplier]
The CCO CAWS shall provide a carrier select switch in the cab equipment to indicate whether the expected track codes are 50 Hz (Carrier 1) or 83.33 Hz (Carrier 2).
[END_REQ]

[REQ:IRS_CLASSB_CCO_00024];[Allocation:Onboard];[Type:Mandatory];[Owner:CLASS B CCO Supplier]
The CCO CAWS shall provide a Red Disable switch in the cab equipment which, when operated to the "Disable" position, shall extinguish the light in the Red aspect display in the cab.
[END_REQ]

Note: The purpose of the Red Disable switch is to ensure that, when a train is operating in an area not fitted with 50 Hz or 83.3 Hz code, the driver is not presented with a continuous red aspect display in the cab.

8 Safety Requirements for operation of Class B CCO and CCT

Note: The following requirements shall be implemented for safety reasons during operation and maintenance of Class B CCO and CCT.

[REQ:IRS_CLASSB_00001];[Allocation: Application Condition];[Type: Mandatory];[Owner:IM and RU]
SRAC: Every SRAC indicated in this document requiring information or training of staff shall, in accordance with [CSM402], be transferred to the relevant actors, through suitable means.
[END_REQ]

[REQ:IRS_CLASSB_00002];[Allocation: Application Condition];[Type: Mandatory];[Owner:IM and RU]
SRAC: Maintenance Procedures shall be produced to define the rules applicable to IMs and RUs for maintaining the CCT and CCO equipment to ensure ongoing fulfilment of all requirements of this IRS for CCT and CCO.
[END_REQ]

[REQ:IRS_CLASSB_CCT_00002];[Allocation: Application Condition];[Type:Mandatory];[Owner:IM]
SRAC: An Operating Rule shall be established to ensure that the requirements for Vehicle Network Access for all trains enforce a braking performance that is compatible at network level with the Non-Class A or Non-Class B CCT installations.
[END_REQ]

Note: Based on current European and national legislation it is expected that this requirement is enforced through the IM's Network Statements. It is expected that RUs and IMs cooperate closely in this regard.

[REQ:IRS_CLASSB_CCT_00007];[Allocation:Application Condition];[Type:Mandatory];[Owner:IM]
SRAC: An Operating Rule shall be established to ensure that any modification of the Fixed Infrastructure does not interfere with the compliance of CCO and CCT with all requirements defined in this standard. This shall at least consider but not be limited to the following:

- Modification of Civil Line speed,
- Modification of Signalling and track infrastructure,
- Changes in the EMC environment.

[END_REQ]

[REQ:IRS_CLASSB_CCT_00008];[Allocation:Application Condition];[Type:Mandatory];[Owner:IM and RU]
SRAC: An Operating Rule shall be established to ensure that IMs inform all RUs operating on their network at least six months before a change to the technical or operation requirements related to CCT or CCO becomes effective.
[END_REQ]

Note: This could relate to a change of CCO pre-configured parameters or the introduction of a change of CCT Area fitment, or the introduction of a new / modified CCO functionality. This would usually be driven by a preceding modification of this IRS.

[REQ:IRS_CLASSB_CCT_00020];[Allocation:Application Condition];[Type:Mandatory];[Owner:IM and RU]
SRAC: An operating rule shall be established to ensure that

- RU and IM staff that may be present in the vicinity of cable loops are trained for appropriate behaviour related to this electrical hazard, and

- the railway network is protected from access by members of the public.

[END_REQ]

[REQ:IRS_CLASSB_CCO_00015];[Allocation:Application Condition];[Type:Mandatory];[Owner:RU]

SRAC: An operating rule shall be established to ensure that the operation of an Actual Train Consist under an active ATP CCO shall only be permitted if the braking performance of that Actual Train Consist complies with the CCO ATP minimum braking performances specified in APPENDIX B.

The determination of the braking performance of the Actual Train Consist with active ATP CCO shall be made in accordance with the requirements of [CSM402], [50126], [50716], and [50129], and shall at least consider:

- Train Emergency Brake Response Time,
- Train Emergency Brake Deceleration,
- Train Service Brake Response Time,
- Train Service Brake Deceleration.
- CCO system reaction times, including code detection and evaluation times.

[END_REQ]

9 Further Clarification

Further clarification can be sought from the CRR by phone at +353 1 206 8110 or by email info@crr.ie.

10 List of Participants

The participants for each revision of this IRS are shown below in Table 4.

Table 4 - List of Participants by Revision

Participant Name and Organisation		**Involved in Issue A**	**Involved in Issue B**	
Istvan Darázsi	IÉ-IM		✓	
Paraic O'Lochlainn	IÉ-IM	✓	✓	
Francois Pignard	IÉ-IM	✓	✓	
Maik Wuttke	CRR	✓	✓	

Appendices

APPENDIX A – Pick up Coil Sensitivity

Note: This appendix supports Section 6.2.2 in relation to the topic of directional sensitivity of the pickup coils.

Magnetic field calculations:

The ratio between

1) the magnetic field B_{OWN} at a pickup coil from current in its own track at the minimum current level and nominal distance (0.6A and 200 mm) and

2) the magnetic induction B_{ADJ} at a pickup coil from current in an adjacent track at the maximum current and nominal distance (20A and approximately 1900 mm),

is determined by four factors;

1. *The ratio of the currents B_{OWN} and B_{ADJ}*
2. *The difference in distance between the pickup coil and the respective code transmission circuit conductors*
3. *The orientation of the pickup coil in relation to the respective code transmission circuit conductors, and*
4. *A coupling factor, k, whose value depends on the electromagnetic characteristics of the area around the pickup coil and the respective code transmission circuit conductors, which describes the reduction in efficiency of the coupling between the conductors and the pickup coil due to their surroundings, and hence the reduction of the output of the pickup coil from the theoretical voltage to a lower actual voltage.*

Effect of Distance from conductor
As shown in the formula defining the magnetic field in Section 6.2.2 the magnetic field around a conductor decreases linearly as the distance from the conductor increases.

Effect of Orientation of the magnetic field
The pickup coil will receive a field, from the adjacent track, which is oriented at almost 90 degrees to the orientation of the field from its own track.
See Figure 4 and Figure 5 below.

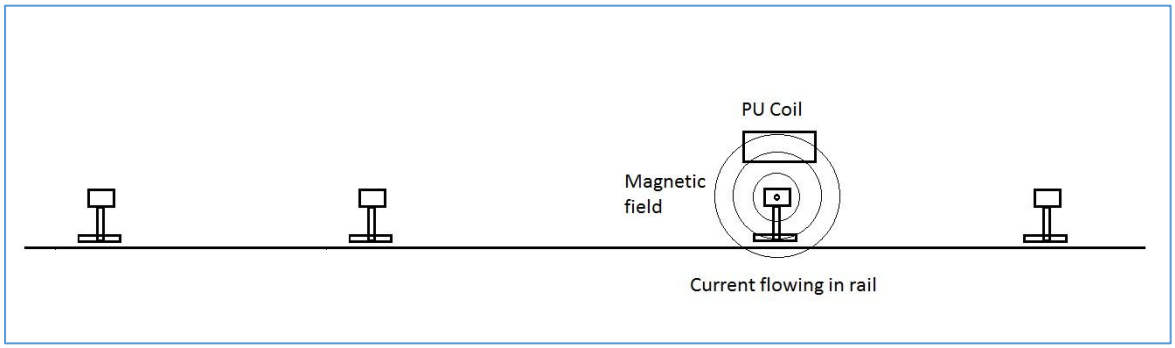

Figure 4 - Magnetic field from own track

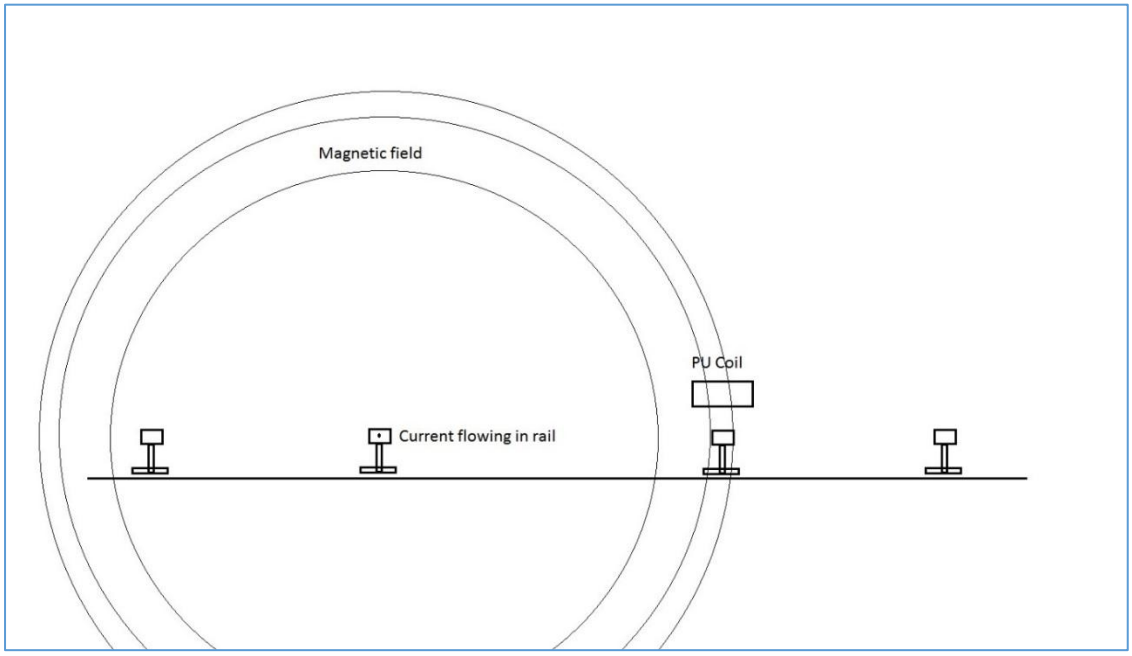

Figure 5 - Magnetic field from adjacent track

It can be seen that the field orientation at the pickup coil electrical centre, due to a current flowing in its own rail, is approximately horizontal, while the field orientation at the pickup coil electrical centre, due to a current flowing in the closer rail of the adjacent track, is close to vertical.

As the pickup coil design shall be such that its orientation with respect to the magnetic field affects the output, the resulting output from the adjacent track's field shall be lower than the output from the own track's field due to its orientation.

Effect of k factor

*The value of the **k** factor relates to the damping and distortion of the field in a real application when compared to a theoretical field around an infinite wire in vacuum. It cannot be easily determined other than by testing in typical reference situations. Its effect is significantly increased by the presence of large metallic structures such as track and rail vehicles within the magnetic field.*

Summary

The combination of these factors is such that the requirement for a 5-to-1 ratio between the pickup coil outputs in the two situations (pickup coil output due to own track's field vs. output due to adjacent track's field) is considered achievable.

In the possible case that a pair of pickup coils is subject to fields from adjacent tracks on both sides, this ratio could in theory reduce to a value of 2.5 to 1, which is considered an acceptable margin.

APPENDIX B - Minimum braking performances for trains operating with CCO ATP active

The table below and the curve in Figure 6 define the minimum braking performance for trains operating with CCO ATP active.

Speed	Formula
0 to 100 km/h	$$s = v.t_f + \frac{v^2}{2.a}$$ where; s = braking distance (m) v = initial speed (m/s) t_f = "free-run" time = 4 seconds a = deceleration = 0.68 m/s²

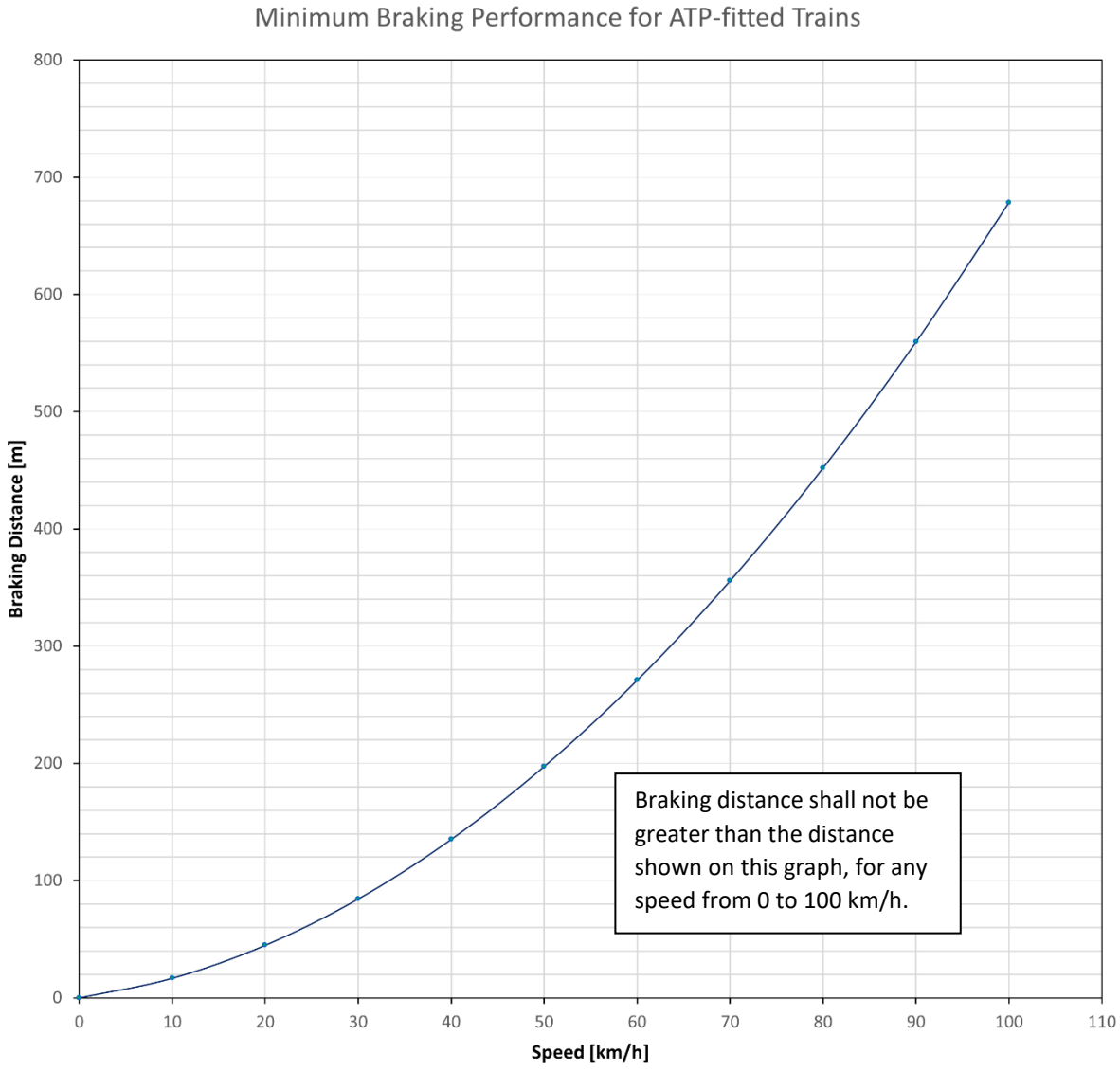

Figure 6 – Minimum Braking Performances for Actual Train Consist with active ATP CCO