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Coordination Requirements and Energy-Saving Potential Evaluation for Energy Feedback Systems in DC Traction
Power Systems

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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

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Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/Figure/ Table/Note	Type of comment	Commend (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	

PROJECT NUMBER: IEC 63477 ED1	
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IEC TC 9 : ELECTRICAL EQUIPMENT AND SYSTEMS FOR RAILWAYS	
SECRETARIAT: France	SECRETARY: Mr Denis MIGLIANICO
OF INTEREST TO THE FOLLOWING COMMITTEES:	PROPOSED HORIZONTAL STANDARD: ☐ Other TC/SCs are requested to indicate their interest, if any, in this CD to the secretary.
FUNCTIONS CONCERNED: ☐ EMC ☐ ENVIRONMENT ☐ QUALITY ASSURANCE ☐ SAFETY	

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Recipients of this document are invited to submit, with their comments, notification of any local regulations or technical reasons that may exist and should be considered should this proposal proceed, recognizing that failure to address such requirements could result in the need for new or existing "In Some Countries" clauses. (See [AC/22/2007](#) or new [GUIDANCE DOC](#)).

TITLE: Railway applications – Coordination requirements and energy-saving performance evaluation for Energy Feedback Systems in DC Traction Power Systems

NOTE FROM TC/SC OFFICERS:

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**RAILWAY APPLICATIONS – FIXED INSTALLATIONS –
COORDINATION REQUIREMENTS
AND ENERGY-SAVING POTENTIAL EVALUATION
FOR ENERGY FEEDBACK SYSTEMS IN DC TRACTION SYSTEM****FOREWORD**

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International Standard IEC 63477 has been prepared by IEC technical committee 9: Electrical equipment and systems for railways.

The text of this standard is based on the following documents:

Draft	Report on voting
9/XXXX/FDIS	9/XXXX/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

In order to save natural resources and meet the challenge of global warming, energy-saving technology has been paid more and more attention. An important measure in the railway industry is to use the regenerative braking energy of the train. This measure not only saves energy, but also improves maintainability and reduces the heat emission of trains.

Due to the unidirectional characteristics of rectifier in DC traction power supply system, the utilization of regenerative braking energy is limited.

The traditional method is to absorb regenerative energy by the other vehicle(s) running under the same DC traction power supply system; otherwise the excess energy will be dissipated by the resistors installed on the vehicle or on the ground to convert the surplus regenerative braking energy into heat, which is called energy consumption system. Because this scheme cannot save energy and may even increase the cooling consumption, there is no new application at present. One of the measures to solve this limitation is energy storage system, which has been widely used in many countries and issued corresponding standards in IEC standard system. The other measure is the Energy Feedback System (EFS). When the regenerative energy cannot be fully utilized within DC traction power supply system, the EFS can be used to convert the surplus regenerative energy to the upstream AC system for reuse.

Many companies are now providing EFSs, but the relevant international standards have not yet been issued. Therefore IEC/TC9 planned two standards. The IEC 62590-2-2 focuses on the converter itself, while in this document EFS is specified on its coordination with other subsystems, the location and sizing, and the energy-saving effect evaluation.

RAILWAY APPLICATIONS – FIXED INSTALLATIONS – COORDINATION REQUIREMENTS AND ENERGY-SAVING PERFORMANCE EVALUATION FOR ENERGY FEEDBACK SYSTEMS IN DC TRACTION SYSTEM

1 Scope

This document applies to coordination between Energy Feedback System (EFS) and other equipment in DC traction power supply system (TPSS), specifies the functions, electric connection, location and capacity coordination requirements and integration tests, provides energy-saving evaluation methods.

This document is applicable to all voltage levels of DC traction power supply system specified in IEC 60850.

This document applies to:

- EFS serving as an inverter with energy feedback function.
- EFS serving as a reversible converter with energy feedback function.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

IEC 60850, *Railway applications - Supply voltages of traction systems*

IEC 62590-2-2, *Railway applications – Electronic power converters for fixed installations –Part 2-2: DC Applications – Controlled converters*

IEC 62427, *Railway applications – Compatibility between rolling stock and train detection systems*

3 Terms, definitions and abbreviations

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at <https://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

3.1 Terms and definitions

3.1.1

energy feedback system

EFS

set of equipment which recovers regenerative energy from DC traction power supply system to 3AC power network operating in coordination with other equipment in DC traction power supply system

3.1.2**threshold voltage <of energy feedback system>** U_{th}

DC voltage value of EFS switching from idle state to energy feedback state

3.1.3**Energy fed back by EFS** E_{EFS}

energy value which is the energy fed back by one EFS or several EFSs.

3.1.4**Ratio of energy-saving** $RoES$

ratio of the reduction of the energy consumption value of the DC TPSS with operated EFS to the energy value of the DC TPSS without operated EFS

According to different application scenarios, three formulas (1) to (3) can be chosen to calculate the RoES.

$$RoES1 = \frac{E_1 - E_2}{E_1} \quad (1)$$

$$RoES2 = \frac{E_{EFS}}{E_{vehicle} + E_{others}} \quad (2)$$

$$RoES3 = \frac{E_{EFS} - E_{RET}}{E_{vehicle} + E_{others}} \quad (3)$$

where

 E_1 represents the energy consumption of the TPSS without operated EFS, E_2 represents the energy consumption of the TPSS with operated EFS under the same operation condition as E_1 , $E_{vehicle}$ represents the energy value which is the energy consumed or generated by vehicle, including vehicle traction energy consumption, vehicle generative energy, and vehicle auxiliary system energy, E_{others} represents the sum of energy consumption of all systems except $E_{vehicle}$ in substation, including Lighting energy consumption, elevator energy consumption, HVAC energy consumption, etc., E_{RET} represents the energy value which is the energy returned to the 3AC power network.

Note 1 to entry: The three formulas are suitable for different application requirements. Formula (1) is universal, but E_1 , E_2 needs to be obtained under exactly the same conditions, and the simulation-based method is more appropriate. Formula (2) considers the ratio of energy saving from the perspective of the EFS device, but if the ratio of energy saving is considered from the perspective of the traction power supply system, it is recommended to choose formula (3).

Note 2 to entry: Formulae (1) to (3) are defined based on applications that do not consider renewable energy and energy storage system.

Note 3 to entry: In the process of obtaining E_1 , E_2 , $E_{vehicle}$, E_{others} , E_{RET} , whether to consider the related energy losses of the equipment and system, and the energy periods, shall be based on the same considerations.

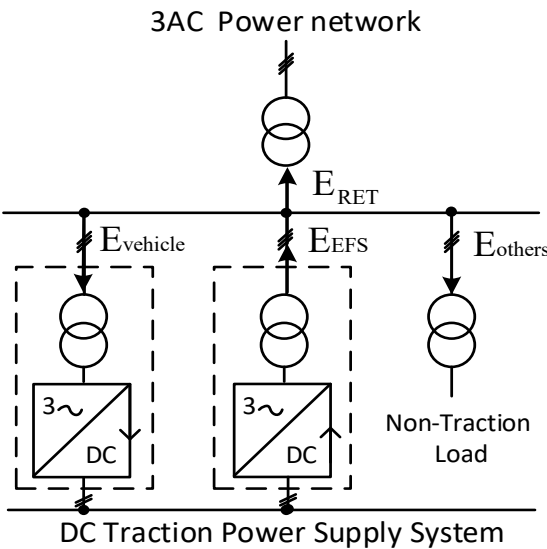


Figure 1 – EFS connection to primary side of the rectifier transformer

3.1.5
Recycling ratio
RR
energy fed back by EFS to traction energy consumption

$$RR = \frac{E_{EFS}}{E_{vehicle}} \tag{4}$$

Note 1 to entry: *RR* is not used to evaluate the energy saving accurately, but can to some extent represent the energy saving effect practically.

3.1.6
island mode
operating mode where the electrical installation operates while disconnected from the 3AC power network

[SOURCE: IEC 60050-826: 2022, 826-20-02, modified – The original “public network” changed to “3AC power network”.]

3.1.7
anti-islanding protection
protection function or combination of protection functions preventing an unintentional island to be supplied with electrical energy by distributed energy resources

Note 1 to entry: An anti-islanding protection usually includes the detection of system conditions which could lead to an unintentional island.

[SOURCE: IEC 60050-617:2017, 617-04-19]

3.1.8
real no-load direct voltage
U_{d00}
actual mean direct voltage at zero direct current

[SOURCE: IEC 60050-551:1998, 551-17-29, modified – “the” removed]

3.1.9**conventional no-load direct voltage** U_{d0}

mean value of the direct voltage which would be obtained by extrapolating the direct voltage/current characteristic from the region of continuous flow of direct current to zero current at zero trigger delay angle, i.e. without phase control

[SOURCE: IEC 551-17-17, modified – “the” removed]

3.1.10**vehicle voltage regulation threshold** U_{b1}

vehicle voltage regulation threshold, which is the instantaneous voltage value when the on-board chopper switching from off-state to on-state if there is with on-board resistor in the vehicle, or when the electric braking beginning to relief if there is without on-board resistor in the vehicle

3.1.11**maximum electric braking voltage** U_{bmax}

maximum electric braking voltage of a vehicle

3.1.12**centralized power supply configuration**

power supply configuration in which the specially set main substation supplies power to all traction substations and step-down substations, shown as Figure 2

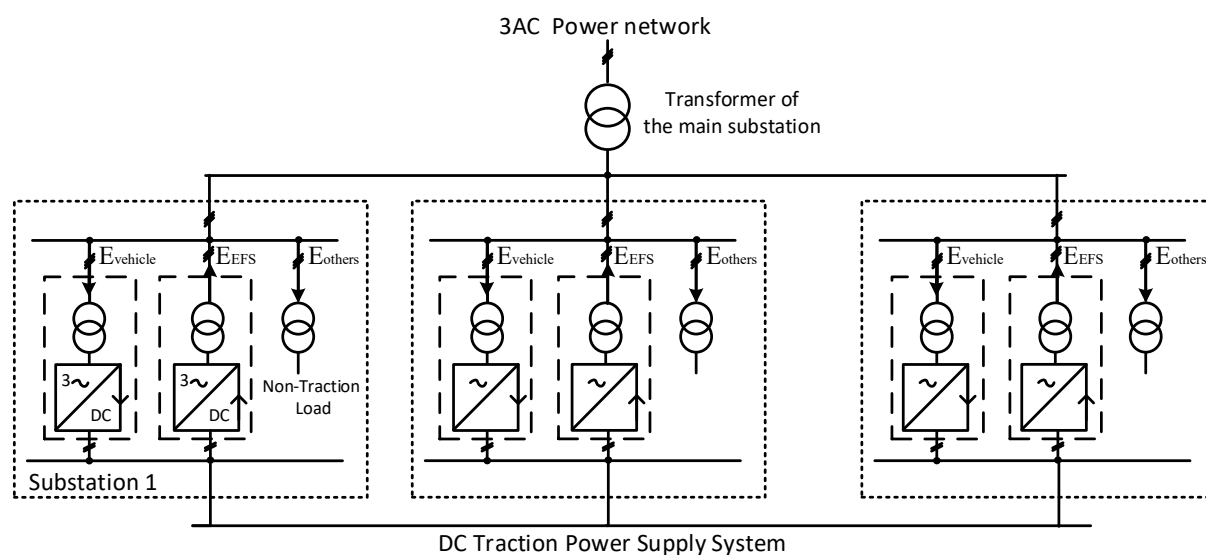


Figure 2 – Centralized power supply configuration

3.1.13**distributed power supply configuration**

power supply configuration in which the each type of substations are supplied power by the medium voltage power supply scattering along the line, shown as Figure 3