

INTERNATIONAL STANDARD

NORME INTERNATIONALE



Wireless power transfer – AirFuel Alliance resonant baseline system specification (BSS)

Transfert d'énergie sans fil – Spécification du système de référence (BSS) pour le système résonant d'AirFuel Alliance



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2017 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

Electropedia - www.electropedia.org

The world's leading online dictionary on electrotechnology, containing more than 22 000 terminological entries in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary

67 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

A propos de l'IEC

La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications IEC

Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Recherche de publications IEC -

webstore.iec.ch/advsearchform

La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études,...). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished

Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et une fois par mois par email.

Service Clients - webstore.iec.ch/csc

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: sales@iec.ch.

Electropedia - www.electropedia.org

Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 000 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 16 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

Glossaire IEC - std.iec.ch/glossary

67 000 entrées terminologiques électrotechniques, en anglais et en français, extraites des articles Termes et Définitions des publications IEC parues depuis 2002. Plus certaines entrées antérieures extraites des publications des CE 37, 77, 86 et CISPR de l'IEC.

INTERNATIONAL STANDARD

NORME INTERNATIONALE



Wireless power transfer – AirFuel Alliance resonant baseline system specification (BSS)

Transfert d'énergie sans fil – Spécification du système de référence (BSS) pour le système résonant d'AirFuel Alliance

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 29.240.99; 33.160.99; 35.200

ISBN 978-2-8322-8732-3

**Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.**

CONTENTS

FOREWORD.....	7
INTRODUCTION.....	9
1 Scope.....	10
2 Normative references	10
3 Terms, definitions, symbols and abbreviated terms.....	10
3.1 Terms and definitions.....	10
3.2 Symbols and abbreviated terms	13
3.2.1 Symbols	13
3.2.2 Abbreviated terms	17
4 System description	17
5 Conformance and backwards compatibility	18
6 Device types.....	19
6.1 PTU classification	19
6.2 PRU category	20
7 Power transfer specifications	21
7.1 System equivalent circuit and reference parameters	21
7.2 General system requirements	21
7.2.1 Operating frequency	21
7.2.2 Z_{TX_IN} relationship to R_{RECT}	21
7.2.3 Power stability.....	21
7.2.4 PTU co-location protection.....	21
7.2.5 PRU self-protection (informative).....	21
7.3 Resonator requirements.....	22
7.3.1 Resonator coupling efficiency (RCE)	22
7.3.2 PTU resonator requirements.....	22
7.3.3 PRU resonator requirements	24
7.4 Load parameters.....	26
7.4.1 Load parameters introduction	26
7.4.2 Minimum load resistance	26
7.4.3 Maximum allowable dynamic load.....	26
7.4.4 Maximum load capacitance.....	26
8 Power control specifications	27
8.1 Control objectives	27
8.2 PTU specifications	27
8.2.1 PTU state	27
8.2.2 General state requirements	27
8.2.3 PTU power save state.....	29
8.2.4 PTU Low Power state	31
8.2.5 PTU Power Transfer state	31
8.2.6 PTU Configuration state	34
8.2.7 PTU Local Fault state	35
8.2.8 PTU latching fault state	35
8.2.9 PTU state transitions	36
8.2.10 PTU Test Mode.....	39
8.3 PRU specifications.....	39
8.3.1 PRU general requirements.....	39

8.3.2	PRU state model	42
8.3.3	Null state	43
8.3.4	PRU boot.....	43
8.3.5	PRU On state	44
8.3.6	PRU System Error state.....	44
8.3.7	PRU state transitions	45
9	Signaling specifications	46
9.1	Architecture and state diagrams.....	46
9.1.1	Architecture	46
9.1.2	Overall charge process	47
9.2	Charge procedure and requirements	49
9.2.1	Removing PRU from WPT network	49
9.2.2	Power Sharing mode	49
9.3	Bluetooth low energy requirements	50
9.3.1	Bluetooth low energy requirements introduction	50
9.3.2	Bluetooth low energy objectives.....	50
9.3.3	PTU hardware requirement.....	50
9.3.4	PRU hardware requirement.....	50
9.3.5	Basic network structure	50
9.3.6	RF requirements.....	50
9.3.7	Timing and sequencing requirements.....	51
9.3.8	Profile structure	54
9.4	BLE profile definition.....	54
9.4.1	GATT sub-procedure	54
9.4.2	Configuration	54
9.4.3	PRU requirements	55
9.4.4	PTU requirements.....	56
9.4.5	Connection establishment.....	56
9.4.6	Security considerations.....	58
9.4.7	Charge completion.....	58
9.5	WPT service characteristics	59
9.5.1	WPT service characteristics introduction.....	59
9.5.2	PRU advertising payload	59
9.5.3	WPT service	61
9.5.4	PRU control.....	63
9.5.5	PTU static parameter	65
9.5.6	PRU static parameter characteristic.....	70
9.5.7	PRU dynamic parameter characteristic	73
9.5.8	PRU alert characteristic.....	77
9.6	Cross connection algorithm.....	79
9.6.1	Cross connection algorithm introduction	79
9.6.2	Definitions	79
9.6.3	Acceptance of advertisement.....	79
9.6.4	Impedance shift sensing	79
9.6.5	Reboot bit handling.....	80
9.6.6	Time set handling	80
9.7	Mode transition	81
9.7.1	Mode transition introduction.....	81
9.7.2	Mode transition procedure	81

9.7.3	BLE reconnection procedure.....	81
10	PTU resonators	84
10.1	PTU resonators introduction.....	84
10.2	Class <i>n</i> design template	84
10.2.1	Class <i>n</i> design template introduction.....	84
10.2.2	Table of specifications	84
10.2.3	PTU resonator structure	84
10.3	Approved PTU resonators	84
Annex A (informative)	Reference PRU for PTU acceptance testing	85
A.1	Category 1	85
A.2	Category 2	85
A.3	Category 3	85
A.3.1	PRU design 3-1	85
A.3.2	Geometry.....	85
A.4	Category 4	88
A.5	Category 5	88
Annex B (informative)	Lost power	89
B.1	Overview.....	89
B.2	General.....	89
B.3	Cross connection issues	89
B.4	Handoff issues	89
B.5	Power noise issues	90
B.6	PTU lost power calculation.....	90
B.6.1	Lost power detection threshold	90
B.6.2	Lost power detection speed	90
B.6.3	PTU lost power calculation	90
B.6.4	PTU power transmission detection accuracy	90
B.6.5	PRU lost power reports.....	91
B.6.6	Accuracy of reported power	91
B.6.7	Other PRU lost power reports	91
Annex C (normative)	User experience requirements	92
C.1	General.....	92
C.2	User indication.....	92
C.2.1	PRU user indication	92
C.2.2	PTU user indication	92
Annex D (informative)	RCE calculations.....	93
D.1	RCE calculation (using S-parameters)	93
D.2	RCE calculation (using Z-parameters).....	94
D.2.1	Series tuned case	95
D.2.2	Other RCE calculations.....	95
D.3	Conversion between S-parameters and Z-parameters	95
Figure 1	– Wireless power transfer system.....	18
Figure 2	– PTU-PRU resonator P_{TX_IN}	19
Figure 3	– PTU-PRU resonator P_{RX_OUT}	20
Figure 4	– Equivalent circuit and system parameters	21
Figure 5	– PTU resonator-load considerations	24

Figure 6 – PTU state model	27
Figure 7 – Beacon sequences	29
Figure 8 – Load variation detection	30
Figure 9 – Discovery	31
Figure 10 – PTU I_{TX} transition responses.....	32
Figure 11 – PRU state model	42
Figure 12 – V_{RECT} operating regions	43
Figure 13 – Basic architecture of WPT system	47
Figure 14 – Basic state procedure (informative)	48
Figure 15 – Registration period timeline example (informative)	53
Figure 16 – PTU/PRU services/characteristics communication.....	55
Figure 17 – PRU mode transition – Device Address field set to a non-zero value.....	82
Figure 18 – PRU mode transition – Device Address field set to all zeros.....	83
Figure A.1 – PRU design 3 block diagram	85
Figure A.2 – Front view	86
Figure A.3 – Back view	86
Figure A.4 – Side view	87
Figure A.5 – Front view, coil only	87
Figure A.6 – Side view, coil only	87
Table 1 – PTU classification.....	20
Table 2 – PRU category	20
Table 3 – Minimum RCE (percent and dB) between PRU and PTU.....	22
Table 4 – Maximum load capacitance	26
Table 5 – Time requirement to enter PTU Power Transfer state	28
Table 6 – Sub-state of PTU Power Transfer	32
Table 7 – PTU latching faults	38
Table 8 – Example of accuracy of reported current	42
Table 9 – PRU system errors	46
Table 10 – RF budget (informative).....	51
Table 11 – Timing constraints	53
Table 12 – BLE profile characteristics	54
Table 13 – GATT sub-procedure	54
Table 14 – PRU advertising payload	59
Table 15 – Impedance shift bit	61
Table 16 – WPT service UUID	61
Table 17 – WPT service	62
Table 18 – GAP service	63
Table 19 – GATT service	63
Table 20 – PRU Control Characteristic.....	64
Table 21 – Detail: bit field for enables	64
Table 22 – Detail: bit field for permission	65
Table 23 – Detail: bit field for time set.....	65

Table 24 – PTU reporting static values to PRU 66

Table 25 – Detail: bit field for optional fields validity..... 66

Table 26 – PTU power 67

Table 27 – Max source impedance..... 68

Table 28 – Max load resistance 69

Table 29 – AirFuel protocol revision field 70

Table 30 – PTU number of devices 70

Table 31 – PRU reporting static values to the PTU 71

Table 32 – Detail: bit field for optional fields validity..... 71

Table 33 – Detail: bit field for PRU information 72

Table 34 – PRU dynamic parameter characteristic 74

Table 35 – Detail: bit field for optional fields validity..... 74

Table 36 – Detail: bit field for PRU alert..... 76

Table 37 – Detail: bit field for PRU alert..... 77

Table 38 – Test mode commands 77

Table 39 – PRU alert fields 78

Table 40 – Detail: bit field for PRU alert notification 78

Table 41 – Mode transition..... 79

Table A.1 – PRU table of specifications 85

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**WIRELESS POWER TRANSFER – AIRFUEL ALLIANCE RESONANT
BASELINE SYSTEM SPECIFICATION (BSS)**

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 63028 has been prepared by technical area 15: Wireless power transfer, of IEC technical committee 100: Audio, video and multimedia systems and equipment.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
100/2901/FDIS	100/2941/RVD

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

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://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.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

In today's world, mainstream consumer mobile devices are ubiquitously supported by wireless technologies for data communication and connectivity functions while charging function is primarily supported by wired technologies. The development of wireless power transfer technologies offers increased user convenience for charging mobile devices; technologies include inductive, resonant, uncoupled (RF, ultrasonic, laser) methods.

IEC 63028 defines a specific wireless charging approach based on resonant technology and specifies technical requirements for the AirFuel™¹ resonant wireless power transfer (WPT) systems.

¹ AirFuel™ is the trade name of a product supplied by AirFuel Alliance. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the product named.

WIRELESS POWER TRANSFER – AIRFUEL ALLIANCE RESONANT BASELINE SYSTEM SPECIFICATION (BSS)

1 Scope

This document defines technical requirements, behaviors and interfaces used for ensuring interoperability for flexibly coupled wireless power transfer (WPT) systems for AirFuel Resonant WPT. This document is based on AirFuel Wireless Power Transfer System Baseline System Specification (BSS) v1.3.

Products implementing this document are expected to follow applicable regulations and global standards.

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.

AirFuel Wireless Power Transfer System Baseline System Specification (BSS) v1.3 [viewed 2017-03-13]. Available at: <http://www.airfuel.org/technologies/specification-download>

AirFuel Wireless Power Transfer System Baseline System Specification (BSS) v1.2.1 [viewed 2017-03-13]. Available at: <http://www.airfuel.org/technologies/specification-download>

Bluetooth core specification v4.0, or later versions as they are available [viewed 2017-03-13]. Available at: https://www.bluetooth.org/docman/handlers/downloaddoc.ashx?doc_id=229737

CSA4, or later versions as they are available [viewed 2017-03-13]. Available at: https://www.bluetooth.org/docman/handlers/DownloadDoc.ashx?doc_id=269452

3 Terms, definitions, symbols and abbreviated terms

3.1 Terms and definitions

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

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

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

3.1.1

advertisement

connectable, undirected advertising event where the device transmits three WPT service specific ADV_IND packets and accepts both scan requests and connect requests

Note 1 to entry: There is one ADV_IND packet transmitted on each of the advertising channels.

Note 2 to entry: Receipt of an advertisement is defined to be receipt of one of the three advertisement packets.