

REDLINE VERSION



Industrial communication networks – High availability automation networks – Part 3: Parallel Redundancy Protocol (PRP) and High-availability Seamless Redundancy (HSR)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**INDUSTRIAL COMMUNICATION NETWORKS –
HIGH AVAILABILITY AUTOMATION NETWORKS –****Part 3: Parallel Redundancy Protocol (PRP) and
High-availability Seamless Redundancy (HSR)****FOREWORD**

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This Redline version is not an official IEC Standard and is intended only to provide the user with an indication of what changes have been made to the previous version. Only the current version of the standard is to be considered the official document.

This Redline version provides you with a quick and easy way to compare all the changes between this standard and its previous edition. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

International Standard IEC 62439-3 has been prepared by subcommittee 65C: Industrial networks, of IEC technical committee 65: Industrial-process measurement, control and automation.

This third edition cancels and replaces the second edition published in 2012. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) technical corrections and extension of specifications;
- b) consideration of IEC 61588 clock synchronization with end-to-end delay measurement alongside the existing peer-to-peer delay measurement in PRP.

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

FDIS	Report on voting
65C/834/FDIS	65C/841/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.

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

This International Standard is to be read in conjunction with IEC 62439-1.

A list of all parts in the IEC 62439 series, published under the general title *Industrial communication networks – High availability automation networks*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication 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 publication using a colour printer.

INTRODUCTION

0.1 General

IEC 62439-3 belongs to the IEC 62439 series “*Industrial communication networks – High availability automation networks*”. It specifies the PRP and HSR **seamless** redundancy protocols. It was adopted by IEC TC57 WG10 as the redundancy method for demanding substation automation networks ~~based on IEC 61850 series, introducing new requirements operating on layer 2 networks, according to IEC 61850-8-1 and IEC 61850-9-2.~~

The **seamless** redundancy principle has been extended to clocks operating according to the Precision Time Protocol (IEC 61588) and attached to redundant networks. Two variants are specified: L3E2E for clocks which operate on layer 3 networks with end-to-end link delay measurement (E2E) and L2P2P for clocks that operate on layer 2 with peer-to-peer link delay measurement (P2P).

0.2 Changes with respect to the previous edition

~~The major changes with respect to IEC 62439-3:2010 are listed below.~~

~~Aligning the sequence number between PRP and HSR, to enable coupling of HSR and PRP networks and simplify the implementation of dual-mode nodes in hardware. At the same time, introduce a suffix in the PRP Redundancy Control Trailer to allow better identification, future extensions and coexistence with other protocols that also happen to use a trailer. This change is not backwards compatible, so means are provided to identify the version and ensure that the networks are homogeneous.~~

~~Removing all implementation restrictions on the Duplicate Discard algorithm (especially references to the drop window algorithm and references to connection orientation) since other methods such as hash tables can be used.~~

~~Removing the purging of the duplicate table. Replace this specific method by requiring that any Duplicate Discard algorithm provides a mechanism to remove old entries, thus ensuring that a node can properly reboot.~~

~~Making node tables optional for simple nodes to simplify hardware implementation.~~

~~Suppression of explicit mention of the HSR-PRP mode (PRP with HSR Tags), but allow it through the Mode N (no forwarding).~~

~~Introducing Mode T (forward through) to allow maintenance laptops to configure an open ring when attached to one end and Mode M (mixed) to allow forwarding of non-HSR tagged frames in a closed ring.~~

~~Recommending the position of connectors, rather than impose it.~~

~~Defining the behaviour of an HSR node when non-HSR frames are encountered without requiring the recording of the source addresses and specify how IEEE 802.1D:2004, Table 7-10 frames are treated.~~

~~Prefixing the supervision frames on HSR by an HSR tag to simplify the hardware implementation and introduce a unique EtherType for HSR to simplify processing.~~

~~Changing the rule for the RedBox to allow more than one PRP network to be connected to an HSR ring, and introduce an identifier per RedBox pair.~~

~~Specifying tagging of IEC 61588 frames to follow IEEE C37.238 recommendations (informal).~~

~~Suppressing MAC address substitution.~~

~~Adapting the MIB to above changes.~~

The major changes with respect to IEC 62439-3:2012 are:

- Subclause 4.1.10.3 has been rewritten to explain the calculation of the duplicate rejection for different speeds.
- Annex A has been redrafted as a general concept for doubly attached clocks applicable to end-to-end (E2E) and to peer-to-peer (P2P) link delay measurement; the principle of paired port operation has now been specified in terms of a state machine based on IEC 61588:2009.
- Annex B of IEC 62439-3:2012 has been deleted; its properties are mentioned in 5.3.7.
- Annex B (new) makes the support of redundancy mandatory for IEC/IEEE 61850-9-3 that specifies doubly attached clocks on layer 2, with peer-to-peer delay measurement.
- Annex C specifies two profiles of a precision clock for industrial automation: L3E2E for layer 3, end-to-end delay measurement and L2P2P for layer 2, peer-to-peer delay measurement.
- Annex D contains the tutorial information on IEC 61588:2009 for understanding the above annexes. It was contained in IEC 62439-3:2012 Annex A.
- Annex E (MIB) contains the SNMP Management Information Base to be used for singly and doubly attached clocks in all profiles.

0.3 Patent declaration

The International Electrotechnical Commission (IEC) draws attention to the fact that it is claimed that compliance with this document may involve the use of patents concerning filtering of redundant frames in a network node (Siemens Aktiengesellschaft – EP 2127329, US 8184650, CN 101611615B) given in 5.2.3.3.

IEC takes no position concerning the evidence, validity and scope of this patent right.

The holder of this patent right has assured the IEC that he/she is willing to negotiate licences under reasonable and non-discriminatory terms and conditions with applicants throughout the world. In this respect, the statement of the holder of this patent right is registered with IEC. Information may be obtained from:

Siemens Aktiengesellschaft
Oto-Hahn-Ring 6
81379 Munich, Germany

The International Electrotechnical Commission (IEC) draws attention to the fact that it is claimed that compliance with this document may involve the use of a patent concerning Reception of redundant and non-redundant frames (ABB ~~Schweiz AG – WO 2006/053459 A1~~ Research Ltd – EP 1825657, US ~~20070223533~~ 8582426, CN 101057483, IN 254425) given in 4.2.7, concerning Identifying improper cabling of devices (ABB ~~Schweiz Technology AG – EP 2-015-501 A1~~ 2163024, US 8344736, CN 101689985) given in 4.3, concerning Critical device with increased availability (ABB ~~Schweiz AG Research Ltd – EP 2090950 A1~~) given in 4.4, concerning Ring coupling nodes for high availability networks (ABB ~~Schweiz AG Research Ltd – WO 2010/010120 A1~~ US 8582424, EP 2327185, CN 102106121) given in 5.2.3.

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ABB Schweiz AG
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ISO (www.iso.org/patents) and IEC (<http://patents.iec.ch>) maintain on-line data bases of patents relevant to their standards. Users are encouraged to consult the data bases for the most up to date information concerning patents.

INDUSTRIAL COMMUNICATION NETWORKS – HIGH AVAILABILITY AUTOMATION NETWORKS –

Part 3: Parallel Redundancy Protocol (PRP) and High-availability Seamless Redundancy (HSR)

1 Scope

The IEC 62439 series is applicable to high-availability automation networks based on the ~~ISO/IEC 8802-3~~ Ethernet technology.

This part of IEC 62439 specifies two redundancy protocols designed to provide seamless recovery in case of single failure of an inter-bridge link or bridge in the network, which are based on the same scheme: ~~duplication of the LAN, resp. duplication of the transmitted~~ parallel transmission of duplicated information.

2 Normative references

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

IEC 60050-191, *International Electrotechnical Vocabulary – Chapter 191: Dependability and quality of service*

IEC 61588:2009, *Precision clock synchronization protocol for networked measurement and control systems*

IEC TR 61850-90-4:2013, *Communication networks and systems for power utility automation – Part 90-4: Network engineering guidelines*

IEC 62439-1, *Industrial communication networks – High availability automation networks – Part 1: General concepts and calculation methods*

~~IEC 62439-2, *Industrial Communication networks – High availability automation networks – Part 2: Media Redundancy Protocol (MRP)*~~

~~IEC 62439-6, *Industrial communication networks – High availability automation networks – Part 6: Distributed Redundancy Protocol (DRP)*~~

~~IEC 62439-7, *Industrial communication networks – High availability automation networks – Part 7: Ring-based Redundancy Protocol (RRP)*~~

IEC/IEEE 61850-9-3:—, *Communication networks and systems for power utility automation - Part 9-3: Precision time protocol profile for power utility automation (proposed IEC 61850-9-3)*¹

¹ To be published.

~~ISO/IEC 8802-3:2000, Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications~~

ISO/IEC/IEEE 8802-3:2014, *Standard for Ethernet*

IEEE 802.1D:2004, *IEEE Standard for Local and metropolitan area networks – Media Access Control (MAC) Bridges*

IEEE 802.1Q:2011 2014, *IEEE Standard for Local and metropolitan area networks – Media Access Control (MAC) Bridges and Virtual Bridge Local Area Network*

IETF RFC 2578, *Structure of Management Information Version 2 (SMIv2)*

IETF RFC 3418, *Management Information Base (MIB) for the Simple Network Management Protocol (SNMP)*

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Industrial communication networks – High availability automation networks –
Part 3: Parallel Redundancy Protocol (PRP) and High-availability Seamless
Redundancy (HSR)**

**Réseaux de communication industriels – Réseaux d'automatisme à haute
disponibilité –**

**Partie 3: Protocole de redondance en parallèle (PRP) et redondance transparente
de haute disponibilité (HSR)**

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**INDUSTRIAL COMMUNICATION NETWORKS –
HIGH AVAILABILITY AUTOMATION NETWORKS –****Part 3: Parallel Redundancy Protocol (PRP) and
High-availability Seamless Redundancy (HSR)****FOREWORD**

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International Standard IEC 62439-3 has been prepared by subcommittee 65C: Industrial networks, of IEC technical committee 65: Industrial-process measurement, control and automation.

This third edition cancels and replaces the second edition published in 2012. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) technical corrections and extension of specifications;
- b) consideration of IEC 61588 clock synchronization with end-to-end delay measurement alongside the existing peer-to-peer delay measurement in PRP.

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

FDIS	Report on voting
65C/834/FDIS	65C/841/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.

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

This International Standard is to be read in conjunction with IEC 62439-1.

A list of all parts in the IEC 62439 series, published under the general title *Industrial communication networks – High availability automation networks*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication 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 publication using a colour printer.

INTRODUCTION

0.1 General

IEC 62439-3 belongs to the IEC 62439 series “*Industrial communication networks – High availability automation networks*”. It specifies the PRP and HSR seamless redundancy protocols. It was adopted by IEC TC57 WG10 as the redundancy method for demanding substation automation networks operating on layer 2 networks, according to IEC 61850-8-1 and IEC 61850-9-2.

The seamless redundancy principle has been extended to clocks operating according to the Precision Time Protocol (IEC 61588) and attached to redundant networks. Two variants are specified: L3E2E for clocks which operate on layer 3 networks with end-to-end link delay measurement (E2E) and L2P2P for clocks that operate on layer 2 with peer-to-peer link delay measurement (P2P).

0.2 Changes with respect to the previous edition

The major changes with respect to IEC 62439-3:2012 are:

- Subclause 4.1.10.3 has been rewritten to explain the calculation of the duplicate rejection for different speeds.
- Annex A has been redrafted as a general concept for doubly attached clocks applicable to end-to-end (E2E) and to peer-to-peer (P2P) link delay measurement; the principle of paired port operation has now been specified in terms of a state machine based on IEC 61588:2009.
- Annex B of IEC 62439-3:2012 has been deleted; its properties are mentioned in 5.3.7.
- Annex B (new) makes the support of redundancy mandatory for IEC/IEEE 61850-9-3 that specifies doubly attached clocks on layer 2, with peer-to-peer delay measurement.
- Annex C specifies two profiles of a precision clock for industrial automation: L3E2E for layer 3, end-to-end delay measurement and L2P2P for layer 2, peer-to-peer delay measurement.
- Annex D contains the tutorial information on IEC 61588:2009 for understanding the above annexes. It was contained in IEC 62439-3:2012 Annex A.
- Annex E (MIB) contains the SNMP Management Information Base to be used for singly and doubly attached clocks in all profiles.

0.3 Patent declaration

The International Electrotechnical Commission (IEC) draws attention to the fact that it is claimed that compliance with this document may involve the use of a patent concerning filtering of redundant frames in a network node (Siemens Aktiengesellschaft – EP 2127329, US 8184650, CN 101611615B) given in 5.2.3.3.

IEC takes no position concerning the evidence, validity and scope of this patent right.

The holder of this patent right has assured the IEC that he/she is willing to negotiate licences under reasonable and non-discriminatory terms and conditions with applicants throughout the world. In this respect, the statement of the holder of this patent right is registered with IEC. Information may be obtained from:

Siemens Aktiengesellschaft
Oto-Hahn-Ring 6
81379 Munich, Germany

The International Electrotechnical Commission (IEC) draws attention to the fact that it is claimed that compliance with this document may involve the use of patents concerning

Reception of redundant and non-redundant frames (ABB Research Ltd – EP 1825657, US 8582426, CN 101057483, IN 254425) given in 4.2.7, concerning Identifying improper cabling of devices (ABB Technology AG – EP 2163024, US 8344736, CN 101689985) given in 4.3, concerning Critical device with increased availability (ABB Research Ltd – EP 2090950) given in 4.4, concerning Ring coupling nodes for high availability networks (ABB Research Ltd – US 8582424, EP 2327185, CN 102106121) given in 5.2.3.

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INDUSTRIAL COMMUNICATION NETWORKS – HIGH AVAILABILITY AUTOMATION NETWORKS –

Part 3: Parallel Redundancy Protocol (PRP) and High-availability Seamless Redundancy (HSR)

1 Scope

The IEC 62439 series is applicable to high-availability automation networks based on the Ethernet technology.

This part of IEC 62439 specifies two redundancy protocols designed to provide seamless recovery in case of single failure of an inter-bridge link or bridge in the network, which are based on the same scheme: parallel transmission of duplicated information.

2 Normative references

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

IEC 60050-191, *International Electrotechnical Vocabulary – Chapter 191: Dependability and quality of service*

IEC 61588:2009, *Precision clock synchronization protocol for networked measurement and control systems*

IEC TR 61850-90-4:2013, *Communication networks and systems for power utility automation – Part 90-4: Network engineering guidelines*

IEC 62439-1, *Industrial communication networks – High availability automation networks – Part 1: General concepts and calculation methods*

IEC/IEEE 61850-9-3:—, *Communication networks and systems for power utility automation - Part 9-3: Precision time protocol profile for power utility automation (proposed IEC 61850-9-3)*¹

ISO/IEC/IEEE 8802-3:2014, *Standard for Ethernet*

IEEE 802.1D:2004, *IEEE Standard for Local and metropolitan area networks – Media Access Control (MAC) Bridges*

IEEE 802.1Q:2014, *IEEE Standard for Local and metropolitan area networks – Media Access Control (MAC) Bridges and Virtual Bridge Local Area Network*

IETF RFC 2578, *Structure of Management Information Version 2 (SMIv2)*

¹ To be published.

IETF RFC 3418, *Management Information Base (MIB) for the Simple Network Management Protocol (SNMP)*

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COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

RÉSEAUX DE COMMUNICATION INDUSTRIELS – RÉSEAUX D'AUTOMATISME A HAUTE DISPONIBILITE –

Partie 3: Protocole de redondance en parallèle (PRP) et redondance transparente de haute disponibilité (HSR)

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La Norme internationale IEC 62439-3 a été établie par le sous-comité 65C: Réseaux industriels, du comité d'études 65 de l'IEC: Mesure, commande et automation dans les processus industriels.

Cette troisième édition annule et remplace la deuxième édition parue en 2012. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

- a) corrections techniques et extension des spécifications;
- b) prise en compte de la synchronisation des horloges selon l'IEC 61588 lors de la mesure du délai entre extrémités et la mesure existante du délai entre homologues dans le protocole PRP.

Le texte de cette norme est issu des documents suivants:

FDIS	Rapport de vote
65C/834/FDIS	65C/841/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette norme.

Cette publication a été rédigée selon les Directives ISO/IEC, Partie 2.

Cette Norme internationale doit être lue conjointement avec l'IEC 62439-1.

Une liste de toutes les parties de la série IEC 62439, publiées sous le titre général *Réseaux industriels de communication – Réseaux d'automatisme à haute disponibilité*, peut être consultée sur le site web de l'IEC.

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- reconduite,
- supprimée,
- remplacée par une édition révisée, ou
- amendée.

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INTRODUCTION

0.1 Généralités

L'IEC 62439-3 fait partie de la série IEC 62439 *Réseaux industriels de communication – Réseaux d'automatisme à haute disponibilité*. Elle spécifie les protocoles de redondance transparente PRP et HSR. Elle a été adoptée par l'IEC TC57 WG10 pour servir de méthode de redondance pour les réseaux d'automatisme de la sous-station demandeuse qui fonctionne sur des réseaux de couche 2, conformément à l'IEC 61850-8-1 et à l'IEC 61850-9-2.

Le principe de redondance transparente a été étendu aux horloges qui fonctionnent conformément au protocole PTP (Precision Time Protocol), comme défini dans l'IEC 61588 et associé aux réseaux redondants. Deux variantes sont spécifiées: L3E2E pour les horloges qui fonctionnent sur des réseaux de couche 3 avec une mesure du retard de ligne entre extrémités (E2E) et L2P2P pour les horloges qui fonctionnent sur des réseaux de couche 2 avec une mesure du retard de ligne entre homologues (P2P).

0.2 Modifications par rapport à l'édition précédente

Les principales modifications par rapport à l'IEC 62439-3:2012 sont:

- Le paragraphe 4.1.10.3 a été réécrit pour expliquer la façon de calculer le rejet des doublons pour différentes vitesses.
- L'Annexe A a été revue pour servir de conception générale pour des horloges à double association utilisables pour une mesure du retard de ligne entre extrémités (E2E) et entre homologues (P2P); le principe du fonctionnement de ports couplés a été désormais spécifié en termes de diagramme d'états basés sur l'IEC 61588:2009.
- L'Annexe B de l'IEC 62439-3:2012 a été supprimée; ses propriétés sont mentionnées en 5.3.7.
- La nouvelle Annexe B rend obligatoire la prise en charge de la redondance pour l'IEC/IEEE 61850-9-3 qui spécifie les horloges à double association sur la couche 2 avec une mesure du retard de ligne entre homologues.
- L'Annexe C spécifie deux profils d'une horloge de précision pour l'automatisation industrielle:
L3E2E pour la couche 3, mesure du retard entre extrémités et
L2P2P pour la couche 2, mesure du retard entre homologues.
- L'Annexe D contient les informations de tutoriel relatives à l'IEC 61588:2009 qui sont nécessaires pour comprendre les annexes ci-dessus. Ces informations se trouvaient à l'Annexe A de l'IEC 62439-3:2012.
- L'Annexe E (MIB) comprend la base d'informations de gestion SNMP à utiliser pour des horloges à une seule association et à double association, quel que soit le profil.

0.3 Déclaration de brevet

La Commission Electrotechnique Internationale (IEC) attire l'attention sur le fait qu'il est déclaré que la conformité avec les dispositions du présent document peut impliquer l'utilisation d'un brevet intéressant le filtrage de trames redondantes dans le nœud d'un réseau (Siemens Aktiengesellschaft – EP 2127329, US 8184650, CN 101611615B) traité en 5.2.3.3.

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Siemens Aktiengesellschaft
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81379 Munich, Allemagne

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RÉSEAUX DE COMMUNICATION INDUSTRIELS – RÉSEAUX D'AUTOMATISME A HAUTE DISPONIBILITE –

Partie 3: Protocole de redondance en parallèle (PRP) et Redondance transparente haute disponibilité (HSR)

1 Domaine d'application

La série IEC 62439 s'applique aux réseaux d'automatisme à haute disponibilité basés sur la technologie Ethernet.

Cette partie de l'IEC 62439 spécifie deux protocoles de redondance conçus pour assurer une reprise transparente en cas de défaillance unique de liaison interpont ou de pont au sein du réseau, basés sur le schéma: transmission en parallèle d'informations dupliquées.

2 Références normatives

Les documents suivants sont cités en référence de manière normative, en intégralité ou en partie, dans le présent document et sont indispensables pour son application. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60050-191, *Vocabulaire Electrotechnique International – Chapitre 191: Sécurité de fonctionnement et qualité de service*

IEC 61588:2009, *Precision clock synchronization protocol for networked measurement and control systems* (disponible en anglais seulement)

IEC TR 61850-90-4, *Communication networks and systems for power utility automation – Part 90-4: Network engineering guidelines* (disponible en anglais seulement)

IEC 62439-1, *Réseaux industriels de communication – Réseaux d'automatisme à haute disponibilité – Partie 1: Concepts généraux et méthodes de calcul*

IEC/IEEE 61850-9-3:—, *Communication networks and systems for power utility automation - Part 9-3: Precision time protocol profile for power utility automation (proposed IEC 61850-9-3)*, (disponible en anglais seulement)¹

ISO/IEC/IEEE 8802-3:2014, *Standard for Ethernet* (disponible en anglais seulement)

IEEE 802.1D:2004, *IEEE Standard for Local and metropolitan area networks – Media Access Control (MAC) Bridges* (disponible en anglais seulement)

IEEE 802.1Q:2014, *IEEE Standard for Local and metropolitan area networks – Media Access Control (MAC) Bridges and Virtual Bridge Local Area Network* (disponible en anglais seulement)

¹ A paraître.

IETF RFC 2578, *Structure of Management Information Version 2 (SMIv2)* (disponible en anglais seulement)

IETF RFC 3418, *Management Information Base (MIB) for the Simple Network Management Protocol (SNMP)* (disponible en anglais seulement)