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

This document is a preview generated by EVS

EESTI STANDARDIKESKUS
ESTONIAN CENTRE FOR STANDARDISATION

## EESTI STANDARDI EESSÕNA

## NATIONAL FOREWORD

| | |
|---|---|
| See Eesti standard EVS-EN 62439-3:2012 sisaldab Euroopa standardi EN 62439-3:2012 ingliskeelset teksti. | This Estonian standard EVS-EN 62439-3:2012 consists of the English text of the European standard EN 62439-3:2012. |
| Standard on jõustunud sellekohase teate avaldamisega EVS Teatajas. | This standard has been endorsed with a notification published in the official bulletin of the Estonian Centre for Standardisation. |
| Euroopa standardimisorganisatsioonid on teinud Euroopa standardi rahvuslikele liikmetele kättesaadavaks 21.09.2012. | Date of Availability of the European standard is 21.09.2012. |
| Standard on kättesaadav Eesti Standardikeskusest. | The standard is available from the Estonian Centre for Standardisation. |

This document is a preview generated by EVS

Tagasisidet standardi sisu kohta on võimalik edastada, kasutades EVS-i veebilehel asuvat tagasiside vormi või saates e-kirja meiliaadressile standardiosakond@evs.ee.

ICS 25.040, 35.040

**Standardite reprodutseerimise ja levitamise õigus kuulub Eesti Standardikeskusele**

Andmete paljundamine, taastekitamine, kopeerimine, salvestamine elektroonsesse süsteemi või edastamine ükskõik millises vormis või millisel teel ilma Eesti Standardikeskuse kirjaliku loata on keelatud.

Kui Teil on küsimusi standardite autorikaitse kohta, võtke palun ühendust Eesti Standardikeskusega:
Aru 10, 10317 Tallinn, Eesti; www.evs.ee; telefon 605 5050; e-post info@evs.ee

**The right to reproduce and distribute standards belongs to the Estonian Centre for Standardisation**

No part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying, without a written permission from the Estonian Centre for Standardisation.

If you have any questions about copyright, please contact Estonian Centre for Standardisation:
Aru 10, 10317 Tallinn, Estonia; www.evs.ee; phone 605 5050; e-mail info@evs.ee

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

# EN 62439-3

September 2012

ICS 25.040; 35.040

Supersedes EN 62439-3:2010

English version

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

(IEC 62439-3:2012)

Réseaux industriels de communication - Réseaux d'automatisme à haute disponibilité - Partie 3 : Protocole de redondance parallèle (PRP) et redondance transparente de haute disponibilité (HSR)
(CEI 62439-3:2012)

Industrielle Kommunikationsnetze - Hochverfügbare Automatisierungsnetze - Teil 3: Parallelredundanz-Protokoll (PRP) und nahtloser Hochverfügbarkeits-Ring (HSR)
(IEC 62439-3:2012)

This European Standard was approved by CENELEC on 2012-08-09. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

CENELEC

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

**Management Centre: Avenue Marnix 17, B - 1000 Brussels**

© 2012 CENELEC - All rights of exploitation in any form and by any means reserved worldwide for CENELEC members.

Ref. No. EN 62439-3:2012 E

This document is a preview generated by EVS

## Foreword

The text of document 65C/687/FDIS, future edition 2 of IEC 62439-3, prepared by SC 65C, "Industrial networks", of IEC TC 65, "Industrial-process measurement, control and automation" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 62439-3:2012.

The following dates are fixed:

| | | |
|---|---|---|
| • latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement | (dop) | 2013-05-09 |
| • latest date by which the national standards conflicting with the document have to be withdrawn | (dow) | 2015-08-09 |

This document supersedes EN 62439-3:2010.

EN 62439-3:2012 includes the following significant technical changes with respect to EN 62439-3:2010:

– specification of the interconnection of PRP and HSR networks;

– introduction of a suffix for PRP frames;

– clarification and modification of specifications to ensure interoperability;

– slackening of the specifications to allow different implementations;

– consideration of clock synchronization according to IEC 61588;

– introduction of test modes to simplify testing and maintenance.

This standard is to be used in conjunction with EN 62439-1:2010.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

## Endorsement notice

The text of the International Standard IEC 62439-3:2012 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following note has to be added for the standard indicated:

IEC 61580 series NOTE Harmonized in EN 61580 series (not modified).

This document is a preview generated by EVS

# Annex ZA
(normative)

## Normative references to international publications with their corresponding European publications

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.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

| Publication | Year | Title | EN/HD | Year |
|---|---|---|---|---|
| IEC 60050-191 | - | International Electrotechnical Vocabulary (IEV) - Chapter 191: Dependability and quality of service | - | - |
| IEC 61588 | - | Precision clock synchronization protocol for networked measurement and control systems | - | - |
| IEC 62439-1 | - | Industrial communication networks - High availability automation networks - Part 1: General concepts and calculation methods | EN 62439-1 | - |
| IEC 62439-2 | - | Industrial communication networks - High availability automation networks - Part 2: Media Redundancy Protocol (MRP) | EN 62439-2 | - |
| IEC 62439-6 | - | Industrial communication networks - High availability automation networks - Part 6: Distributed Redundancy Protocol (DRP) | EN 62439-6 | - |
| IEC 62439-7 | - | Industrial communication networks - High availability automation networks - Part 7: Ring-based Redundancy Protocol (RRP) | EN 62439-7 | - |
| 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 | - | - |
| IEEE 802.1D | 2004 | IEEE Standard for Local and Metropolitan Area Networks - Media Access Control (MAC) Bridges | - | - |
| IEEE 802.1Q | 2011 | IEEE Standard for Local and Metropolitan Area Networks - Virtual Bridged Local Area Networks | - | - |

This document is a preview generated by EVS

# CONTENTS

FOREWORD ..... 5
0 INTRODUCTION ..... 7
0.1 General ..... 7
0.2 Changes with respect to the previous edition ..... 7
0.3 Patent declaration ..... 8
1 Scope ..... 9
2 Normative references ..... 9
3 Terms, definitions, abbreviations, acronyms, and conventions ..... 10
3.1 Terms and definitions ..... 10
3.2 Abbreviations and acronyms ..... 10
3.3 Conventions ..... 10
4 Parallel Redundancy Protocol (PRP) ..... 10
4.1 PRP principle of operation ..... 10
4.1.1 PRP network topology ..... 10
4.1.2 PRP LANs with linear or bus topology ..... 11
4.1.3 PRP LANs with ring topology ..... 12
4.1.4 DANP node structure ..... 12
4.1.5 PRP attachment of singly attached nodes ..... 13
4.1.6 Compatibility between singly and doubly attached nodes ..... 14
4.1.7 Network management ..... 14
4.1.8 Implication on configuration ..... 14
4.1.9 Transition to non-redundant networks ..... 14
4.1.10 Duplicate handling ..... 15
4.1.11 Network supervision ..... 19
4.1.12 Redundancy management interface ..... 19
4.2 PRP protocol specifications ..... 19
4.2.1 Installation, configuration and repair guidelines ..... 19
4.2.2 MAC addresses ..... 20
4.2.3 Multicast MAC addresses ..... 20
4.2.4 IP addresses ..... 20
4.2.5 Nodes ..... 20
4.2.6 Duplicate Accept mode (testing only) ..... 21
4.2.7 Duplicate Discard mode ..... 21
4.3 PRP_Supervision frame ..... 24
4.3.1 Supervision frame for DANP ..... 24
4.3.2 PRP_Supervision frame contents ..... 27
4.3.3 PRP_Supervision frame for RedBox ..... 27
4.3.4 Reception of a PRP_Supervision frame and NodesTable ..... 27
4.4 Bridging node ..... 28
4.5 Constants ..... 28
4.6 PRP service specification ..... 28
5 High-availability Seamless Redundancy (HSR) ..... 28
5.1 HSR objectives ..... 28
5.2 HSR principle of operation ..... 29
5.2.1 Basic operation with a ring topology ..... 29
5.2.2 DANH node structure ..... 30

This document is a preview generated by EVS

5.2.3 Topology ..... 31
5.2.4 RedBox structure ..... 39
5.3 HSR node specifications ..... 41
5.3.1 HSR operation ..... 41
5.3.2 DANH receiving from its link layer interface ..... 41
5.3.3 DANH receiving from an HSR port ..... 42
5.3.4 DANH forwarding rules ..... 43
5.3.5 CoS ..... 43
5.3.6 Clock synchronization ..... 43
5.3.7 Deterministic medium access ..... 44
5.4 HSR RedBox specifications ..... 44
5.4.1 RedBox properties ..... 44
5.4.2 RedBox receiving from interlink ..... 44
5.4.3 RedBox forwarding on the ring ..... 46
5.4.4 RedBox receiving from an HSR port ..... 46
5.4.5 RedBox receiving from its link layer interface ..... 47
5.4.6 Redbox ProxyNodeTable handling ..... 47
5.4.7 RedBox CoS ..... 48
5.4.8 RedBox clock synchronization ..... 48
5.4.9 RedBox medium access ..... 48
5.5 QuadBox specification ..... 48
5.6 Duplicate Discard method ..... 48
5.7 Frame format for HSR ..... 48
5.7.1 Frame format for all frames ..... 48
5.7.2 HSR_Supervision frame ..... 50
5.8 Constants ..... 52
5.9 HSR service specification ..... 53
6 Protocol Implementation Conformance Statement (PICS) ..... 54
7 PRP/HSR Management Information Base (MIB) ..... 55
Annex A (normative) Use of IEC 61588 and IEEE C37.238 for IEC 62439-3 ..... 69
Annex B (informative) Deterministic medium access in HSR ..... 83
Bibliography ..... 84

Figure 1 – PRP example of general redundant network ..... 11
Figure 2 – PRP example of redundant network as two LANs (bus topology) ..... 12
Figure 3 – PRP example of redundant ring with SANs and DANPs ..... 12
Figure 4 – PRP with two DANPs communicating ..... 13
Figure 5 – PRP RedBox, transition from single to double LAN ..... 15
Figure 6 – PRP frame extended by an RCT ..... 16
Figure 7 – PRP VLAN-tagged frame extended by an RCT ..... 17
Figure 8 – PRP padded frame closed by an RCT ..... 17
Figure 9 – Duplicate Discard algorithm boundaries ..... 18
Figure 10 – HSR example of ring configuration for multicast traffic ..... 29
Figure 11 – HSR example of ring configuration for unicast traffic ..... 30
Figure 12 – HSR structure of a DANH ..... 31
Figure 13 – HSR example of topology using two independent networks ..... 32

This document is a preview generated by EVS

Figure 14 – HSR example of peer coupling of two rings ..... 33
Figure 15 – HSR example of connected rings ..... 34
Figure 16 – HSR example of coupling two redundant PRP LANs to a ring ..... 35
Figure 17 – HSR example of coupling from a ring node to redundant PRP LANs ..... 36
Figure 18 – HSR example of coupling from a ring to two PRP LANs ..... 37
Figure 19 – HSR example of coupling three rings to one PRP LAN ..... 38
Figure 20 – HSR example of meshed topology ..... 39
Figure 21 – HSR structure of a RedBox ..... 40
Figure 22 – HSR frame without a VLAN tag ..... 49
Figure 23 – HSR frame with VLAN tag ..... 49
Figure 24 – HSR node with management counters ..... 53
Figure 25 – HSR RedBox with management counters ..... 54
Figure A.1 – PTP one-step clock synchronization and delay measurement ..... 71
Figure A.2 – PTP two-step clock synchronization and delay measurement ..... 72
Figure A.3 – Two-step and one-step transparent clocks translator ..... 73
Figure A.4 – Two-step to one-step translation ..... 73
Figure A.5 – Connection of a Grandmaster Clock to an Ordinary Clock over PRP ..... 74
Figure A.6 – HSR with one GMC ..... 76
Figure A.7 – PTP messages sent and received by an HSR node (one-step) ..... 77
Figure A.8 – PTP messages sent and received by an HSR node (two-step) ..... 78
Figure A.9 – Attachment of a GMC to an HSR ring through a RedBox ..... 80
Figure A.10 – PRP to HSR coupling by Transparent Clocks ..... 81
Figure A.11 – PRP to HSR coupling by BCs ..... 82

Table 1 – NodesTable attributes ..... 22
Table 2 – PRP_Supervision frame with no VLAN tag ..... 25
Table 3 – PRP_Supervision frame with (optional) VLAN tag ..... 26
Table 4 – PRP constants ..... 28
Table 5 – HSR_Supervision frame with no VLAN tag ..... 50
Table 6 – HSR_Supervision frame with optional VLAN tag ..... 51
Table 7 – HSR Constants ..... 52

This document is a preview generated by EVS

# 0 INTRODUCTION

## 0.1 General

IEC 62439-3 standard belongs to IEC 62439 series, *Industrial communication networks – High availability automation networks*, specifying the HSR and PRP redundancy protocols, and was adopted by TC57 WG10 as the redundancy method for demanding substation automation networks based on IEC 61850 series, introducing new requirements.

## 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.

This document is a preview generated by EVS

### 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 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

80333 München, 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, EP 1825657, US 20070223533, CN 101057483) given in 4.2.7, concerning Identifying improper cabling of devices (ABB Schweiz AG – EP 2 015 501 A1) given in 4.3, concerning Critical device with increased availability (ABB Schweiz AG – EP 2 090 950 A1) given in 4.4, concerning Ring coupling nodes for high availability networks (ABB Schweiz AG – WO 2010/010120 A1) given in 5.2.3.

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:

ABB Schweiz AG

Brown Boveri Strasse 6

5400 Baden, Switzerland

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights other than those identified above. IEC shall not be held responsible for identifying any or all such patent rights.

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.

This document is a preview generated by EVS

# INDUSTRIAL COMMUNICATION NETWORKS – HIGH AVAILABILITY AUTOMATION NETWORKS –

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

This document is a preview generated by EVS

## 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 the IEC 62439 series 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 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, *Precision clock synchronization protocol for networked measurement and control systems*

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)*

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*

IEEE 802.1D:2004, *IEEE Standard for Local and Metropolitan Area Networks – Media Access Control (MAC) Bridges*

IEEE 802.1Q:2011, *IEEE Standard for Local and Metropolitan Area Networks – Media Access Control (MAC) Bridges and Virtual Bridge Local Area Network*