IEC 62439-3

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

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

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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 second edition cancels and replaces the first edition published in 2010. This edition constitutes a technical revision. The main changes with respect to the previous edition are listed below:

– 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.

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

FDIS	Report on voting
65C/687/FDIS	65C/705/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 International Standard is to be read in conjunction with IEC 62439-1:2011.

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

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

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- withdrawn,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.

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.

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.

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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 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*

3 Terms, definitions, abbreviations, acronyms, and conventions

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-191, as well as in IEC 62439-1, as well as the following, apply.

3.1.1
interlink
link that connects two network hierarchies

3.1.2
RedBox
device attaching single attached nodes to a redundant network

3.1.3
QuadBox
quadruple port device connecting two peer HSR rings, which behaves as an HSR node in each ring and is able to filter the traffic and forward it from ring to ring

3.1.4
HSR frame
frame that carries as EtherType the HSR_ethertype

3.1.5
switching logic
hardware that transmits a frame from one port to another port, possibly providing cut-through

Note 1 to entry: In this document, the words "bridge" respectively "bridging" are synonymous to the words "switch", respectively "switching" when they apply to layer 2 connectivity.

3.2 Abbreviations and acronyms

For the purposes of this document, the abbreviations and acronyms given in IEC 62439-1, as well as the acronyms below, apply.

CoS Class of Service (layer 2 quality of service)

DANH Double attached node implementing HSR

DANP Double attached node implementing PRP

RCT Redundancy Check Trailer

VDAN Virtual Doubly Attached Node (SAN as visible through a RedBox)

3.3 Conventions

This part of the IEC 62439 series follows the conventions defined in IEC 62439-1.

4 Parallel Redundancy Protocol (PRP)

4.1 PRP principle of operation

4.1.1 PRP network topology

This redundancy protocol implements redundancy in the nodes rather than in the network, using doubly attached nodes obeying to PRP (DANPs).

A DANP is attached to two independent Local Area Networks (LANs) of similar topology, named LAN_A and LAN_B, which operate in parallel. A source DANP sends the same frame over both LANs and a destination DANP receives it from both LANs within a certain time, consumes the first frame and discards the duplicate.

Figure 1 shows a redundant network consisting of two LANs, each of which can have any topology, e.g. tree, ring or meshed.

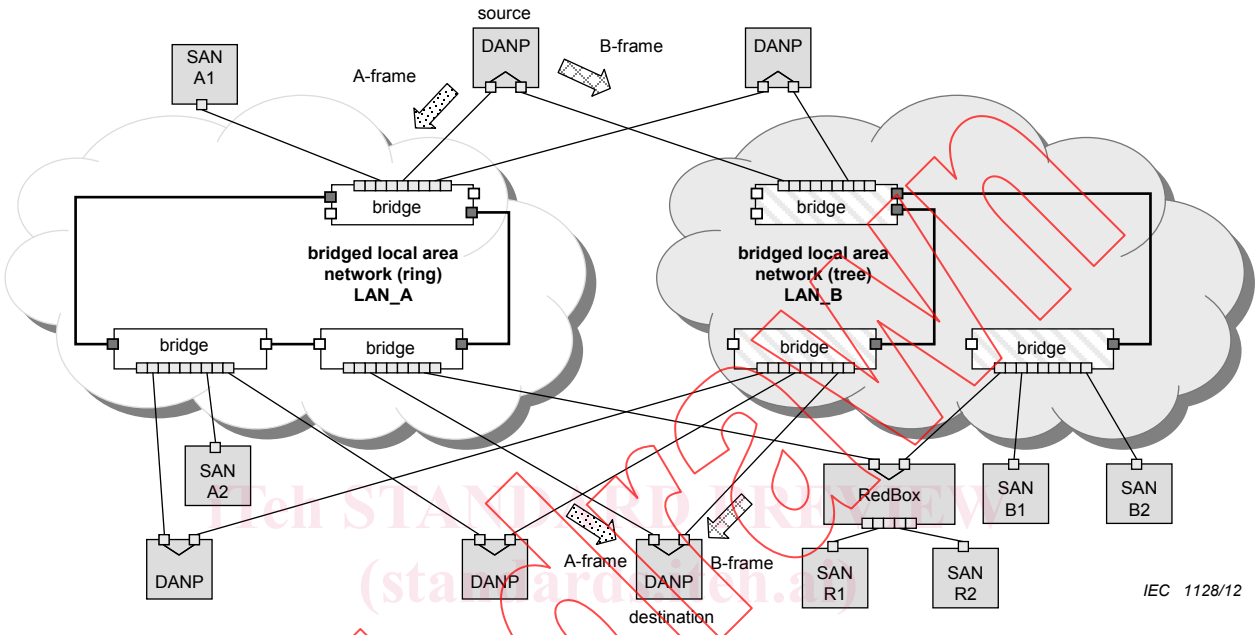

Figure 1 – PRP example of general redundant network

The two LANs are identical in protocol at the MAC-LLC level, but they can differ in performance and topology. Transmission delays may also be different, especially if one of the networks reconfigures itself, e.g. using RSTP, to overcome an internal failure.

The two LANs follow configuration rules that allow the network management protocols such as Address Resolution Protocol (ARP) and Simple Network Management Protocol (SNMP) to operate correctly.

The two LANs have no connection between them and are assumed to be fail-independent. Redundancy can be defeated by single points of failure, such as a common power supply or a direct connection whose failure brings both networks down. Installation guidelines in this document provide guidance to the installer to achieve fail-independence.

4.1.2 PRP LANs with linear or bus topology

As an example of a simpler topology, Figure 2 draws a PRP network as two LANs in linear topology, which may also be a bus topology.

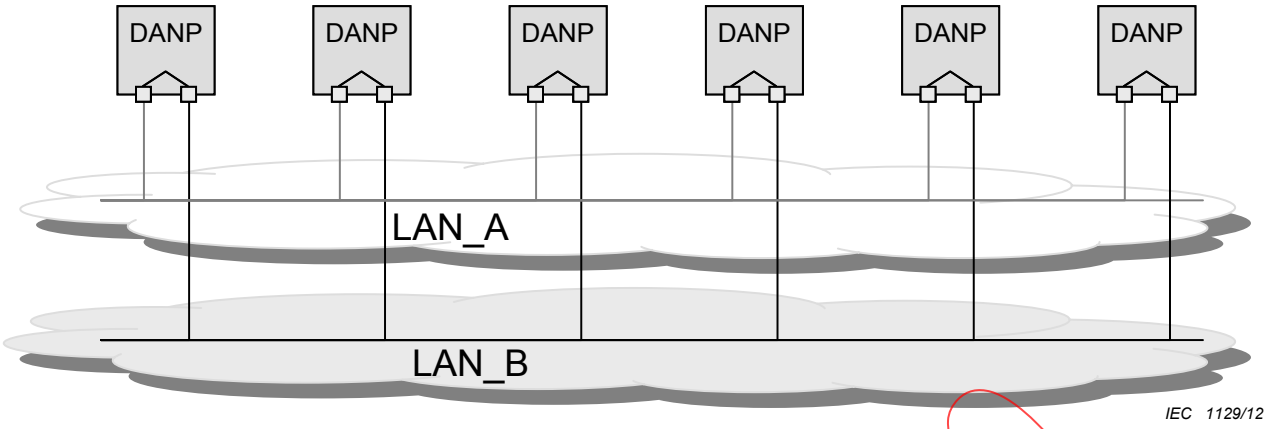

Figure 2 – PRP example of redundant network as two LANs (bus topology)

4.1.3 PRP LANs with ring topology

The two LANs can have a ring topology, as Figure 3 shows.

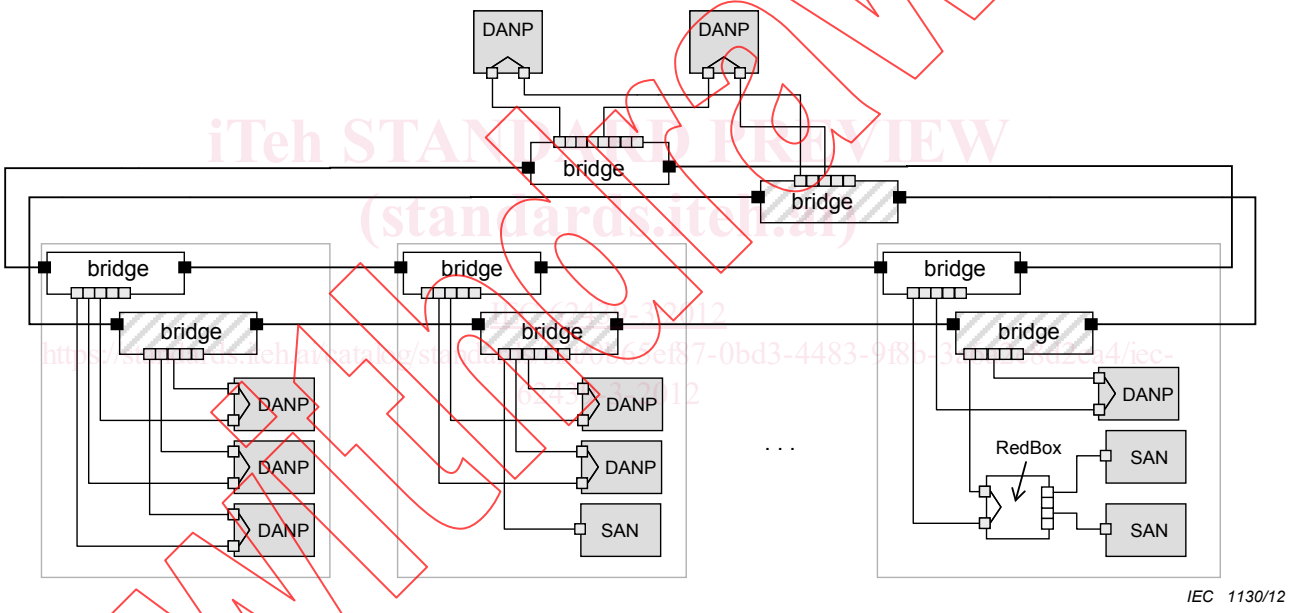

Figure 3 – PRP example of redundant ring with SANs and DANPs

NOTE In this case ring redundancy is provided by a different mechanism, for instance as defined in IEEE 802.1D or in other IEC 62439 protocols, i.e. MRP.

4.1.4 DANP node structure

Each node has two ports that operate in parallel and that are attached to the same upper layers of the communication stack through the Link Redundancy Entity (LRE), as Figure 4 shows.

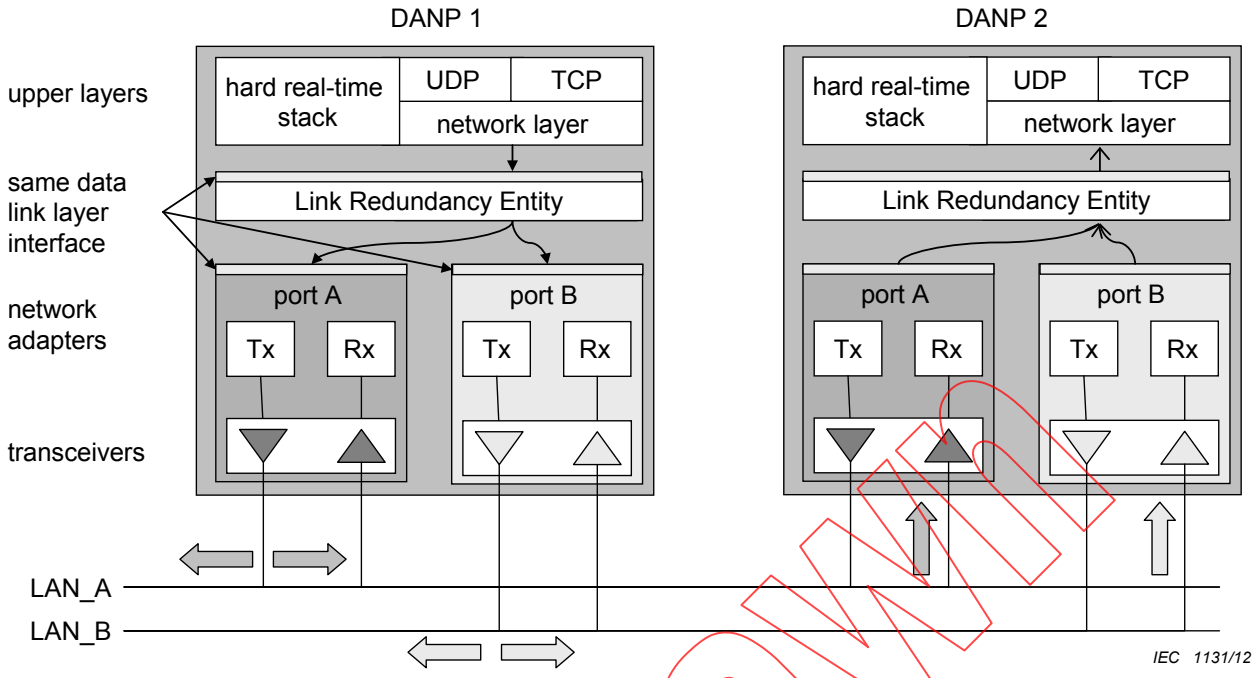

Figure 4 – PRP with two DANPs communicating

For the basic communication, the LRE presents toward its upper layers the same interface as a non-redundant network adapter, so the upper layers are unaware of redundancy.

The LRE has two tasks: handling of duplicates and management of redundancy.

When receiving a frame from the node's upper layers, the LRE appends to the frame a Redundancy Check Trailer (RCT) containing a sequence number and sends the frame through both its ports at nearly the same time. The two frames are nearly identical except for the LAN identifier (and the checksum).

The two frames transit through the two LANs with different delays, ideally they arrive at nearly the same time at the destination node.

When receiving frames from the network, the LRE forwards the first received frame of a pair to its node's upper layers and discards the duplicate frame (if it arrives). It removes the RCT if required.

For management of redundancy and checking of the presence of other DANPs, an LRE periodically sends PRP_Supervision frames and can evaluate the PRP_Supervision frames sent by other DANPs.

4.1.5 PRP attachment of singly attached nodes

Singly attached nodes (SANs) can be attached in two ways:

SANs can be attached directly to one LAN only. Such SANs can only communicate with other SANs on the same LAN. For instance, in Figure 1, SAN A1 can communicate with SAN A2, but not with SAN B1 or SAN B2. SANs can communicate (not redundantly) with all DANPs.

SANs can be attached over a RedBox (redundancy box) to both LANs, as Figure 1 shows for SAN R1 and SAN R2 (see also 4.1.9). Such SANs can communicate with all DANP and SANs, for instance SAN A1 and SAN R1 can communicate.

NOTE SANs are not aware of PRP; they can be off-the-shelf computers or printers.