IEC 62439-3

Edition 1.0 2010-02

INTERNATIONAL STANDARD

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colour inside

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

Réseaux de communications industriels –Réseaux de haute disponibilite pour l'automation – Partie 3: Protocole de redondance en parallèle (PRP) et redondance transparente de haute disponibilité (HSR)

IEC 62439-3:2010-02(en-fr)

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 25.040; 35.040

ISBN 978-2-8322-3228-6

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FOREWORD

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

This bilingual version (2016-07) corresponds to the English version, published in 2012-07.

This standard cancels and replaces IEC 62439 published in 2008. This first edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to IEC 62439 (2008):

– adding a calculation method for RSTP (rapid spanning tree protocol, IEEE 802.1Q),
– adding two new redundancy protocols: HSR (High-availability Seamless Redundancy) and DRP (Distributed Redundancy Protocol),

– moving former Clauses 1 to 4 (introduction, definitions, general aspects) and the Annexes (taxonomy, availability calculation) to IEC 62439-1, which serves now as a base for the other documents,
– moving Clause 5 (MRP) to IEC 62439-2 with minor editorial changes,
– moving Clause 6 (PRP) to IEC 62439-3 with minor editorial changes,
– moving Clause 7 (CRP) to IEC 62439-4 with minor editorial changes, and
– moving Clause 8 (BRP) to IEC 62439-5 with minor editorial changes,
– adding a method to calculate the maximum recovery time of RSTP in a restricted configuration (ring) to IEC 62439-1 as Clause 8,
– adding specifications of the HSR (High-availability Seamless Redundancy) protocol, which shares the principles of PRP to IEC 62439-3 as Clause 5, and
– introducing the DRP protocol as IEC 62439-6.

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

FDIS	Report on voting
65C/583/FDIS	65C/589/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 French version of this standard has not been voted upon.

This International Standard is to be read in conjunction with IEC 62439-1:2010, *Industrial communication networks – High availability automation networks – Part 1: General concepts and calculation methods.*

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 amendment and the base 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

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INTRODUCTION

The IEC 62439 series specifies relevant principles for high availability networks that meet the requirements for industrial automation networks.

In the fault-free state of the network, the protocols of the IEC 62439 series provide ISO/IEC 8802-3 (IEEE 802.3) compatible, reliable data communication, and preserve determinism of real-time data communication. In cases of fault, removal, and insertion of a component, they provide deterministic recovery times.

These protocols retain fully the typical Ethernet communication capabilities as used in the office world, so that the software involved remains applicable.

The market is in need of several network solutions, each with different performance characteristics and functional capabilities, matching diverse application requirements. These solutions support different redundancy topologies and mechanisms which are introduced in IEC 62439-1 and specified in the other parts of the IEC 62439 series. IEC 62439-1 also distinguishes between the different solutions, giving guidance to the user.

The IEC 62439 series follows the general structure and terms of IEC 61158 series.

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 detection of redundant frames given in 4.1.10.3, and concerning coupling of PRP and HSR LANs given in 5.4 (patent pending).

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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 (IEEE 802.3) (Ethernet) technology.

This part of IEC 62439 specifies two redundancy protocols based on the duplication of the LAN, resp. duplication of the transmitted information, designed to provide seamless recovery in case of single failure of an inter-switch link or switch in the network.

2 Normative references

The following referenced documents are indispensable for the application 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 60050-191:1990, *International Electrotechnical Vocabulary – Chapter 191: Dependability and quality of service*

IEC 62439-1:2010, *Industrial communication networks – High availability automation networks – Part 1: General concepts and calculation methods*

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 Local and metropolitan area networks Media Access Control (MAC) Bridges*

IEEE 802.1Q*, IEEE standards for local and metropolitan area network. Virtual bridged local area networks*

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, apply, in addition to the following.

3.1.1
extended frame
frame that has been extended by a Redundancy Control Trailer

3.1.2

interlink
link that connects two network hierarchies

3.1.3
RedBox
device allowing to attach single attached nodes to a redundant network

3.1.4

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

3.1.5

HSR frame
frame that carries the HSR EtherType

3.2 Abbreviations and acronyms

For the purposes of this document, the following abbreviations and acronyms apply, in addition to those given in IEC 62439-1:

DANH Double attached node implementing HSR

DANP Double attached node implementing PRP

ICMP Internet Control Message Protocol (part of the Internet protocol suite)

RCT Redundancy Check Tag

SRP Serial Redundancy Protocol

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

3.3 Conventions

This document 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 devices, through doubly attached nodes operating according to PRP (DANPs).

A DANP is attached to two independent 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 switched LANs, which can have any topology, e.g. tree, ring or meshed.

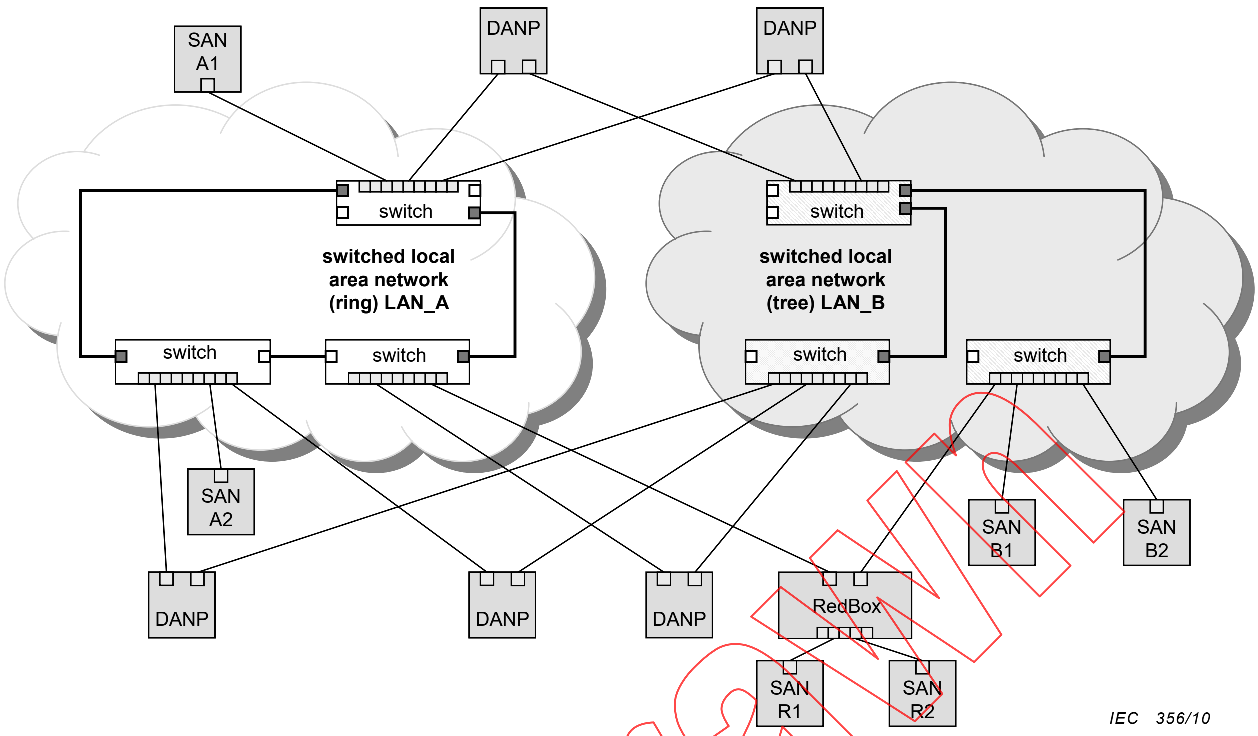

Figure 1 – PRP example of general redundant network

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) 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 configuration, Figure 2 draws a PRP network as two LANs in linear topology, which may also be a bus topology.

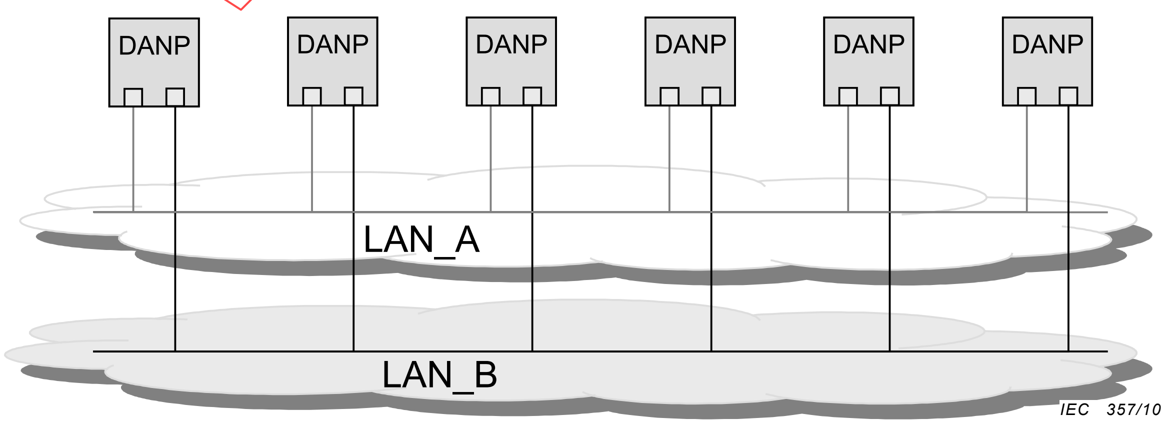

Figure 2 – PRP example of redundant network as two LANs (bus topology)

4.1.3 PRP LANs with ring topology

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

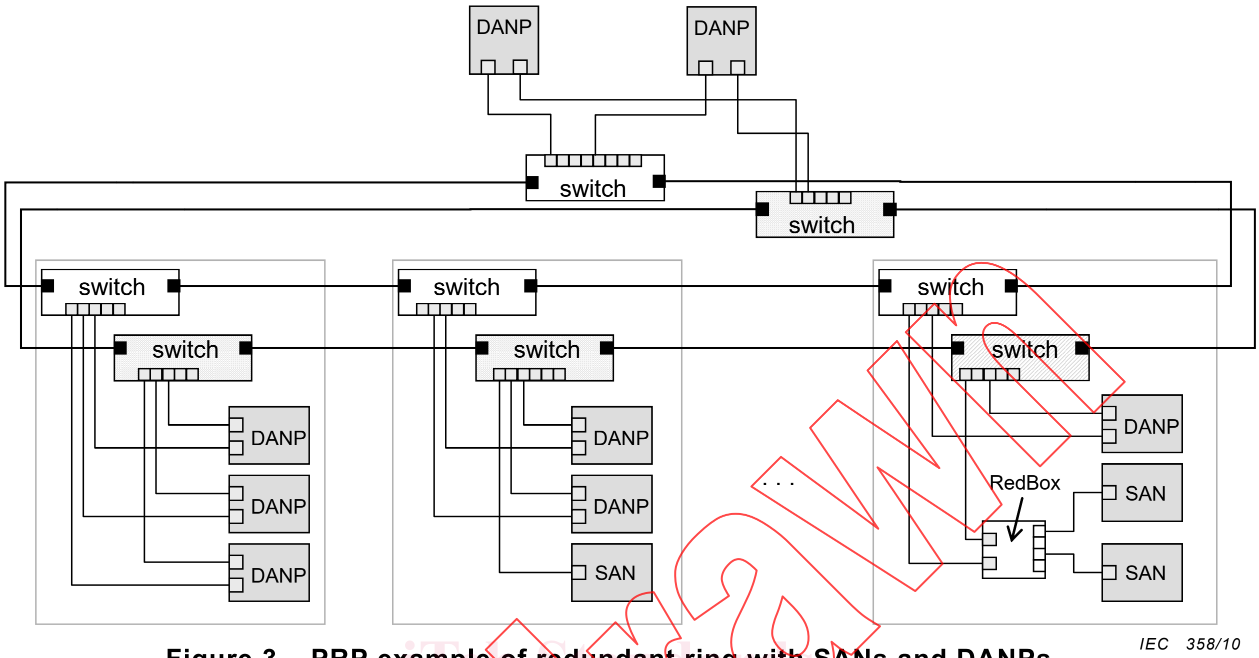

Figure 3 – PRP example of redundant ring with SANs and DANPs

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.

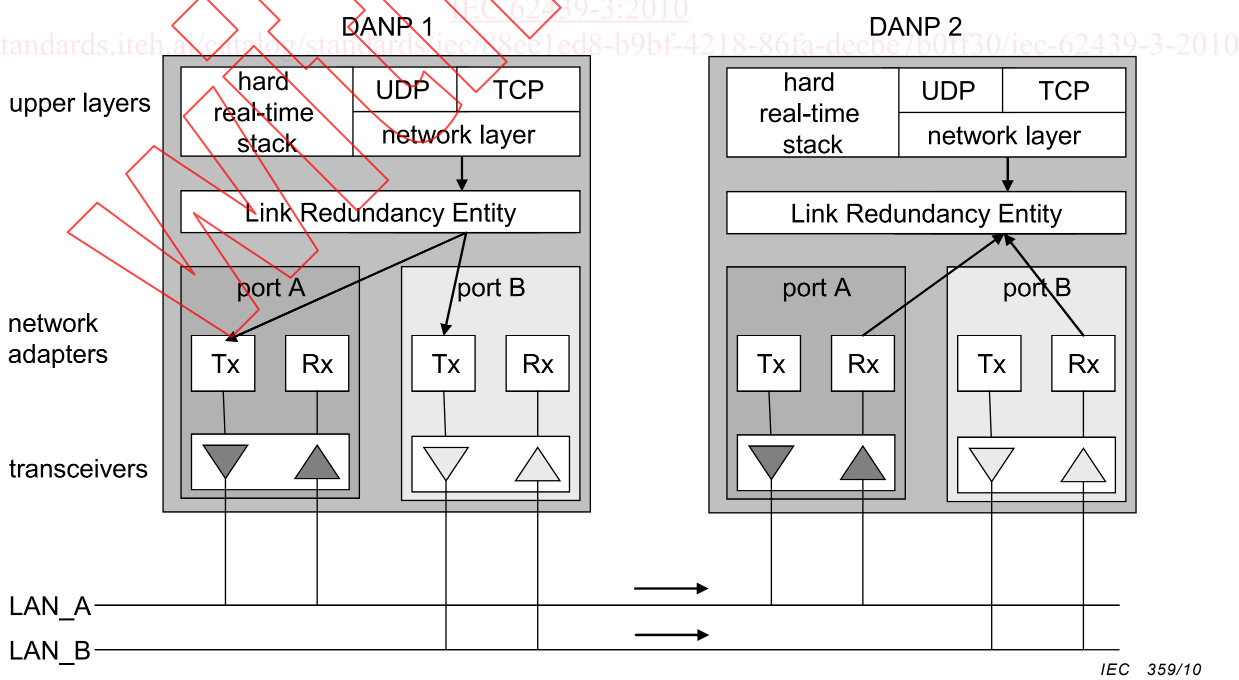

Figure 4 – PRP with two DANPs communicating

The Link Redundancy Entity (LRE) has two tasks: handling of duplicates and management of redundancy. This layer presents toward its upper layers the same interface as the network adapter of a non-redundant adapter.

When receiving a frame from the node's upper layers, the LRE sends the frame through both its ports at nearly the same time.

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

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

For management of redundancy, the LRE can append a Redundancy Check Trailer (RCT) including a sequence number to the frames it sends to keep track of duplicates. In addition, the LRE periodically sends PRP_Supervision frames and evaluates the PRP_Supervision frames of the 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. 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 with all DANPs.
- SANs can be attached over a RedBox (redundancy box) to both LANs, as Figure 1 shows for R1 and R2 (see also 4.1.9). Such SANs can communicate with all SANs, for instance SAN A1 and SAN R1 can communicate.

NOTE SANs do not need to be aware of PRP, they can be off-the-shelf computers.

In some applications, only availability-critical devices need a double attachment, for instance the operator workplaces, while the majority of the devices are SANs. Taking advantage of the basic infrastructure of PRP, a DANP can be attached to two different switches of the same LAN (e.g. a ring) and use protocols different from PRP to reconfigure the network in case of failure. The DANP then behaves as a switch element according to IEEE 802.1D. For instance, the switch element may implement the MRP protocol, the RSTP protocol, or a subset of RSTP, where there is no forwarding of traffic between the ports. These abilities are optional and not detailed in this International Standard. The supported mode is specified in the PICS (see 6).

4.1.6 Compatibility between singly and doubly attached nodes

Singly attached nodes (SAN), for instance maintenance laptops or printers that belong to one LAN, can be connected to any LAN. A SAN connected to one LAN cannot communicate directly to a SAN connected to the other LAN. Switches are always SANs. These SANs are not aware of PRP redundancy, so DANPs generate a traffic that these SANs understand. The condition is however that the SANs ignore the RCT in the frames, which should be the case since a SAN cannot distinguish the RCT from ISO/IEC 8802-3 (IEEE 802.3) padding. Conversely, DANPs understand the traffic generated by SANs, since these do not append a RCT. They only forward one frame to their upper layers since the SAN traffic uses one LAN only. If a DANP cannot positively identify that the remote device is a DANP, it considers it as a SAN.

4.1.7 Network management

A node has the same MAC address on both ports, and only one set of IP addresses assigned to that address. This makes redundancy transparent to the upper layers. Especially, this allows the Address Resolution Protocol (ARP) to work the same as with a SAN. Switches in a LAN are not doubly attached devices, and therefore all managed switches have different IP addresses. A network management tool is preferably a DANP and can access nodes and switches as if they all belong to the same network. Especially, network management implemented in a DANP is able to see SANs connected to either LAN.