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TECHNICAL REPORT

colour inside

Communication networks and systems for power utility automation – Part 90-4: Network engineering guidelines

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

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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.
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IEC 61850-90-4, which is a technical report, has been prepared by IEC technical committee 57: Power systems management and associated information exchange.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
57/1238/DTR	57/1330/RVC

Full information on the voting for the approval of this technical report 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.

A list of all parts in the IEC 61850 series, published under the general title *Communication networks and systems for power utility automation,* 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- withdrawn,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.

A bilingual version of this publication may be issued at a later date.

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

The growing success of the IEC 61850 series calls for guidelines for engineering Ethernet networks. The IEC 61850 series specifies the basic requirements for the networks but not how to achieve them. Instead, the IEC 61850 series of standards focuses on data modelling and the interchange of that data, leaving out physical interconnection details that are nevertheless needed for full interoperability.

This Technical Report provides definitions, guidelines and specifications for the network engineering of IEC 61850-based substation automation.

This Technical Report addresses issues such as Ethernet technology, network topology, redundancy, traffic latency and quality of service, traffic management by multicast and VLAN, network-based clock synchronization and testing of the network. It does not address network-based security.

The Technical Report is based on existing standards for semantics, services, protocols, system configuration language and architecture. It is based on work done by IEC TC 57 WG 10 (Power system IED communication and associated data models) and IEC TC 57 WG 15 (Data and communications security), on IEC 61918 (*Industrial communication networks – Installation of communication networks in industrial premises*), IEC 62439 (*Industrial communication networks – High-availability automation networks*) and IEC 61588 (*Precision clock synchronization protocol for networked measurement and control systems*), on the work of the IEEE 802.1 Working Group, the UCA International Users Group 9-2LE and the IEEE Power System Relaying Committee (PSRC), and on contributions by different companies.

The contents of this Technical Report have been coordinated with the Working Groups producing IEC 62439, IEC 62351 and with the IEEE PSRC.

COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

Part 90-4: Network engineering guidelines

1 Scope

This part of IEC 61850, which is a Technical Report, is intended for an audience familiar with network communication and/or IEC 61850-based systems and particularly for substation protection and control equipment vendors, network equipment vendors and system integrators.

This Technical Report focuses on engineering a local area network limited to the requirements of IEC 61850-based substation automation. It outlines the advantages and disadvantages of different approaches to network topology, redundancy, clock synchronization, etc. so that the network designer can make educated decisions. In addition, this report outlines possible improvements to both substation automation and networking equipment.

This Technical Report addresses the most critical aspects of IEC 61850, such as protection related to tripping over the network. This Technical Report addresses in particular the multicast data transfer of large volumes of sampled values (SV) from merging units (MUs). It also considers the high precision clock synchronization and “seamless” guaranteed transport of data across the network under failure conditions that is central to the process bus concept.

This Technical Report is not a tutorial on networking or on IEC 61850. Rather, it references and summarizes standards and publications to assist the engineers. Many publications discuss the Ethernet technology but do not address the networks in terms of substation automation. Therefore, many technologies and options have been ignored, since they were not considered relevant for a future-proof substation automation network design.

This Technical Report does not address network security.

This Technical Report does not address substation-to-substation communication, or substation to control centre communication. Inter-substation communication involves WAN technologies other than Ethernet, but when it uses Ethernet on layer 2, parts of this report can be applied. For inter-substation communication which uses exclusively the routable Internet Protocol, more adapted guidelines are in discussion within IEC TC 57, especially in documents IEC/TR 61850-90-1, IEC 61850-90-2[1], and IEC/TR 61850-90-5, which will be addressed in the WAN engineering guidelines, IEC 61850-90-12[2].

This Technical Report does not dispense the responsible system integrator from an analysis of the actual application configuration, which is the base for a dependable system.

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1 Under consideration.

2 Under consideration.

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 (all parts), *International Electrotechnical Vocabulary* (<available at: http://www.electropedia.org/>)

IEC 60834-1, *Teleprotection equipment of power systems – Performance and testing – Part 1: Command systems*

IEC 60870-2-2, *Telecontrol equipment and systems – Part 2: Operating conditions – Section 2: Environmental conditions (climatic, mechanical and other non-electrical influences)*

IEC 61000-4-4, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-5, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61000-6-2, *Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments*

IEC 61508-4, *Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 4: Definitions and abbreviations*

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

IEC 61754-2, *Fibre optic connector interfaces – Part 2: Type BFOC/2,5 connector family*

IEC 61754-20, *Fibre optic interconnecting devices and passive components – Fibre optic connector interfaces – Part 20: Type LC connector family*

IEC 61800-3, *Adjustable speed electrical power drive systems – Part 3: EMC requirements and specific test methods*

IEC 61850-3, *Communication networks and systems for power utility automation – Part 3: General requirements*

IEC 61850-4, *Communication networks and systems for power utility automation – Part 4: System and project management*

IEC 61850-5:2013, *Communication networks and systems for power utility automation – Part 5: Communication requirements for functions and device models*

IEC 61850-6:2009, *Communication networks and systems for power utility automation – Part 6: Configuration description language for communication in electrical substations related to IEDs*

IEC 61850-7-1:2011, *Communication networks and systems for power utility automation – Part 7-1: Basic communication structure – Principles and models*

IEC 61850-7-2:2010, *Communication networks and systems for power utility automation – Part 7-2: Basic information and communication structure – Abstract communication service interface (ACSI)*

IEC 61850-7-3, *Communication networks and systems for power utility automation – Part 7-3: Basic communication structure – Common data classes*

IEC 61850-7-4:2010, *Communication networks and systems for power utility automation – Part 7-4: Basic communication structure – Compatible logical node classes and data object classes*

IEC 61850-8-1:2011, *Communication networks and systems for power utility automation – Part 8-1: Specific communication service mapping (SCSM) – Mappings to MMS (ISO 9506-1 and ISO 9506-2) and to ISO/IEC 8802-3*

IEC 61850-9-2:2011, *Communication networks and systems for power utility automation – Part 9-2: Specific communication service mapping (SCSM) – Sampled values over ISO/IEC 8802-3*

IEC/TR 61850-90-1, *Communication networks and systems for power utility automation – Part 90-1: Use of IEC 61850 for the communication between substations*

IEC/TR 61850-90-5, *Communication networks and systems for power utility automation – Part 90-5: Use of IEC 61850 to transmit synchrophasor information according to IEEE C37.118*

IEC 61869-9:__[3], *Instrument transformers – Part 9: Digital interface for instrument transformers*

IEC 62351 (all parts), *Power systems management and associated information exchange – Data and communications security*

IEC/TS 62351-6, *Power systems management and associated information exchange – Data and communications security – Part 6: Security for IEC 61850*

IEC 62439-1:2010, *Industrial communication networks – High availability automation networks – Part 1: General concepts and calculation methods*
Amendment 1:2012

IEC 62439-3:2012, *Industrial communication networks – High availability automation networks – Part 3: Parallel Redundancy Protocol (PRP) and High availability Seamless Redundancy (HSR)*

IEC 81346 (all parts), *Industrial systems, installations and equipment and industrial products – Structuring principles and reference designations*

ISO/IEC 8326:1996, *Information processing system – Open Systems Interconnection – Session service definition*

ISO/IEC 8649, *Information technology – Open Systems Interconnection – Service definition for the Association Control Service Element*[4]

[3] To be published.

[4] Withdrawn.

ISO/IEC 8802-2, *Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 2: Logical link control*

ISO/IEC 8824-1, *Information technology – Abstract Syntax Notation One (ASN.1): Specification of basic notation*

ISO 9506-1:2003, *Industrial automation systems – Manufacturing Message Specification – Part 1: Service definition*

ISO 9506-2:2003, *Industrial automation systems – Manufacturing Message Specification – Part 2: Protocol specification*

IEEE 802.1AB-2005, *IEEE standard for Local and metropolitan area networks – Station and Media Access Control Connectivity Discovery*

IEEE 802.1D-2004, *IEEE standard for Local and metropolitan area networks – Common specifications – 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 Networks*

IEEE 802.3, *Local Area Network (LAN) protocols*

IEEE 1344, *IEEE Standard for Synchrophasors for Power Systems* (replaced by IEEE C37.118)

IEEE 1613-2009, *IEEE Standard – Environmental and Testing Requirements for Communications Networking Devices Installed in Electric Power Substations*

IEEE C37.118.1-2011, *IEEE Standard for Synchrophasor Measurements for Power Systems*

IEEE C37.118.2-2011, *IEEE Standard for Synchrophasor Data Transfer for Power Systems*

IEEE C37.238-2011, *IEEE Standard Profile for Use of IEEE 1588 Precision Time Protocol in Power System Applications*

RFC 793: 1981, *DARPA Internet Program, Transmission Control Protocol, Protocol Specification, 1981*

RFC 1006: 1987, *Network Working Group, ISO Transport Service on top of the TCP Version:3*

RFC 1305: 1992, *Network Working Group, Network Time Protocol (Version 3)*

RFC 2328: 1998, *The Internet Society, OSPF Version 2*

RFC 2661: 1999, *The Internet Society, Layer Two Tunneling Protocol "L2TP"*

RFC 3416: 2002, *The Internet Society, Version 2 of the Protocol Operations for the Simple Network Management Protocol (SNMP)*

RFC 4330: 2006, *The Internet Society, Simple Network Time Protocol (SNTP) Version 4 for IPv4, IPv6 and OSI*

RFC 4836: 2007, *IETF Trust, Definitions of Managed Objects for IEEE 802.3 Medium Attachment Units (MAUs)*

TIA/EIA 568A, *Commercial building telecommunications cabling standard set (contains: TIA-568-C.0, TIA-568-C.1, TIA-568-C.2, TIA-568-C.3 AND TIA-568-C.4 – with addendums and erratas)*

3 Terms, definitions, abbreviations and conventions

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-191:1990, as well as the following, apply.

3.1.1
bridge
network device that connects network segments at the data link layer (layer 2) of the OSI model, according to the principles of IEEE 802.1D Clause 7

Note 1 to entry: A bridge is often referred to as a “layer 2 switch”. In this document, the word “bridge” means the logic used to forward a frame from one port to another at layer 2, while “switch” designates a device with additional functionalities.

3.1.2
broadcast domain
set of all network nodes that receive a layer 2 frame with a broadcast destination address

Note 1 to entry: The broadcast domain is the entire layer 2 subnet.

3.1.3
broadcast storm
condition on a network where there is an abnormally huge broadcast traffic that consumes resources and renders the network unable to transport normal traffic

3.1.4
bus
communication medium that supports broadcast, either physically (e.g. radio, multi-drop cable) or logically (e.g. switched layer 2 network), as opposed to links that are point-to-point connections

3.1.5
cut-through
basic operation of a bridge, in which frames on ingress are forwarded to the appropriate egress port(s) before the whole frame has been received, on the basis of their header

Note 1 to entry: “Cut-through” is in contrast to “store-and-forward”.

3.1.6
doubly attached node
node that has two ports for the purpose of redundant operation

[SOURCE: IEC 62439-1:2010, 3.1.11]

3.1.7
layer 2
data link layer of the OSI model

Note 1 to entry: At layer 2, data packets are encoded and decoded into bits. Layer 2 is divided into sub layers: Media Access Control (MAC) and Logical Link Control (LLC). The MAC sub layer controls how a network node gains access to the media and the LLC sub layer handles flow control and error checking. Ethernet is a layer 2 technology.

[SOURCE: ISO/IEC 7498-1:1994]