

# TECHNICAL REPORT



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

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

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## CONTENTS

FOREWORD.....	12
INTRODUCTION.....	14
1 Scope.....	15
2 Normative references .....	16
3 Terms, definitions, abbreviations and conventions.....	19
3.1 Terms and definitions .....	19
3.2 Abbreviations .....	22
3.3 Conventions .....	25
3.3.1 Network diagram symbols.....	25
3.3.2 Port and link symbols .....	26
3.3.3 Bridges symbols .....	26
4 Overview of IEC 61850 networks.....	27
4.1 Logical allocation of functions and interfaces.....	27
4.2 IEC 61850 protocol stack .....	29
4.2.1 General .....	29
4.2.2 IEC 61850 traffic classes.....	29
4.2.3 MMS protocol .....	30
4.2.4 GOOSE protocol.....	30
4.2.5 SV protocol.....	32
4.3 Station bus and process bus.....	32
5 Network design checklist.....	34
5.1 Design principles.....	34
5.2 Engineering flow.....	34
5.3 Checklist to be observed .....	35
5.3.1 Summary.....	35
5.3.2 Environmental issues .....	36
5.3.3 EMI immunity.....	36
5.3.4 Form factor.....	36
5.3.5 Physical media .....	36
5.3.6 Substation application and network topology .....	36
5.3.7 Redundancy .....	37
5.3.8 Reliability, availability, maintainability.....	37
5.3.9 Logical data flows and traffic patterns.....	37
5.3.10 Latency for different types of traffic .....	37
5.3.11 Performance.....	37
5.3.12 Network management.....	38
5.3.13 Network supervision .....	38
5.3.14 Time synchronization and accuracy .....	38
5.3.15 Remote connectivity .....	38
5.3.16 Cyber security .....	38
5.3.17 Scalability, upgradeability and future-proof .....	39
5.3.18 Testing .....	39
5.3.19 Cost .....	39
6 Ethernet technology for substations.....	39
6.1 Ethernet subset for substation automation.....	39
6.2 Topology .....	39

6.3	Physical layer .....	41
6.3.1	Data rate and medium .....	41
6.3.2	Full-duplex communication and auto-negotiation .....	41
6.3.3	Copper cabling at 100 Mbit/s .....	41
6.3.4	Optical cabling at 100 Mbit/s (100BASE-FX) .....	42
6.3.5	Optical cabling at 1 Gbit/s (1000BASE-LX) .....	44
6.3.6	Copper cabling at 1 Gbit/s .....	44
6.4	Link layer .....	44
6.4.1	Unicast and multicast MAC addresses .....	44
6.4.2	Link layer and bridges .....	45
6.4.3	Bridging nodes .....	45
6.4.4	Loop prevention and RSTP .....	45
6.4.5	Traffic control in the bridges .....	47
6.4.6	Unicast MAC address filtering .....	47
6.4.7	Multicast MAC address filtering .....	47
6.4.8	Virtual LANs (VLANs) traffic control .....	48
6.4.9	Comparison VLAN versus multicast filtering .....	53
6.4.10	Layer 2 redundancy protocols .....	53
6.5	Network layer .....	57
6.5.1	Internet protocol .....	57
6.5.2	IP public and private addresses .....	57
6.5.3	Subnet masks .....	58
6.5.4	Network address translation .....	59
7	Network and substation topologies .....	59
7.1	General rule .....	59
7.2	Reference topologies and network redundancy .....	60
7.3	Reference topologies .....	64
7.3.1	Station bus topologies .....	64
7.3.2	Process bus and attachment of primary equipment .....	77
7.3.3	Station bus and process bus connection .....	92
8	Addressing in the substation .....	98
8.1	Network IP address plan for substations .....	98
8.1.1	General structure .....	98
8.1.2	IP address allocation of NET .....	99
8.1.3	IP address allocation of BAY .....	100
8.1.4	IP address allocation of device .....	100
8.1.5	IP address allocation of devices with PRP .....	101
8.2	Routers and GOOSE / SV traffic .....	101
8.3	Communication outside the substation .....	101
9	Application parameters .....	102
9.1	MMS parameters .....	102
9.2	GOOSE parameters .....	102
9.3	SV parameters .....	102
10	Performance .....	103
10.1	Station bus performance .....	103
10.1.1	Logical data flows and traffic patterns .....	103
10.1.2	GOOSE traffic estimation .....	104
10.1.3	MMS traffic estimation .....	104

10.1.4	station bus measurements .....	105
10.2	Process bus performance .....	106
11	Latency .....	106
11.1	Application requirements .....	106
11.2	Latency requirements for different types of traffic .....	107
11.2.1	Latency requirements in IEC 61850-5 .....	107
11.2.2	Latencies of physical paths .....	107
11.2.3	Latencies of bridges .....	107
11.2.4	Latency and hop counts .....	108
11.2.5	Network latency budget .....	108
11.2.6	Example of traffic delays .....	109
11.2.7	Engineering a network for IEC 61850 protection .....	109
12	Network traffic control .....	110
12.1	Factors that affect performance .....	110
12.1.1	Influencing factors .....	110
12.1.2	Traffic reduction .....	110
12.1.3	Example of traffic reduction scheme .....	111
12.1.4	Multicast domains in a combined station bus and process bus network .....	112
12.2	Traffic control by VLANs .....	113
12.2.1	Trunk traffic reduction by VLANs .....	113
12.2.2	VLAN usage .....	114
12.2.3	VLAN handling at the IEDs .....	114
12.2.4	Example of correct VLAN configuration .....	114
12.2.5	Example of incorrect VLAN configuration .....	115
12.2.6	Retaining priority throughout the network .....	117
12.2.7	Traffic filtering with VLANs .....	117
12.3	Traffic control by multicast filtering .....	118
12.3.1	Trunk traffic reduction by multicast filtering .....	118
12.3.2	Multicast/VLAN management and redundancy protocol reconfiguration .....	119
12.3.3	Physical topologies and multicast management implications .....	119
12.4	Configuration support from tools and SCD files .....	122
13	Dependability .....	122
13.1	Resiliency requirements .....	122
13.2	Availability and reliability requirements .....	123
13.3	Recovery time requirements .....	123
13.4	Maintainability requirements .....	123
13.5	Dependability calculations .....	124
13.6	Risk analysis attached to "unwanted events" .....	124
14	Time services .....	125
14.1	Clock synchronization and accuracy requirements .....	125
14.2	Global time sources .....	125
14.3	Time scales and leap seconds .....	126
14.4	Epoch .....	127
14.5	Time scales in IEC 61850 .....	127
14.6	Synchronization mechanisms in IEC 61850 .....	128
14.6.1	Clock synchronization protocols .....	128
14.6.2	1 PPS .....	130

14.6.3	IRIG-B .....	130
14.6.4	NTP/SNTP clock synchronization for IEC 61850-8-1 (station bus) .....	130
14.6.5	PTP (IEC 61588) synchronization .....	132
14.6.6	PTP clock synchronization and IEC 62439-3:2012 .....	137
14.6.7	IEEE C37.238-2011 Power profile .....	140
14.7	PTP network engineering .....	141
14.7.1	PTP reference clock location .....	141
14.7.2	PTP connection of station bus and process bus .....	142
14.7.3	Merging units synchronization .....	143
15	Network security .....	143
16	Network management .....	143
16.1	Protocols for network management .....	143
16.2	Network management tool .....	144
16.3	Network diagnostic tool .....	144
17	Remote connectivity .....	145
18	Network testing .....	145
18.1	Introduction to testing .....	145
18.2	Environmental type testing .....	146
18.3	Conformance testing .....	146
18.3.1	Protocols subject to conformance testing .....	146
18.3.2	Integrator acceptance and verification testing .....	147
18.3.3	Simple verification test set-up .....	147
18.3.4	Simple VLAN handling test .....	148
18.3.5	Simple priority tagging test .....	148
18.3.6	Simple multicast handling test .....	149
18.3.7	Simple RSTP recovery test .....	149
18.3.8	Simple HSR test .....	150
18.3.9	Simple RRP test .....	150
18.3.10	Simple PTP test .....	150
18.4	Factory and site acceptance testing .....	150
19	IEC 61850 bridge and port object model .....	151
19.1	Purpose .....	151
19.2	Bridge model .....	152
19.2.1	Simple model .....	152
19.2.2	Bridge Logical Node linking .....	154
19.3	Clock model .....	154
19.3.1	IEC 61588 datasets .....	154
19.3.2	Clock objects .....	155
19.3.3	Simple clock model .....	155
19.3.4	Linking of clock objects .....	156
19.4	Autogenerated IEC 61850 objects .....	157
19.4.1	General .....	157
19.4.2	Abbreviated terms used in data object names .....	157
19.4.3	Logical nodes .....	158
19.4.4	Data semantics .....	171
19.4.5	Enumerated data attribute types .....	174
19.4.6	SCL enumerations .....	176
19.4.7	Common data class specifications .....	176

19.4.8 Enumerated types .....	182
19.4.9 SCL enumerations .....	183
19.5 Mapping of bridge objects to SNMP .....	183
19.5.1 Mapping of LLN0 and LPHD attributes to SNMP .....	183
19.5.2 Mapping of LBRI attributes to SNMP for bridges .....	184
19.5.3 Mapping of LPCP attributes to SNMP for bridges .....	184
19.5.4 Mapping of LPLD attributes to SNMP for bridges .....	184
19.5.5 Mapping of HSR/PRP link redundancy entity to SNMP .....	185
19.6 Mapping of clock objects to the C37.238 SNMP MIB .....	186
19.7 Machine-readable description of the bridge objects .....	189
19.7.1 Method and examples .....	189
19.7.2 Four-port bridge .....	189
19.7.3 Simple IED with PTP .....	199
19.7.4 RedBox wit HSR .....	206
Annex A (informative) Case study – Process bus configuration for busbar protection system .....	214
Annex B (informative) Case study – Simple Topologies (Transener/Transba, Argentina) .....	218
Annex C (informative) Case study – An IEC 61850 station bus (Powerlink, Australia) .....	226
Annex D (informative) Case study – Station bus with VLANs (Trans-Africa, South Africa) .....	242
Bibliography .....	263
Figure 1 – Network symbols .....	26
Figure 2 – Port symbols .....	26
Figure 3 – Bridge symbol as beam .....	27
Figure 4 – Bridge symbol as bus .....	27
Figure 5 – Levels and logical interfaces in substation automation systems .....	28
Figure 6 – IEC 61850 protocol stack .....	29
Figure 7 – MMS protocol time/distance chart .....	30
Figure 8 – GOOSE protocol time/distance chart .....	31
Figure 9 – GOOSE protocol time chart .....	32
Figure 10 – Example of SV traffic (4 800 Hz) .....	32
Figure 11 – Station bus, process bus and traffic example .....	33
Figure 12 – Example of engineering flow .....	35
Figure 13 – Ethernet local area network (with redundant links) .....	40
Figure 14 – Switch with copper (RJ45) ports .....	40
Figure 15 – RJ45 connector .....	42
Figure 16 – LC connector .....	43
Figure 17 – Switch with optical fibres (LC connectors) .....	44
Figure 18 – RSTP principle .....	46
Figure 19 – IEEE 802.3 frame format without and with VLAN tagging .....	49
Figure 20 – PRP principle .....	54
Figure 21 – HSR principle .....	56
Figure 22 – HSR and PRP coupling (multicast) .....	57
Figure 23 – Mapping of electrical grid to data network topology .....	60

Figure 24 – Station bus as single bridge .....	64
Figure 25 – Station bus as hierarchical star .....	65
Figure 26 – Station bus as dual star with PRP .....	66
Figure 27 – Station bus as ring of RSTP bridges .....	67
Figure 28 – Station bus as separated Main 1 (Bus 1) and Main 2 (Bus 2) LANs .....	68
Figure 29 – Station bus as ring of HSR bridging nodes .....	70
Figure 30 – Station bus as ring and subrings with RSTP .....	71
Figure 31 – Station bus as parallel rings with bridging nodes .....	72
Figure 32 – Station bus as parallel HSR rings .....	73
Figure 33 – Station bus as hierarchical rings with RSTP bridging nodes .....	74
Figure 34 – Station bus as hierarchical rings with HSR bridging nodes .....	76
Figure 35 – Station bus as ring and subrings with HSR .....	77
Figure 36 – Double busbar bay with directly attached sensors .....	78
Figure 37 – Double busbar bay with SAMUs and process bus .....	79
Figure 38 – Double busbar bay with ECT/EVTs and process bus .....	80
Figure 39 – 1 ½ CB diameter with conventional, non-redundant attachment .....	81
Figure 40 – 1 ½ CB diameter with SAMUs and process bus .....	82
Figure 41 – 1 ½ CB diameter with ECT/EVT and process bus .....	83
Figure 42 – Process bus as connection of PIA and PIB (non-redundant protection) .....	84
Figure 43 – Process bus as single star (not redundant protection) .....	85
Figure 44 – Process bus as dual star .....	87
Figure 45 – Process bus as a single bridge (no protection redundancy) .....	88
Figure 46 – Process bus as separated LANs for main 1 and main 2 .....	90
Figure 47 – Process bus as ring of HSR nodes .....	91
Figure 48 – Process bus as star to merging units and station bus as RSTP ring .....	93
Figure 49 – Station bus and process bus as rings connected by a router .....	95
Figure 50 – Station bus ring and process bus ring with HSR .....	96
Figure 51 – Station bus as dual PRP ring and process bus as HSR ring .....	98
Figure 52 – Station bus used for the measurements .....	105
Figure 53 – Typical traffic (packet/s) on the station bus .....	105
Figure 54 – Generic multicast domains .....	110
Figure 55 – Traffic patterns .....	112
Figure 56 – Multicast domains for a combined process bus and station bus .....	113
Figure 57 – Bridges with correct VLAN configuration .....	115
Figure 58 – Bridges with poor VLAN configuration .....	116
Figure 59 – Bridges with traffic segmentation through VLAN configuration .....	118
Figure 60 – Station bus separated into multicast domains by voltage level .....	119
Figure 61 – Multicast traffic on an RSTP ring .....	120
Figure 62 – RSTP station bus and HSR ring .....	121
Figure 63 – RSTP station bus and HSR process bus .....	121
Figure 64 – Clock synchronization channels .....	129
Figure 65 – 1 PPS synchronisation .....	130
Figure 66 – SNTP clock synchronization and delay measurement .....	131



Figure 67 – PTP elements .....	133
Figure 68 – PTP one-step clock synchronization and delay measurement.....	134
Figure 69 – PTP two-step clock synchronization and delay measurement .....	136
Figure 70 – Clocks in a PRP network coupled by BCs with an HSR ring.....	139
Figure 71 – C37.238-specific TLV .....	141
Figure 72 – Hierarchy of clocks.....	142
Figure 73 – Quality assurance stages (copied from IEC 61850-4) .....	145
Figure 74 – Test set-up for verification test.....	147
Figure 75 – Multiport device model .....	153
Figure 76 – Linking of bridge objects .....	154
Figure 77 – Clock model .....	156
Figure 78 – Linking of clock objects .....	157
Figure 79 – Class diagram LogicalNodes_90_4::LogicalNodes_90_4.....	158
Figure 80 – Class diagram LNGroupL::LNGroupLExt .....	159
Figure 81 – Class diagram LNGroupL::LNGroupLNew .....	160
Figure 82 – Usage of VLAN filtering .....	163
Figure 83 – Usage of clock references .....	169
Figure 84 – Class diagram DetailedDiagram::DOEnums_90_4.....	175
Figure 85 – Class diagram CommonDataClasses_90_4::CommonDataClasses_90_4 .....	176
Figure 86 – Class diagram CDCStatusInfo::CDCStatusInfo.....	177
Figure 87 – Class diagram CDCStatusSet::CDCStatusSet.....	180
Figure 88 – Four-port bridge.....	189
Figure 89 – Simple IED with PTP but no LLDP support.....	199
Figure 90 – RedBox with LLDP but no PTP.....	207
Figure A.1 – Preconditions for the process bus configuration example.....	215
Figure B.1 – First Ethernet-based Transba substation automation network .....	218
Figure B.2 – Transba SAS architecture .....	219
Figure B.3 – Transener substation automation network.....	220
Figure B.4 – Transener SAS architecture – ET Esperanza .....	222
Figure B.5 – Transener 500 kV architecture – El Morejón .....	223
Figure B.6 – 500 kV kiosk topology.....	224
Figure B.7 – 33 kV kiosk topology.....	225
Figure C.1 – Example HV and LV single line diagram and IEDs .....	226
Figure C.2 – HV bay and cabinet module .....	228
Figure C.3 – Data network areas .....	232
Figure C.4 – Substation LAN topology .....	234
Figure C.5 – SAS Gen1 High level traffic flows .....	235
Figure C.6 – SCADA & gateway connection .....	236
Figure C.7 – Station Core .....	236
Figure C.8 – Overall VLANs .....	238
Figure C.9 – Three domains.....	238
Figure C.10 – One domain per diameter, bus zone and transformer protection .....	239
Figure D.1 – Conceptual topology of substation LAN network with redundancy .....	245



Figure D.2 – Detailed topology of substation LAN with redundancy .....	246
Figure D.3 – Original IPv4 Type of Service (ToS) octet .....	249
Figure D.4 – Differentiated Services (DiffServ) codepoint field .....	249
Table 1 – IEC 61850-5 interface definitions .....	28
Table 2 – Example of port ingress setting table .....	51
Table 3 – Example of port egress settings .....	52
Table 4 – Advantages and drawbacks of VLAN versus multicast filtering .....	53
Table 5 – IANA private IP address blocks (copied from RFC 1918) .....	58
Table 6 – IP address and mask example .....	58
Table 7 – Summary of reference topologies .....	62
Table 8 – Reference topologies and redundancy protocols used .....	63
Table 9 – Station bus as single bridge .....	64
Table 10 – Station bus as hierarchical star .....	65
Table 11 – Station bus as dual star .....	66
Table 12 – Station bus as ring .....	67
Table 13 – Station bus as separated Main 1 and Main 2 protection .....	69
Table 14 – Station bus as ring of bridging nodes .....	70
Table 15 – Station bus as ring and subrings .....	71
Table 16 – Station bus as parallel rings .....	73
Table 17 – Station bus as parallel HSR rings .....	74
Table 18 – Station bus as ring of rings with RSTP .....	75
Table 19 – Station bus as ring of rings with HSR .....	76
Table 20 – Station bus as ring and subrings with HSR .....	77
Table 21 – Process bus as connection of PIA and PIB .....	84
Table 22 – Process bus as single star .....	86
Table 23 – Process bus as dual star .....	87
Table 24 – Process bus as single bridge .....	89
Table 25 – Process bus as separated LANs .....	90
Table 26 – Process bus as simple ring .....	91
Table 27 – Advantages and drawbacks of physical separation .....	92
Table 28 – Advantages and drawbacks of logical separation .....	92
Table 29 – Process bus as star to merging units .....	93
Table 30 – Connection of station bus to process bus by routers .....	95
Table 31 – Connection of station bus to process bus by RedBoxes .....	97
Table 32 – Connection of duplicated station bus to process bus by RedBoxes .....	98
Table 33 – Example IP address allocation of NET .....	99
Table 34 – Example IP address allocation of BAY .....	100
Table 35 – Example IP address allocation of device .....	100
Table 36 – Example IP address allocation of switches in PRP .....	101
Table 37 – IEC 61850-5 interface traffic .....	103
Table 38 – Message types and addresses .....	104
Table 39 – Transfer time requirements of IEC 61850-5 .....	107

Table 40 – Elapsed time for an IEEE 802.3 frame to traverse the physical medium.....	107
Table 41 – Delay for an IEEE 802.3 frame to ingress or to egress a port .....	108
Table 42 – Latencies caused by waiting for a lower-priority frame to egress a port .....	109
Table 43 – Synchronization classes of IEC 61850-5.....	125
Table 44 – Time representations.....	128
Table 45 – Standards applicable to network elements.....	146
Table 46 – Normative abbreviations for data object names .....	157
Table 47 – Data objects of LNGroupL::LPHDExt .....	161
Table 48 – Data objects of LNGroupL::LBRI.....	162
Table 49 – Data objects of LNGroupL::LCCF .....	163
Table 50 – Data objects of LNGroupL::LCCHExt .....	164
Table 51 – Data objects of LNGroupL::PortBindingLN.....	165
Table 52 – Data objects of LNGroupL::LPCP .....	165
Table 53 – Data objects of LNGroupL::LPLD.....	166
Table 54 – Data objects of LNGroupL::LBSP .....	168
Table 55 – Data objects of LNGroupL::LTIMEExt .....	168
Table 56 – Data objects of LNGroupL::LTMSEExt .....	170
Table 57 – Data objects of LNGroupL::LTPC .....	170
Table 58 – Data objects of LNGroupL::LTPP.....	171
Table 59 – Attributes defined on classes of LogicalNodes_90_4 package .....	171
Table 60 – Literals of DOEnums_90_4::ChannelRedundancyKind.....	174
Table 61 – Literals of DOEnums_90_4::LeapSecondKind.....	175
Table 62 – Literals of DOEnums_90_4::RstpStateKind.....	175
Table 63 – Clock grandmaster status common data class definition .....	177
Table 64 – Clock port status common data class definition .....	178
Table 65 – Clock ordinary settings common data class definition .....	180
Table 66 – VLAN filters common data class definition .....	182
Table 67 – Literals of DAEnums_90_4::VlanTagKind .....	182
Table 68 – Mapping of LLN0 and LPHD attributes to SNMP .....	183
Table 69 – Mapping of LBRI and LBSP attributes to SNMP for bridges .....	184
Table 70 – Mapping of LPCP attributes to SNMP for bridges.....	184
Table 71 – Mapping of LPLD attributes to SNMP for bridges.....	185
Table 72 – Mapping of LCCH attributes for SNMP for HSR/PRP LREs.....	186
Table 73 – Mapping of clock objects in IEC 61850, IEC 61588 and IEEE C37.238 .....	186
Table A.1 – Summary of expected latencies.....	215
Table C.1 – Site categories HV.....	227
Table C.2 – Site categories MV.....	227
Table C.3 – Building modules .....	228
Table C.4 – Network modules .....	233
Table C.5 – Domain assignment for three domains .....	239
Table C.6 – Domain assignment for one domain per diameter.....	239
Table C.7 – Summary of expected latencies .....	241
Table C.8 – Traffic types and estimated network load .....	241

Table D.1 – VLAN numbering and allocation .....	247
Table D.2 – Prioritization selection for various applications.....	248
Table D.3 – Mapping of applications to service levels .....	249
Table D.4 – List of DiffServ codepoint field values .....	250
Table D.5 – Example of DSCP to class of service mapping.....	250
Table D.6 – Example of DSCP mappings .....	251
Table D.7 – Typical substation IP Address map (IP range: 10.0.16.0/21) .....	251
Table D.8 – SNMP MIBs applicable to substation devices.....	253
Table D.9 – Example of device naming .....	255
Table D.10 – Example of interface addressing and allocation.....	255
Table D.11 – Example of device access and SNMP assignment.....	256
Table D.12 – Example of hardware identification.....	257
Table D.13 – Example of device name table .....	257
Table D.14 – Example of firmware and software table.....	257
Table D.15 – Example of interface addressing and allocation.....	258
Table D.16 – Example of network switch details.....	258
Table D.17 – Example of VLAN definitions.....	259
Table D.18 – Example of IP routing.....	259
Table D.19 – Example of QoS mapping.....	259
Table D.20 – Example of trunk and link aggregation table (void).....	260
Table D.21 – LAN switch port speed and duplex configuration .....	260
Table D.22 – LAN switch port security settings .....	261
Table D.23 – Example of DHCP snooping.....	262
Table D.24 – Example of storm control table.....	262

INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

Part 90-4: Network engineering guidelines

FOREWORD

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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 ICA (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<sup>1</sup>, and IEC/TR 61850-90-5, which will be addressed in the WAN engineering guidelines, IEC 61850-90-12<sup>2</sup>.

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:\_\_\_<sup>3</sup>, *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<sup>4</sup>*

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<sup>3</sup> To be published.

<sup>4</sup> 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)*

Withdrawn