



BSI Standards Publication

Power systems management and associated information exchange

Part 200: Guidelines for migration from
Internet Protocol version 4 (IPv4) to Internet
Protocol version 6 (IPv6)

National foreword

This Published Document is the UK implementation of IEC/TR 62357-200:2015.

The UK participation in its preparation was entrusted to Technical Committee PEL/57, Power systems management and associated information exchange.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

© The British Standards Institution 2015.

Published by BSI Standards Limited 2015

ISBN 978 0 580 90080 8

ICS 33.200

Compliance with a British Standard cannot confer immunity from legal obligations.

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 31 August 2015.

Amendments/corrigenda issued since publication

Date	Text affected
-------------	----------------------



TECHNICAL REPORT



**Power systems management and associated information exchange –
Part 200: Guidelines for migration from Internet Protocol version 4 (IPv4) to
Internet Protocol version 6 (IPv6)**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 33.200

ISBN 978-2-8322-2795-4

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

FOREWORD.....	6
INTRODUCTION.....	8
1 Scope.....	9
2 Normative references	9
3 Terms, definitions, abbreviated terms, acronyms and conventions	13
3.1 Terms and definitions.....	13
3.2 Abbreviations	14
3.3 Conventions.....	16
3.4 Network diagram symbols	16
4 Internet technologies	17
4.1 Internet Protocol Version 4 (IPv4)	17
4.1.1 Origin	17
4.1.2 IPv4 packet transmission over Ethernet	17
4.1.3 IPv4 header	18
4.1.4 IPv4 addresses.....	19
4.1.5 IPv4 fragmentation and packet size	20
4.1.6 IPv4 auxiliary protocols.....	20
4.1.7 IPv4 routing.....	21
4.2 Internet Protocol Version 6 (IPv6)	21
4.2.1 IPv6 motivation.....	21
4.2.2 IPv6 packets on Ethernet.....	21
4.2.3 IPv6 addresses.....	22
4.2.4 IPv6 auxiliary protocols.....	24
4.2.5 IPv6 fragmentation and packet size	25
4.2.6 IPv6 routing.....	25
4.3 Comparison IPv4 and IPv6.....	25
4.3.1 Main differences	25
4.3.2 IPv4 and IPv6 address classes	25
4.3.3 Address representation in IEC 61850.....	26
5 Transition from IPv4 to IPv6	27
5.1 IPv6 migration necessity	27
5.2 Migration types	27
5.3 IPv6 migration impact on power systems communications.....	28
6 Migration methods	29
6.1 Migration principles.....	29
6.2 Address mapping	29
6.2.1 Address mapping from IPv4 to IPv6	29
6.2.2 General application impact of IPv6 addresses	30
6.2.3 Address migration in IEC 61850.....	30
6.3 Dual-stack devices.....	32
6.3.1 General	32
6.3.2 Standard dual-stack.....	34
6.3.3 IEC 61850 stack with IPv4 and IPv6	35
6.3.4 Migrating applications in dual-stack by Bump-in-the Host	35
6.3.5 Dual-stack recommendations.....	36
6.4 Tunneling.....	37

6.4.1	Tunneling principle	37
6.4.2	Standardized tunneling protocols	37
6.4.3	Tunneling IPv4 over IPv6.....	38
6.4.4	Standardized IPv6 over IPv4 tunneling protocols	41
6.4.5	Tunneling conclusion	42
6.5	Translation.....	42
6.5.1	Translation principle	42
6.5.2	Translation from IPv4 to IPv6.....	43
6.5.3	Translation implementation.....	44
6.5.4	Standardized translators	45
6.5.5	Translator conclusion	45
6.6	Migration plan	45
6.6.1	Procedure.....	45
6.6.2	Security considerations.....	46
7	Utility protocols based on the Internet Protocol	46
7.1	Utility protocols on Layer 3.....	46
7.2	Layer 3 communication in IEC 61850	47
7.2.1	Direct Layer 3 communication.....	47
7.2.2	Layer 3 communication by Network Address Translator (NAT).....	47
7.2.3	Layer 3 communication by Application-Level Gateway (proxy)	48
7.3	IEC 61850 Layer 3 communication for Layer 2 traffic	49
7.4	Other utility protocols	50
7.5	Virtual Private Network and overlays.....	50
8	Scenarios for substation automation	50
8.1	Scenario overview.....	50
8.2	Scenario 1: Substation-external communication over IPv6 only	51
8.2.1	Scenario 1: Description.....	51
8.2.2	Scenario 1.1: Substation to substation Layer 2 tunneling IPv4 over IPv6	51
8.2.3	Scenario 1.2: substation to control centre: tunneling IPv4 over IPv6	52
8.2.4	Scenario 1: Evaluation.....	52
8.3	Scenario 2: Access from IPv6 devices through ALGs and translators	53
8.3.1	Scenario 2.1: substation to engineering over dual-stack engineering	53
8.3.2	Scenario 2.2 substation to control centre by ALG.....	53
8.3.3	Scenario 2.3: substation to SCADA / engineering by translator/proxy	54
8.3.4	Scenario 2: Evaluation.....	55
8.4	Scenario 3: Substation partially or totally IPv6	55
8.4.1	Scenario 3: Description.....	55
8.4.2	Scenario 3.1: substation with dual-stack devices	55
8.4.3	Scenario 3: Evaluation.....	56
8.5	Scenario 4: Intermediate devices as ALGs	56
8.5.1	Phasor Data Concentrators (PDC) as ALGs.....	56
8.5.2	XMPP servers as ALGs	57
8.5.3	Scenario 4 evaluation	58
8.6	Scenario 5: Integration of IPv6-only devices in a legacy IPv4 network.....	58
8.6.1	IPv6-only devices communicating over an IPv4 network	58
8.6.2	IPv6-only devices accessed from an IPv4 SCADA	59
8.6.3	Scenario 5 evaluation	60
9	Use Case: Generation plant- IPv4 to IPv6 migration	60
9.1	General description.....	60

9.2	Legacy IPv4 addressing plan	62
9.3	IPv6 addressing plan and coexistence	62
9.4	Advantages	63
9.5	Issues	63
10	Recommendations	63
10.1	Recommendations for manufacturers	63
10.2	Recommendations for network engineers	64
10.3	Recommendations for IEC standardization	64
10.4	Timetable for implementation of the migration plan	65
	Bibliography	66
	Figure 1 – Symbols	17
	Figure 2 – Ethernet frame with IP network header	18
	Figure 3 – Mapping of IPv4 header to Ethernet frames	19
	Figure 4 – Transmission of an IPv6 packet in an Ethernet frame	22
	Figure 5 – IPv6 unicast address structure	23
	Figure 6 – IPv6 ULA address structure	24
	Figure 7 – IPv6 link local address structure	24
	Figure 8 – IPv6 evolution	27
	Figure 9 – Mapping of IPv4 to IPv6 addresses	29
	Figure 10 – Dual-Stack devices (with two and one port)	32
	Figure 11 – Dual-Stack devices in a mixed domain	33
	Figure 12 – Dual-Stack devices across routers	34
	Figure 13 – IEC 61850 stack with IPv4 and IPv6 (doubly attached)	35
	Figure 14 – Bump-in-the-host migration method	36
	Figure 15 – Tunneling principle	37
	Figure 16 – Tunneling IPv4 over IPv6	38
	Figure 17 – Tunneling IPv4 over IPv6 and VLANs	40
	Figure 18 – Translator principle	43
	Figure 19 – Translation of IPv4 to IPv6	43
	Figure 20 – Translation of IPv6 to IPv4	44
	Figure 21 – Translator principle of IPv4 to IPv6	45
	Figure 22 – Layer 3 direct connection	47
	Figure 23 – Layer 3 connection over NAT	48
	Figure 24 – Layer 3 connection via ALG	49
	Figure 25 – Layer 2 tunneling over Layer 3 WAN or other transport	49
	Figure 26 – Layer 2 frames tunneled over IPv4 in IEC TR 61850-90-5 (simplified)	50
	Figure 27 – IPv4 substation to substation over IPv6	52
	Figure 28 – IPv4 substation to external IPv6 over tunnel	52
	Figure 29 – IPv4 substation to external IPv6 client for engineering	53
	Figure 30 – IPv4 substation to external IPv6 over gateway	54
	Figure 31 – IPv4 substation to external IPv6 over translator / proxy	54
	Figure 32 – IPv4 substation with dual-stack devices	55
	Figure 33 – PDCs as ALGs	57

Figure 34 – Translation by XMPP servers 58

Figure 35 – IPv6-only sensors connected to legacy IPv4 network 59

Figure 36 – IPv6-only sensors connected to legacy IPv4 network 60

Figure 37 – Generation system telecontrol overview 61

Table 1 – Differences between IPv4 and IPv6 25

Table 2 – IPv6 vs IPv4 addresses (RFC 4291) 26

Table 3 – Dual-stack comparison 35

Table 4 – IPv4 over IPv6 tunnels 41

Table 5 – IPv6 over IPv4 tunnels 42

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**POWER SYSTEMS MANAGEMENT AND
ASSOCIATED INFORMATION EXCHANGE –****Part 200: Guidelines for migration from Internet Protocol version 4 (IPv4)
to Internet Protocol version 6 (IPv6)**

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.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a technical report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

IEC TR 62357-200, 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
57/1563/DTR	57/1580/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 62357 series, published under the general title *Power systems management and associated information exchange*, 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 website 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

This Technical Report provides definitions, guidelines, and recommendations for migration of data communication protocols which are today using the Internet Protocol version 4 (IPv4) to the Internet Protocol version 6 (IPv6).

This Technical Report addresses data communication for power systems at all voltage levels, from transmission level down to the low voltage. It is in addition useful for any other application domain which specifies the use of IP transport.

This Technical Report starts with a tutorial on the aspects of IPv4 and IPv6 technologies that are relevant for the migration.

This Technical Report addresses issues such as motivation for migration, migration strategies in general and specific application in power systems communications.

This Technical Report contains recommendations for the device manufacturers, network engineers and for standardization bodies.

This Technical Report defines a time table for the standard bodies defining data communication in power systems, as follows:

- All new or revised IEC documents support IPv6 as an option for projects that mandate it, starting in 2015.
- All IEC documents request both IPv6 and IPv4 support, while use is not mandatory, until 2030.
- All IEC documents consider IPv4 as deprecated after 2050.

POWER SYSTEMS MANAGEMENT AND ASSOCIATED INFORMATION EXCHANGE –

Part 200: Guidelines for migration from Internet Protocol version 4 (IPv4) to Internet Protocol version 6 (IPv6)

1 Scope

This part of IEC 62357, which is a Technical Report, applies to information exchange in power systems including, but not restricted to, substations, control centre, maintenance centre, energy management systems, synchrophasor-based grid stability systems, bulk energy generation (including fossil fuel plants), distributed energy generation (renewables, wind and solar), energy storage, load management (demand side management and demand response for distribution level consumers or producers).

This Technical Report addresses the issues encountered when migrating from Internet Protocol version 4 (IPv4) to the Internet Protocol version 6 (IPv6). It describes migration strategies, covering impact on applications, communication stack, network nodes, configuration, address allocation, cyber security and the related management.

This Technical Report considers backward compatibility and show concepts as well as necessary migration paths to IPv6 from IPv4 where necessary, for a number of protocols in the IEC 61850 framework.

Following a review of IEC standards and technical reports according to the reference architecture for power system information exchange (IEC 62357-1), this Technical Report supports modifications caused by the introduction of IPv6 for revision of these documents, considering the impact of permitting or requiring IPv6.

This Technical Report does not impose the use of the IPv6 technology in utility communications.

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 60870-5-104, *Telecontrol equipment and systems – Part 5-104: Transmission protocols – Network access for IEC 60870-5-101 using standard transport profiles*

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

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*