

DIN EN 62056-8-4



ICS 33.200; 35.240.99; 91.140.50

Einsprüche bis 2018-04-09

Entwurf

**Datenkommunikation der elektrischen Energiemessung –
DLMS/COSEM –
Teil 8-4: Kommunikationsprofile für Schmalband-OFDM-PLC-PRIME-
Nachbarschaftsnetzwerke
(IEC 13/1749/CDV:2017);
Englische Fassung prEN 62056-8-4:2017**

Electricity metering data exchange –
The DLMS/COSEM suite –
Part 8-4: Communication profiles for narrow-band OFDM PLC PRIME neighbourhood
networks
(IEC 13/1749/CDV:2017);
English version prEN 62056-8-4:2017

Échange de données de comptage de l'électricité –
La suite DLMS/COSEM –
Partie 8-4: Profils de communication pour réseaux de voisinage OFDM PLC PRIME à
bande étroite
(IEC 13/1749/CDV:2017);
Version anglaise prEN 62056-8-4:2017

Anwendungswarnvermerk

Dieser Norm-Entwurf mit Erscheinungsdatum 2018-02-09 wird der Öffentlichkeit zur Prüfung und
Stellungnahme vorgelegt.

Weil die beabsichtigte Norm von der vorliegenden Fassung abweichen kann, ist die Anwendung dieses
Entwurfs besonders zu vereinbaren.

Stellungnahmen werden erbeten

- vorzugsweise online im Norm-Entwurfs-Portal von DIN unter www.din.de/go/entwuerfe bzw. für Norm-Entwürfe der DKE auch im Norm-Entwurfs-Portal der DKE unter www.entwuerfe.normenbibliothek.de, sofern dort wiedergegeben;
- oder als Datei per E-Mail an dke@vde.com möglichst in Form einer Tabelle. Die Vorlage dieser Tabelle kann im Internet unter www.din.de/go/stellungnahmen-norm-entwuerfe oder für Stellungnahmen zu Norm-Entwürfen der DKE unter www.dke.de/stellungnahme abgerufen werden;
- oder in Papierform an die DKE Deutsche Kommission Elektrotechnik Elektronik Informationstechnik in DIN und VDE, Stresemannallee 15, 60596 Frankfurt am Main.

Die Empfänger dieses Norm-Entwurfs werden gebeten, mit ihren Kommentaren jegliche relevanten
Patentrechte, die sie kennen, mitzuteilen und unterstützende Dokumentationen zur Verfügung zu stellen.

Gesamtumfang 83 Seiten

DKE Deutsche Kommission Elektrotechnik Elektronik Informationstechnik in DIN und VDE

Nationales Vorwort

Die Englische Fassung des europäischen Dokuments prEN 62056-8-4:2017 „Datenkommunikation der elektrischen Energiemessung – DLMS/COSEM – Teil 8-4: Kommunikationsprofile für Schmalband-OFDM-PLC-PRIME-Nachbarschaftsnetzwerke“ (Entwurf in der Umfrage) ist unverändert in diesen Norm-Entwurf übernommen worden.

Die Internationale Elektrotechnische Kommission (IEC) und das Europäische Komitee für Elektrotechnische Normung (CENELEC) haben vereinbart, dass ein auf IEC-Ebene erarbeiteter Entwurf für eine Internationale Norm zeitgleich (parallel) bei IEC und CENELEC zur Umfrage (CDV-Stadium) und Abstimmung als FDIS (en: Final Draft International Standard) bzw. Schluss-Entwurf für eine Europäische Norm gestellt wird, um eine Beschleunigung und Straffung der Normungsarbeit zu erreichen. Dem entsprechend ist das internationale Dokument IEC 13/1749/CDV:2017 „Electricity metering data exchange – The DLMS/COSEM suite – Part 8-4: Communication profiles for narrow-band OFDM PLC PRIME neighbourhood networks“ unverändert in den Entwurf prEN 62056-8-4:2017 übernommen worden.

Das internationale Dokument wurde vom TC 13 „Electrical energy measurement and control“ der Internationalen Elektrotechnischen Kommission (IEC) erarbeitet.

Bei der Abstimmung zu dem Europäischen Schluss-Entwurf bei CENELEC und dem Internationalen Schluss-Entwurf bei IEC [Final Draft International Standard (FDIS)] sind jeweils nur „JA/NEIN“-Entscheidungen möglich, wobei „NEIN“-Entscheidungen fundiert begründet werden müssen. Dokumente, die bei CENELEC als Europäische Norm angenommen und ratifiziert werden, sind unverändert als Deutsche Normen zu übernehmen.

Für dieses Dokument ist das nationale Arbeitsgremium K 461 „Messeinrichtungen und -systeme für Elektrizität“ der DKE Deutsche Kommission Elektrotechnik Elektronik Informationstechnik in DIN und VDE (www.dke.de) zuständig.

Für den Fall einer undatierten Verweisung im normativen Text (Verweisung auf ein Dokument ohne Angabe des Ausgabedatums und ohne Hinweis auf eine Abschnittsnummer, eine Tabelle, ein Bild usw.) bezieht sich die Verweisung auf die jeweils aktuellste Ausgabe des in Bezug genommenen Dokuments.

Für den Fall einer datierten Verweisung im normativen Text bezieht sich die Verweisung immer auf die in Bezug genommene Ausgabe des Dokuments.

Der Zusammenhang der zitierten Dokumente mit den entsprechenden deutschen Dokumenten ergibt sich, soweit ein Zusammenhang besteht, grundsätzlich über die Nummer der entsprechenden IEC-Publikation. Beispiel: IEC 60068 ist als EN 60068 als Europäische Norm durch CENELEC übernommen und als DIN EN 60068 ins Deutsche Normenwerk aufgenommen.

Das Präsidium des DIN hat mit Präsidialbeschluss 1/2004 festgelegt, dass DIN-Normen, deren Inhalt sich auf internationale Arbeitsergebnisse der Informationsverarbeitung gründet, unter bestimmten Bedingungen allein in englischer Sprache veröffentlicht werden dürfen. Diese Bedingungen sind für den vorliegenden Normentwurf erfüllt.

Da sich die Benutzer des vorliegenden Normentwurfs der englischen Sprache als Fachsprache bedienen, wird die Englische Fassung der EN 62056-8-4 veröffentlicht. Zu deren Abschnitt 1, der den Anwendungsbereich festlegt, Abschnitt 3, der die Begriffe festlegt, und Abschnitt 4 wurde eine Übersetzung angefertigt und als informativer Nationaler Anhang NA des vorliegenden Normentwurfs hinzugefügt. Für viele der verwendeten Begriffe existieren keine gebräuchlichen deutschen Benennungen, da sich die deutschen Anwender in der Regel ebenfalls der englischen Benennungen bedienen. Dieser Normentwurf steht nicht in unmittelbarem Zusammenhang mit Rechtsvorschriften und ist nicht als Sicherheitsnorm anzusehen.

Es ist vorgesehen, auch bei der entsprechenden zukünftigen Deutschen Norm auf die deutsche Sprachfassung zu verzichten und diese in der englischsprachigen Fassung zu veröffentlichen.

Es wird auf die Möglichkeit hingewiesen, dass einige Elemente dieses Dokuments Patentrechte berühren können. IEC ist nicht dafür verantwortlich, einige oder alle diesbezüglichen Patentrechte zu identifizieren.

Nationaler Anhang NA (informativ)

Auszugsweise Übersetzung^{N1)}

1 Anwendungsbereich

Diese Internationale Norm legt DLMS/COSEM-Kommunikationsprofile für Schmalband-OFDM-PRIME-Nachbarschaftsnetzwerke mit Trägerfrequenzübertragung auf Hochspannungsleitungen unter Verwendung der in Recommendation ITU-T G.9904:2012 festgelegten Modulation fest.

Es werden drei Kommunikationsprofile festgelegt:

- ein Profil, das die LLC-Schicht nach IEC 61334-4-32 verwendet;
- ein Profil, das TCP-UDP/IPv4 verwendet;
- ein Profil, das TCP-UDP/IPv6 verwendet.

3 Begriffe und Abkürzungen

3.1 Begriffe

Für die Anwendung dieses Dokuments gelten die folgenden Begriffe.

Siehe auch Recommendation ITU-T G.9904:2012.

3.1.1

Basisknoten

Masterknoten, der die Ressourcen eines Teilnetzes steuert und verwaltet

3.1.2

Registrierung

Prozess, durch den ein Dienstknoten als Teilnehmer des Teilnetzes akzeptiert und ihm eine LNID zugewiesen wird

3.1.3

Dienstknoten

jeder Knoten eines Teilnetzes, der kein Basisknoten ist

3.1.4

Registrierungsaufhebung

Prozess, durch den ein Dienstknoten ein Teilnetz verlässt

3.2 Abkürzungen

AA	Anwendungsassoziation	(en: Application Association)
AARE	A-Associate-Antwort	(en: Application Association Response)
AARQ	A-Associate-Anforderung	(en: Application Association Request)
ACSE	Anwendungssteuerungs-Dienstelement	(en: Application Control Service Element)
AL	Anwendungsschicht	(en: Application Layer)

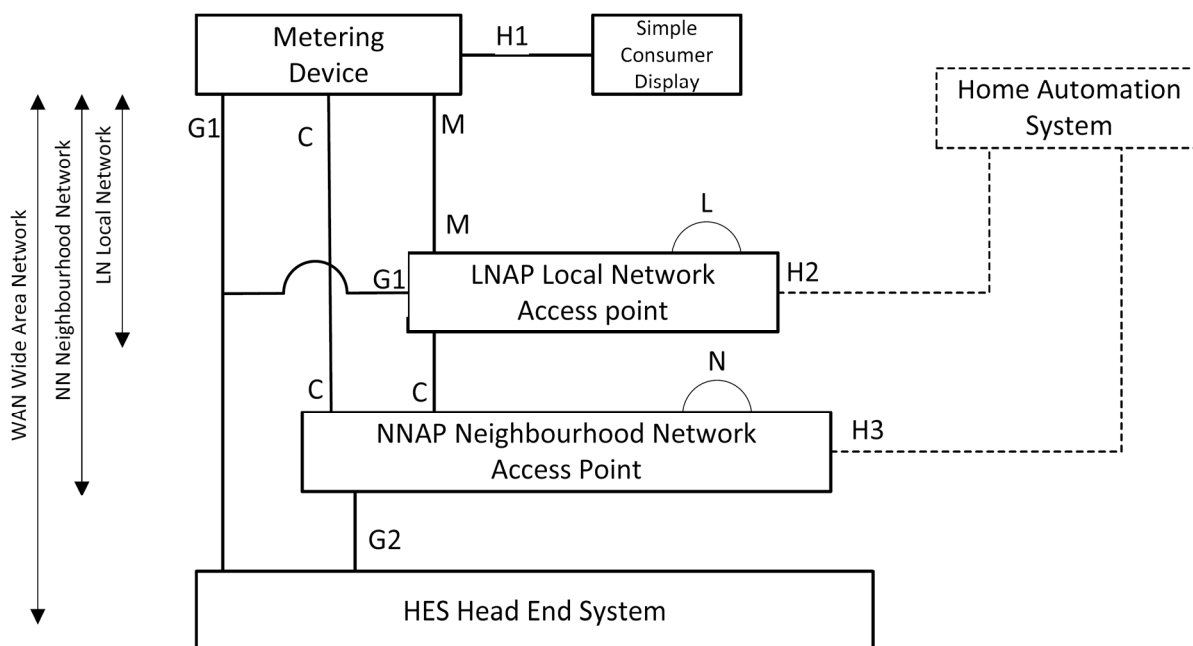
^{N1)} Nationale Fußnote: Die Nummerierung aus IEC 13/1749/CDV:2017-08 wurde beibehalten.

AP	Anwendungsprozess	(en: Application Process)
APDU	Protokolldateneinheit der Anwendungsschicht	(en: Application Protocol Data Unit)
ARQ	automatische Wiederholungsanfrage	(en: Automatic Repeat Request)
CL	Konvergenzschicht	(en: Convergence Layer)
.cnf	Bestätigungs-Dienstprimitiv	(en: Confirm service primitive)
COSEM	Begleitspezifikation für die Energiemessung	(en: Companion Specification for Energy Metering)
CPCS	gemeinsamer Teil der Konvergenzteilschicht	(en: Common Part Convergence Sublayer)
CSMA/CA	Carrier Sense Multiple Access mit Kollisionsvermeidung	(en: Carrier Sense Multiple Access – Collision Avoidance)
D8PSK	differentielle Achtphasenumtastung	(en: Differential Eight-Phase Shift Keying)
DBPSK	differentielle binäre Phasenumtastung	(en: Differential Binary Phase Shift Keying)
DGW	Standardgateway	(en: Default Gateway)
DHCP	dynamisches Konfigurations-Protokoll	(en: Dynamic Host Configuration Protocol)
DLMS	Device Language Message Specification	(en: Device Language Message Specification)
DQPSK	differentielle Quadraturphasenumtastung	(en: Differential Quaternary Phase Shift Keying)
EUI-48	Erweiterte eindeutige Kennung mit einer Länge von 48 Bit	(en: 48-bit Extended Unique Identifier)
FU	Firmware-Upgrade	(en: Firmware Upgrade)
FW	Firmware	(en: Firmware)
IANA	Internet Assigned Numbers Authority	(en: Internet Assigned Numbers Authority)
IGMP	Internet-Gruppenmanagementprotokoll	(en: Internet Group Management Protocol)
.ind	Anzeige-Dienstprimitiv	(en: Indication service primitive)
IP	Internetprotokoll	(en: Internet Protocol)
IPv4	Internetprotokoll, Version 4	(en: Internet Protocol, version 4)
IPv6	Internetprotokoll, Version 6	(en: Internet Protocol, version 6)
LCID	lokale Verbindungskennung	(en: Local Connection Identifier)
LD	logisches Gerät	(en: Logical Device)
LLC	logische Verknüpfungssteuerung (Teilschicht)	(en: Logical Link Control (sub-layer))
LNID	lokale Knotenkennung	(en: Local Node Identifier)
MAC	Steuerung für Mediumzugriff, MAC-Teilschicht-Einheit	(en: Medium Access Control, MAC sublayer entity)
MLME	MAC-Schicht-Managmenteinheit	(en: MAC Layer Management Entity)
MPDU	MAC-Protokolldateneinheit	(en: MAC Protocol Data Unit)
NAT	Netzwerkadressübersetzung	(en: Network Address Translation)
NHC	Kompression des nächsten Headers	(en: Next Header Compression)

NL	Rauschpegel	(en: Noise Level)
OBIS	Objektidentifikationssystem	(en: Object Identification System)
OFDM	orthogonales Frequenzmultiplexverfahren	(en: Orthogonal Frequency Division Multiplexing)
OSI	Kommunikation offener Systeme	(en: Open System Interconnection)
PHY	Einheit der Bitübertragungsschicht	(en: Physical Layer entity)
PLC	Kommunikation offener Systeme	(en: Power Line Communication)
PIB	PLC-Informationsdatenbank	(en: PLC Information Base)
PLME	Managementeinheit der Bitübertragungsschicht	(en: Physical Layer Management Entity)
PPDU	Protokolldateneinheit der Bitübertragungsschicht	(en: PHY Protocol Data Unit)
.req	Anforderungs-Dienstprimitiv	(en: Request service primitive)
RFC	Request for Comment	(en: Request For Comment)
.rsp	Antwort-Dienstprimitiv	(en: Response service primitive)
SDU	Dienstdateneinheit	(en: Service Data Unit)
SID	Schalterkennung	(en: Switch Identifier)
SNA	Teilnetzadresse	(en: Subnetwork Address)
SNR	Signal-Rausch-Verhältnis	(en: Signal-to-Noise Ratio)
SSCS	dienstspezifische Konvergenzteilschicht	(en: Service Specific Convergence Sublayer)
TCP	Übertragungssteuerungsprotokoll	(en: Transmission Control Protocol)
TOS	Dienststart	(en: Type Of Service)
UDP	Benutzer-Datagramm-Protokoll	(en: User Datagram Protocol)
xDLMS_ASE	erweitertes DLMS-Anwendungsdienstelement	(en: extended DLMS Application Service Element)
ZCT	Nulldurchgangs-Zeitpunkt	(en: Zero Crossing Time)

4 Betroffene Kommunikationsumgebungen

Die DLMS/COSEM-Kommunikationsprofile für Schmalband-OFDM-PLC-PRIME-Nachbarschaftsnetzwerke sind für den Datenfernaustausch in Nachbarschaftsnetzwerken (en: neighbourhood network; NN) zwischen Nachbarschaftsnetzwerk-Zugangspunkten (en: neighbourhood network access point; NNAP) und Zugangspunkten zum lokalen Netzwerk (en: local network access point; LNAP) oder Endgeräten mit OFDM-PLC-Technik über das Niederspannungs-Elektrizitätsverteilungsnetz als Kommunikationsmedium vorgesehen. Die funktionale Referenzarchitektur ist in Bild 1 dargestellt.



Text im Bild:

englisch

WAN Wide Area Network

NN Neighbourhood Network

LN Local Network

Metering Device

H1

G1

C

M

Simple Consumer Display

Home Automation System

LNAP Local Network Access Point

NNAP Neighbourhood Network Access Point

HES Head End System

N

deutsch

WAN Weitverkehrsnetz

NN Nachbarschaftsnetzwerk

LN Lokales Netz

Zählerendgerät

H1

G1

C

M

Einfache Verbraucheranzeige

Gebäudeautomatisierungssystem

LNAP Zugangspunkt zum lokalen Netzwerk

NNAP Nachbarschaftsnetzwerk-Zugangspunkt

HES-Konzentrator

N

Bild 1 – Kommunikationsarchitektur

Die Endgeräte – üblicherweise Elektrizitätszähler – sind mit Anwendungsfunktionen und Kommunikationsfunktionen ausgestattet. Sie dürfen entweder direkt über die Schnittstelle C mit dem NNAP oder über eine Schnittstelle M mit einem LNAP verbunden werden, wobei der LNAP über die Schnittstelle C mit dem NNAP verbunden wird. Die LNAP-Funktion darf in die Messfunktionen integriert sein.

Ein NNAP umfasst Gatewayfunktionen und darf Konzentratorfunktionen übernehmen. In Aufwärtsrichtung ist er über geeignete Kommunikationsmedien und -protokolle mit dem Zähler-Konzentrator (en: head end system; HES) verbunden.

Endgeräte und LNAPs dürfen mit verschiedenen NNAPs kommunizieren, jedoch nicht zeitgleich mit mehreren NNAPs. Aus Sicht der PLC-Kommunikation fungiert der NNAP als Basisknoten, während Endgeräte und LNAPs als Dienstknoten fungieren.

NNAPs und auch LNAPs dürfen miteinander kommunizieren, dies fällt jedoch nicht in den Anwendungsbereich dieser Internationalen Norm, welche nur die Schnittstelle C behandelt.

Wenn der NNAP Konzentratorkfunktionen übernimmt, fungiert er als DLMS/COSEM-Client. Wenn der NNAP nur die Gatewayfunktion übernimmt, so fällt die Rolle des DLMS/COSEM-Clients dem HES zu. Die Endgeräte oder die LNAPs übernehmen die Rolle von DLMS/COSEM-Servern.

Auch eine gemischte Architektur ist möglich, sowohl der HES als auch der NNAP können also als Client fungieren.

– Leerseite –

CONTENTS

2			
3			
4	1	Scope	12
5	2	Normative references	12
6	3	Terms, definitions and abbreviations	14
7	3.1	Terms and definitions.....	14
8	3.2	Abbreviations.....	14
9	4	Targeted communication environments.....	16
10	5	Use of the communication layers for this profile.....	16
11	5.1	Information related to the use of the standard specifying the lower layers	16
12	5.2	The structure of the communication profiles	17
13	5.2.1	Overview	17
14	5.2.2	The IEC 61334-4-32 profile.....	17
15	5.2.3	The TCP-UDP/IPv4 profile	18
16	5.2.4	The TCP-UDP/IPv6 profile	18
17	5.3	Lower protocol layers and their use	18
18	5.3.1	General	18
19	5.3.2	Physical layer	18
20	5.3.2.1	General.....	18
21	5.3.2.2	PRIME PHY data plane services	18
22	5.3.2.3	PRIME PHY control plane services	18
23	5.3.2.4	PRIME PHY management plane services	18
24	5.3.3	MAC layer	19
25	5.3.3.1	Overview – main features and functions.....	19
26	5.3.3.2	Services used by base node and service nodes	19
27	5.3.3.3	Management services	20
28	5.4	Service mapping and convergence layers	20
29	5.4.1	Overview	20
30	5.4.2	The IEC 61334-4-32 LLC SSCS.....	20
31	5.4.2.1	General.....	20
32	5.4.2.2	CL_432_DATA services	21
33	5.4.2.2.1	General	21
34	5.4.2.2.2	CL_432_DATA services	22
35	5.4.2.2.3	DL_Broadcast services	22
36	5.4.2.2.4	DL_Reply and DL_Update_Reply services	22
37	5.4.3	The IPv4 SSCS	22
38	5.4.3.1	Data services.....	22
39	5.4.3.1.1	General	22
40	5.4.3.1.2	CL_IPv4_DATA.request	22
41	5.4.3.1.3	CL_IPv4_DATA.confirm	23
42	5.4.3.1.4	CL_IPv4_DATA.indicate	23
43	5.4.4	The IPv6 SSCS	23
44	5.4.4.1	Data services.....	23
45	5.4.4.1.1	General	23
46	5.4.4.1.2	CL_IPv6_DATA.request	23
47	5.4.4.1.3	CL_IPv6_DATA.confirm	24
48	5.4.4.1.4	CL_IPv6_DATA.indicate	24
49	5.5	Registration and connection management.....	24

50	5.5.1	Overview	24
51	5.5.2	IEC 61334-4-32 profile.....	25
52	5.5.2.1	Connection management services.....	25
53	5.5.2.1.1	Overview	25
54	5.5.2.1.2	CL_432_ESTABLISH.request	25
55	5.5.2.1.3	CL_432_ESTABLISH.confirm.....	25
56	5.5.2.1.4	CL_432_JOIN.indicate	26
57	5.5.2.1.5	CL_432_RELEASE.request.....	27
58	5.5.2.1.6	CL_432_RELEASE.confirm.....	27
59	5.5.2.1.7	CL_432_LEAVE.indicate	28
60	5.5.2.2	Summary of the connection management services	28
61	5.5.3	TCP-UDP/IPv4 profile	29
62	5.5.3.1	Overview.....	29
63	5.5.3.1.1	General architecture	29
64	5.5.3.1.2	The TCP connection manager.....	30
65	5.5.3.1.3	TCP-UDP/IPv4.....	30
66	5.5.3.1.4	Subnetwork gateway.....	30
67	5.5.3.2	Opening and closing the IPv4 SSCS	31
68	5.5.3.2.1	General	31
69	5.5.3.2.2	CL_IPv4_ESTABLISH.request	31
70	5.5.3.2.3	CL_IPv4_ESTABLISH.confirm	31
71	5.5.3.2.4	CL_IPv4_RELEASE.request	32
72	5.5.3.2.5	CL_IPv4_RELEASE.confirm.....	32
73	5.5.3.3	Unicast address management	32
74	5.5.3.3.1	General	32
75	5.5.3.3.2	CL_IPv4_REGISTER.request.....	33
76	5.5.3.3.3	CL_IPv4_REGISTER.confirm.....	33
77	5.5.3.3.4	CL_IPv4_UNREGISTER.request.....	34
78	5.5.3.3.5	CL_IPv4_UNREGISTER.confirm	34
79	5.5.3.4	Multicast group management	34
80	5.5.3.4.1	General	34
81	5.5.3.4.2	CL_IPv4_IGMP_Join.req.....	34
82	5.5.3.4.3	CL_IPv4_IGMP_JOIN.confirm.....	35
83	5.5.3.4.4	CL_IPv4_IGMP_LEAVE.request	35
84	5.5.3.4.5	CL_IPv4_IGMP_LEAVE.confirm.....	35
85	5.5.3.5	IPv4 SSCS PDUs.....	36
86	5.5.3.5.1	General	36
87	5.5.3.5.2	Address resolution PDUs	36
88	5.5.3.5.2.1	General	36
89	5.5.3.5.2.2	AR_REGISTER_S.....	36
90	5.5.3.5.2.3	AR_REGISTER_B.....	36
91	5.5.3.5.2.4	AR_UNREGISTER_S.....	37
92	5.5.3.5.2.5	AR_MCAST_REG_S.....	37
93	5.5.3.5.2.6	AR_MCAST_REG_B.....	37
94	5.5.3.5.2.7	AR_MCAST_UNREG_S.....	37
95	5.5.3.5.2.8	AR_MCAST_UNREG_B.....	38
96	5.5.3.5.3	Data connection establishment	38
97	5.5.3.5.3.1	Overview	38
98	5.5.3.5.3.2	AR_LOOKUP_S.....	

99		5.5.3.5.3.3 AR_LOOKUP_B.....	38
100	5.5.3.6	IPv4 SSCS packet format.....	39
101		5.5.3.6.1 General	39
102		5.5.3.6.2 IPv4 packet format without header compression	39
103		5.5.3.6.3 IPv4 packet format with Van Jacobsen header	
104		compression	39
105	5.5.3.7	Connection data.....	39
106		5.5.3.7.1 General	39
107		5.5.3.7.2 Connection data from the initiator	39
108		5.5.3.7.3 Connection data from the responder	40
109	5.5.4	TCP-UDP/IPv6 profile	40
110		5.5.4.1 Overview.....	40
111		5.5.4.1.1 General architecture	40
112		5.5.4.1.2 IPv6 unicast addressing assignment	40
113		5.5.4.1.3 Role of the base node.....	41
114		5.5.4.2 IPv6 SSCS.....	41
115		5.5.4.2.1 General	41
116		5.5.4.2.2 Routing in the subnetwork	41
117		5.5.4.2.3 CPCS: Segmentation and reassembly.....	41
118		5.5.4.3 IPv6 Address Configuration.....	41
119		5.5.4.3.1 General	41
120		5.5.4.3.2 Interface identifier.....	41
121		5.5.4.3.3 IPv6 Link local address configuration	41
122		5.5.4.3.4 Stateless address auto configuration	42
123		5.5.4.3.5 Stateful address auto configuration.....	42
124		5.5.4.3.6 Multicast address.....	42
125		5.5.4.3.7 Address resolution	42
126		5.5.4.3.7.1 General	42
127		5.5.4.3.7.2 Unicast address	42
128		5.5.4.4 IPv6 packet transfer	43
129		5.5.4.5 Segmentation and reassembly	44
130		5.5.4.6 Compression.....	44
131		5.5.4.7 Quality of Service Mapping	44
132		5.5.4.8 Opening and closing the IPv6 SSCS	44
133		5.5.4.8.1 General	44
134		5.5.4.8.2 CL_IPv6_ESTABLISH.request	45
135		5.5.4.8.3 CL_IPv6_Establish.confirm	45
136		5.5.4.8.4 CL_IPv6_Release.request	45
137		5.5.4.8.5 CL_IPv6_Release.confirm.....	46
138		5.5.4.9 Unicast address management	46
139		5.5.4.9.1 General	46
140		5.5.4.9.2 CL_IPv6_Register.request	46
141		5.5.4.9.3 CL_IPv6_Register.confirm	47
142		5.5.4.9.4 CL_IPv6_UNREGISTER.request.....	47
143		5.5.4.9.5 CL_IPv6_Unregister.confirm	47
144		5.5.4.10 Multicast group management	48
145		5.5.4.10.1 General	48
146		5.5.4.10.2 CL_IPv6_MUL_Join.request.....	48
147		5.5.4.10.3 CL_IPv6_MUL_Join.confirm.....	48

148	5.5.4.10.4 CL_IPv6_MUL_Leave.request.....	48
149	5.5.4.10.5 CL_IPv6_MUL_Leave.confirm.....	49
150	5.5.4.11 IPv6 Packet formats and PDUs	49
151	5.5.4.11.1 Overview	49
152	5.5.4.11.2 Address resolution PDUs	49
153	5.5.4.11.2.1 General	49
154	5.5.4.11.2.2 AR_REGISTERv6_S	49
155	5.5.4.11.2.3 AR_REGISTERv6_B	49
156	5.5.4.11.2.4 AR_UNREGISTERv6_S	50
157	5.5.4.11.2.5 AR_UNREGISTERv6_B	50
158	5.5.4.11.2.6 AR_LOOKUPv6_S	50
159	5.5.4.11.2.7 AR_LOOKUPv6_B	50
160	5.5.4.11.2.8 AR_MCAST_REGv6_S	51
161	5.5.4.11.2.9 AR_MCAST_REGv6_B	51
162	5.5.4.11.2.10 AR_MCAST_UNREGv6_S	51
163	5.5.4.11.3 IPv6 Packet format	52
164	5.5.4.11.3.1 General	52
165	5.5.4.11.3.2 No negotiated header compression.....	52
166	5.5.4.11.3.3 Header compression.....	52
167	5.5.4.11.4 Connection data	53
168	5.5.4.11.4.1 Overview	53
169	5.5.4.11.4.2 Connection data from the initiator	53
170	5.5.4.11.4.3 Connection data from the	
171	responder	53
172	6 Identification and addressing schemes	54
173	6.1 IEC 61334-4-4 profile addressing.....	54
174	6.1.1 Overview	54
175	6.1.2 MAC address.....	54
176	6.1.3 IEC 61334-4-32 SSCS addresses	54
177	6.1.4 LLC addresses	54
178	6.2 TCP-UDP/IPv4 profile addressing	55
179	6.3 TCP-UDP/IPv6 profile	55
180	7 Specific consideration for the application layer services	55
181	7.1 Overview	55
182	7.2 Application Association (AA) establishment and release: ACSE services	55
183	7.2.1 AA establishment: IEC 61334-4-32 profile	55
184	7.2.2 AA establishment: IP based profile	56
185	7.2.3 Application association release.....	56
186	7.2.3.1 General.....	56
187	7.2.3.2 IEC 61334-4-32 profile	57
188	7.2.3.3 TCP-UDP/IP profile.....	57
189	7.3 xDLMS services	57
190	7.4 Security mechanisms.....	57
191	7.4.1 DLMS/COSEM security.....	57
192	7.4.2 Lower layers security.....	57
193	7.5 Transferring long application messages	57
194	7.6 Media access, bandwidth and timing considerations	57
195	7.7 Other considerations.....	57
196	8 Communication configuration and management.....	

197	9	The COSEM application process	57
198	10	Additional considerations for the use of this profile	58
199		Annex A (informative) Examples	59
200	A.1	Data exchange between to IP communication peers	59
201	A.2	Joining a multicast group	61
202	A.3	PRIME encoding examples	62
203		Annex B (normative) New COSEM interfaces classes and OBIS codes	75
204		Annex C (informative) IEC 61334-4-32 profile: Error cases during connection	
205		establishment	76
206		Annex D (normative) Convergence layer constants	77
207			
208		Figure 1 – Communication architecture	16
209		Figure 2 – OFDM PLC PRIME communication profile architectures	17
210		Figure 3 – IEC 61334-4-32 SSCS services	21
211		Figure 4 – MSC for Data services in the case of logical name referencing	22
212		Figure 5 – IEC 61334-4-32 SSCS	25
213		Figure 6 – MSC for IEC 61334-4-32 SSCS services	28
214		Figure 7 – IPv4 SSCS services	30
215		Figure A. 1 – MSC of IPv4 SSCS services	60
216		Figure A. 2 – Joining MSC IPv4 profile	61
217		Figure C. 1 – Error cases during connection establishment	76
218			
219		Table 1 – Result values for SSCS services	28
220		Table 2 – AR_REGISTER_S message format	36
221		Table 3 – AR_REGISTER B message format	36
222		Table 4 – AR_UNREGISTER_S message format	37
223		Table 5 – AR_MCAST_REG_S message format	37
224		Table 6 – AR_MCAST_REG_B message format	37
225		Table 7 – AR_MCAST_UNREG_S message format	37
226		Table 8 – AR_MCAST_UNREG_B message format	38
227		Table 9 – AR_LOOKUP_S message format	38
228		Table 10 – AR_LOOKUP_B message format	38
229		Table 11 – IPv4 packet format without header compression negotiated	39
230		Table 12 – IPv4 packet format with VJ header compression	39
231		Table 13 – Connection data sent by the initiator	39
232		Table 14 – Connection data sent by the responder	40
233		Table 15 – IPv6 SSCS table entry	43
234		Table 16 – Mapping IPv6 precedence to PRIME MAC priority	44
235		Table 17 – AR_REGISTERv6_S message format	49
236		Table 18 – AR_REGISTERv6_B message format	50
237		Table 19 – AR_UNREGISTERv6_S message format	50
238		Table 20 – AR_UNREGISTERv6_B message format	50
239		Table 21 – AR_LOOKUPv6_S message format	50
240		Table 22 – AR_LOOKUPv6_B message format	50

241	Table 23 – AR_MCAST_REGv6_S message format	51
242	Table 24 – AR_MCAST_REGv6_B message format	51
243	Table 25 – AR_MCAST_UNREGv6_B message format	51
244	Table 26 – IPv6 Packet format without negotiated header compression	52
245	Table 27 – UDP/IPv6 Packet format with LOWPAN_IPHC header compression and	
246	LOWPAN_NHC	52
247	Table 28 – IPv6 Packet format with LOWPAN_IPHC negotiated header compression	52
248	Table 29 – IPv6 Connection signalling data sent by the initiator	53
249	Table 30 – IPv6 Connection signalling data sent by the responder	53
250	Table 31 – Client service access point values	55
251	Table 32 – Server service access point values	55
252	Table 33 – Application associations and data exchange in the IEC 61334-4-32 profile	56
253	Table D. 1 – TYPE value assignment	77
254		

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTRICITY METERING DATA EXCHANGE –
THE DLMS/COSEM SUITE –Part 8-4: Communication profiles for narrow-band OFDM PLC PRIME
neighbourhood networks

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 International Electrotechnical Commission (IEC) draws attention to the fact that it is claimed that compliance with this International Standard may involve the use of a maintenance service concerning the stack of protocols on which the present standard IEC 62056-8-20 is based.

The IEC takes no position concerning the evidence, validity and scope of this maintenance service.

The provider of the maintenance service has assured the IEC that he is willing to provide services under reasonable and non-discriminatory terms and conditions for applicants throughout the world. In this respect, the statement of the provider of the maintenance service is registered with the IEC. Information may be obtained from:

PRIME Alliance
2-12, Avenue de la Renaissance
1000, Brussels/ (BE)
www.prime-alliance.org.com

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

FDIS	Report on voting
XX/XX/FDIS	XX/XX/RVD

313

314 Full information on the voting for the approval of this standard can be found in the report on
315 voting indicated in the above table.

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

317 The committee has decided that the contents of this publication will remain unchanged until
318 the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data
319 related to the specific publication. At this date, the publication will be

- 320 • reconfirmed,
- 321 • withdrawn,
- 322 • replaced by a revised edition, or
- 323 • amended.

324

325 The National Committees are requested to note that for this publication the stability date
326 is 2023.

327 THIS TEXT IS INCLUDED FOR THE INFORMATION OF THE NATIONAL COMMITTEES AND WILL BE DELETED
328 AT THE PUBLICATION STAGE.

INTRODUCTION

As defined in IEC 62056-1-0, the IEC 62056 DLMS/COSEM suite provides specific communication profile standards for communication media relevant for smart metering.

Such communication profile standards specify how the COSEM data model and the DLMS/COSEM application layer can be used on the lower, communication media-specific protocol layers.

Communication profile standards refer to communication standards that are part of the IEC 62056 DLMS/COSEM suite or to any other open communication standard.

This International Standard specifies DLMS/COSEM communication profiles using Recommendation ITU-T G.9904:2012 *Narrow-band orthogonal frequency division multiplexing power line communication transceivers for PRIME networks*. It applies for devices installed on the neighbourhood network.

It follows the rules defined in IEC 62056-5-3, Annex A.

The communication profile specified in this standard is based on the results of the European OPEN Meter project, Topic Energy 2008.7.1.1, Project no.: 226369, www.openmeter.com, and has been prepared by the PRIME Alliance Technical Working Group, www.prime-alliance.org.

ELECTRICITY METERING DATA EXCHANGE – THE DLMS/COSEM SUITE –

Part 8-4: Communication profiles for narrow-band OFDM PLC PRIME neighbourhood networks

1 Scope

This International Standard specifies DLMS/COSEM communication profiles for narrow-band OFDM power line carrier PRIME neighbourhood networks using the modulation as specified in Recommendation ITU-T G.9904:2012.

Three communication profiles are specified:

- a profile using the IEC 61334-4-32 LLC layer;
- a profile using TCP-UDP/IPv4;
- a profile using TCP-UDP/IPv6.

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)

EN 50065-1, *Signalling on low-voltage electrical installations in the frequency range 3 kHz to 148.5 kHz - Part 1: General requirements, frequency bands and electromagnetic disturbances*

IEC 61334-4-1:1996, *Distribution automation using distribution line carrier systems – Part 4: Data communication protocols – Section 1: Reference model of the communication system*

IEC 61334-4-32:1996, *Distribution automation using distribution line carrier systems – Part 4: Data communication protocols – Section 32: Data link layer – Logical link control (LLC)*

IEC 61334-4-511:2000, *Distribution automation using distribution line carrier systems – Part 4-511: Data communication protocols – Systems management – CIASE protocol*

IEC 62056-1-0, *Electricity metering data exchange – Part 1-0: Smart metering standardization framework*

IEC TS 62056-1-1, *Electricity metering data exchange – The DLMS/COSEM suite – Part 1-1: Template for DLMS/COSEM communication profile standards*

IEC 62056-4-7:2014, *Electricity metering data exchange - The DLMS/COSEM suite – Part 4-7: DLMS/COSEM transport layer for IP networks (IEC 62056-4-7:2015)*

IEC 62056-5-3, *Electricity metering data exchange – The DLMS/COSEM suite – Part 5-3: DLMS/COSEM application layer (IEC 62056-5-3)*

IEC 62056-6-1, *Electricity metering data exchange – The DLMS/COSEM suite – Part 6-1: Object identification system (OBIS) (IEC 62056-6-1)*

IEC 62056-6-2, *Electricity metering data exchange – The DLMS/COSEM suite – Part 6-2: COSEM interface classes (IEC 62056-6-2)*

IEC 62056-9-7:2013, *Electricity metering data exchange – the DLMS/COSEM suite – Part 9-7: Communication profile for TCP-UDP/IP networks (IEC 62056-9-7:2013)*

387 Recommendation ITU-T G.9904:2012, *SERIES G: TRANSMISSION SYSTEMS AND MEDIA,*
388 *DIGITAL SYSTEMS AND NETWORKS Access networks – In premises networks. Narrowband*
389 *orthogonal frequency division multiplexing power line communication transceivers for PRIME*
390 *networks*

391 STD0005 – Internet Protocol

392 Author: J. Postel

393 Date: September 1981

394 Also: RFC0791, RFC0792, RFC0919, RFC0922, RFC0950, RFC1112

395 Available from: <http://www.ietf.org/rfc/rfc0791.txt>

396
397 STD0006 – User Datagram Protocol

398 Author: J. Postel

399 Date: 28 August 1980

400 Also: RFC0768

401 Available from: <http://www.ietf.org/rfc/rfc0768.txt>

402
403 STD0007 – Transmission Control Protocol

404 Author: J. Postel

405 Date: September 1981

406 Available from: <http://www.ietf.org/rfc/rfc0793.txt>

407
408 RFC 1144 Compressing TCP/IP Headers for Low Speed serial Link

409 Author: V. Jacobson

410 Date: February 1990

411 Available from <https://tools.ietf.org/rfc/rfc1144.txt>

412
413 RFC 2460 Internet Protocol, Version 6 (IPv6) Specification

414 Authors: S. Deering, Cisco, R. Hinden Nokia

415 Date: December 1998

416 Available from: <http://www.ietf.org/rfc/rfc2460.txt>

417
418 RFC 2464 Transmission of IPv6 Packets over Ethernet Networks

419 Authors M. Crawford Fermilab

420 Date: December 1998

421 Available from: <http://www.ietf.org/rfc/rfc2464.txt>

422
423 RFC 4291 IP Version 6 Addressing Architecture

424 Authors R. Hinden Nokia, S. Deering Cisco Systems

425 Date: February 2006.

426 Available from: <http://www.ietf.org/rfc/rfc4291.txt>

427
428 RFC 6282 Compression Format for IPv6 Datagrams over IEEE 802.15.4–Based Networks

429 Authors J. Hui, Ed. Arch Rock Corporation P. Thubert Cisco

430 Date: September 2011.

431 Available from: <http://www.ietf.org/rfc/rfc6282.txt>

432
433 RFC 4862 IPv6 Stateless Address Configuration

434 Authors S. Thomson, Cisco, T. Narten IBM, T. Jinmei, Toshiba

435 Date: September 2007.

436 Available from: www.ietf.org/rfc/rfc4862.txt

437
438 RFC 3315 Dynamic Host Configuration Protocol for IPv6 (DHCPv6)

439 Authors R. Droms, E J. Bound, B. Volz, T. Lemon, C. Perkins, M. Carney

440 Date: July 2003

441 Available from: www.ietf.org/rfc/rfc3315.txt

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

See also Recommendation ITU-T G.9904:2012.

3.1.1

base node

master node which controls and manages the resources of a subnetwork

3.1.2

registration

process by which a service node is accepted as member of the subnetwork and allocated with an LNID

3.1.3

service node

any one node of a subnetwork which is not a base node

3.1.4

unregistration

process by which a service node leaves a subnetwork

3.2 Abbreviations

AA	Application Association
AARE	Application Association Response
AARQ	Application Association Request
ACSE	Application Control Service Element
AL	Application Layer
AP	Application Process
APDU	Application Protocol Data Unit
ARQ	Automatic Repeat Request
CL	Convergence Layer
.cnf	Confirm service primitive
COSEM	Companion Specification for Energy Metering
CPCS	Common Part Convergence Sublayer
CSMA/CA	Carrier Sense Multiple Access – Collision Avoidance
D8PSK	Differential Eight-Phase Shift Keying
DBPSK	Differential Binary Phase Shift Keying
DGW	Default Gateway
DHCP	Dynamic Host Configuration Protocol
DLMS	Device Language Message Specification
DQPSK	Differential Quaternary Phase Shift Keying
EUI-48	48-bit Extended Unique Identifier
FU	Firmware Upgrade
FW	Firmware
IANA	Internet Assigned Numbers Authority

IGMP	Internet Group Management Protocol
.ind	Indication service primitive
IP	Internet Protocol
IPv4	Internet Protocol, version 4
IPv6	Internet Protocol version 6
LCID	Local Connection Identifier
LD	Logical Device
LLC	Logical Link Control (sub-layer)
LNID	Local Node Identifier
MAC	Medium Access Control, MAC sublayer entity
MLME	MAC Layer Management Entity
MPDU	MAC Protocol Data Unit
NAT	Network Address Translation
NHC	Next Header Compression
NL	Noise Level
OBIS	OBject Identification System
OFDM	Orthogonal Frequency Division Multiplexing
OSI	Open System Interconnection
PHY	Physical Layer entity
PLC	Power Line Communication
PIB	PLC Information Base
PLME	Physical Layer Management Entity
PPDU	PHY Protocol Data Unit
.req	Request service primitive
RFC	Request For Comment
.rsp	Response service primitive
SDU	Service Data Unit
SID	Switch Identifier
SNA	Subnetwork Address
SNR	Signal-to-Noise Ratio
SSCS	Service Specific Convergence Sublayer
TCP	Transmission Control Protocol
TOS	Type Of Service
UDP	User Datagram Protocol
xDLMS_ASE	extended DLMS Application Service Element
ZCT	Zero Crossing Time

4 Targeted communication environments

The DLMS/COSEM communication profiles for narrow-band OFDM PLC PRIME neighbourhood networks are intended for remote data exchange on Neighbourhood Networks (NN) between *Neighbourhood Network Access Points* (NNAP) and *Local Network Access Points* (LNAPs) or *End Devices* using OFDM PLC technology over the low voltage electricity distribution network as a communication medium. The functional reference architecture is shown Figure 1.

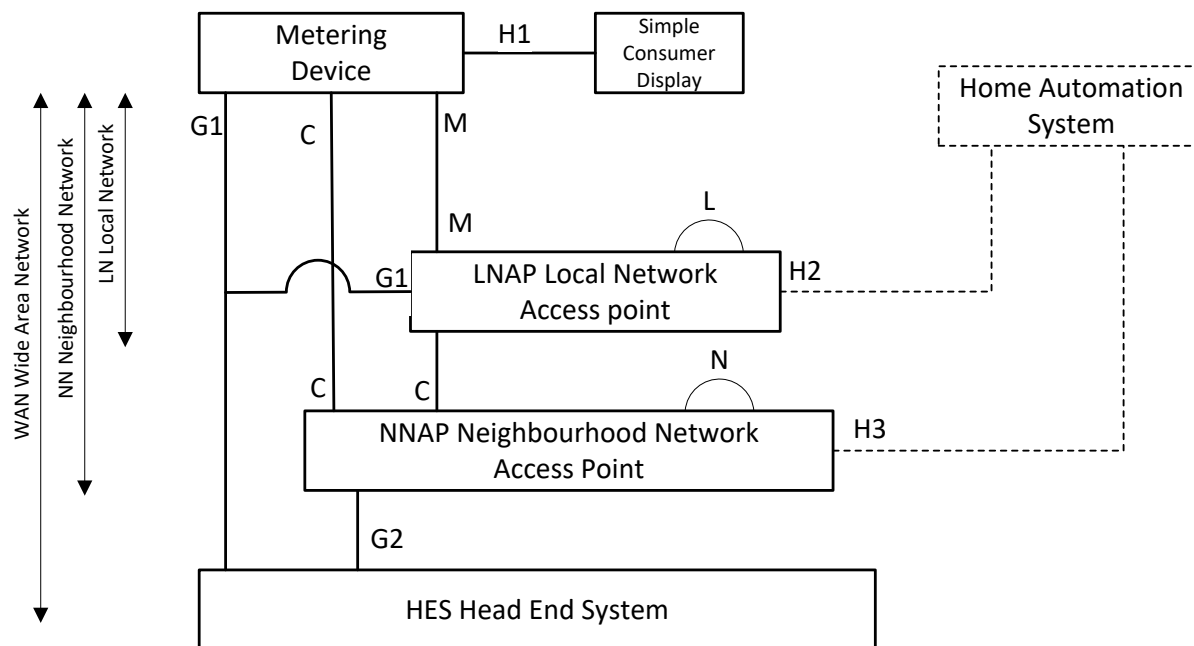


Figure 1 – Communication architecture

End devices – typically electricity meters – comprise application functions and communication functions. They may be connected directly to the NNAP via the C interface, or to an LNAP via an M interface, while the LNAP is connected to the NNAP via the C interface. The LNAP function may be co-located with the metering functions.

A NNAP comprises gateway functions and it may comprise concentrator functions. Upstream, it is connected to the Metering Head End System (HES) using suitable communication media and protocols.

End devices and LNAPs may communicate to different NNAPs, but to one NNAP only at a time. From the PLC communication point of view, the NNAP acts as the Base Node while end devices and LNAPs act as Service Nodes.

NNAPs and similarly LNAPs may communicate to each other, but this is out of the scope of this International Standard, which covers the C interface only.

When the NNAP has concentrator functions, it acts as a DLMS/COSEM client. When the NNAP has gateway functionality only, then the HES plays the role of a DLMS/COSEM client. The end devices or the LNAPs play the role of DLMS/COSEM servers.

A mixed architecture is also possible, i.e. both the HES and the NNAP can act as a client.

5 Use of the communication layers for this profile

5.1 Information related to the use of the standard specifying the lower layers

Recommendation ITU-T G.9904:2012 defines PHY and MAC layers for power line communication using OFDM. At the top of the MAC layer it defines also a number of Convergence layers, the purpose of which is to match the lower protocol layers with the higher protocol layers.

This standard makes use of the entire part of the PHY and MAC layers. Additionally it defines – in 5.5 – the use of the respective Convergence layers.

5.2 The structure of the communication profiles

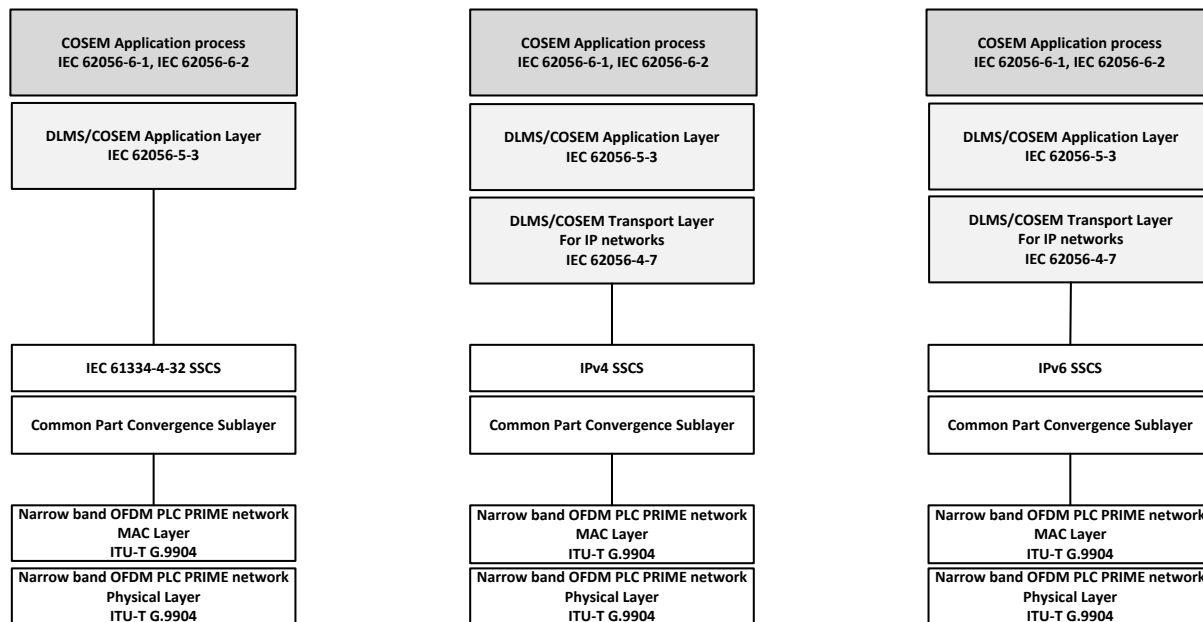
5.2.1 Overview

The proposed protocol stacks use the following OSI layers as shown in Figure 2.

- the DLMS/COSEM Application layer as specified in IEC 62056-5-3 covering the Application, Presentation and Session functionalities;
- the LLC sublayer as specified in IEC 61334-4-32, used with the DLMS/COSEM 61334-4-32 profile over PRIME networks;
- the DLMS/COSEM transport layer for IP networks as specified in IEC 62056-4-7:2014, used with the DLMS/COSEM TCP-UDP/IPv4 and TCP-UDP/IPv6 profiles over PRIME networks;
- the PRIME MAC layer, the CPCS and the corresponding SSCS, according to the selected profile (IEC 61334-4-32, TCP-UDP/IPv4 or TCP-UDP/IPv6);
- the PRIME Physical layer.

Following this reference model, three distinct profiles can be identified, all of them using the PRIME PHY, MAC layers as lower layers and the Common Part Convergence Sublayer on one hand, and the DLMS/COSEM Application layer specified in IEC 62056-5-3 and the COSEM object model specified in IEC 62056-6-1 and IEC 62056-6-2 on the other hand. Lower layers – meaning PHY and MAC – are based on the principles of IEEE 802.15.4.

NOTE The COSEM interface classes for setting up and managing data exchange over narrow-band OFDM PLC PRIME network are specified in IEC 62056-6-2.



PRIME IEC 61334-4-32 profile

PRIME TCP-UDP/IPv4 profile

PRIME TCP-UDP/IPv6 profile

Figure 2 – OFDM PLC PRIME communication profile architectures

5.2.2 The IEC 61334-4-32 profile

The IEC 61334-4-32 profile uses the PRIME IEC 61334-4-32 SSCS making the necessary adaptation between the PRIME PHY and MAC layers and the DLMS/COSEM application layer.

5.2.3 The TCP-UDP/IPv4 profile

The TCP-UDP/IPv4 profile uses the PRIME IPv4 SSCS making the necessary adaptation between the PRIME PHY and MAC layers and the IPv4 layer, supporting the DLMS/COSEM transport layer and application layer.

5.2.4 The TCP-UDP/IPv6 profile

The TCP-UDP/IPv6 profile uses the PRIME IPv6 SSCS making the necessary adaptation between the PRIME PHY and MAC layers and the IPv6 layer, supporting the DLMS/COSEM transport layer and application layer.

5.3 Lower protocol layers and their use

5.3.1 General

All three profiles specified in this standard share the same PHY and MAC layers.

5.3.2 Physical layer

5.3.2.1 General

This layer provides the interface between the equipment and the physical transmission medium that is the electricity distribution network. It transmits and receives MPDUs between neighbour nodes.

5.3.2.2 PRIME PHY data plane services

PHY DATA services are generated / used by the MAC layer entity whenever data – PPDU – have to be transmitted to / received from (a) peer MAC entity(ies) using the PHY transmission procedures. See Recommendation ITU-T G.9904:2012, 7.10.2.

5.3.2.3 PRIME PHY control plane services

PRIME PHY control plane services are used to control the physical layer by the MAC layer. See Recommendation ITU-T G.9904:2012, 7.10.3. They are the following:

- PHY_AGC: allows the MAC layer entity to set or get the Automatic Gain Mode of the PHY;
- PHY_TIMER: allows the MAC layer entity to get the time at which the transmission has to be started;
- PHY_CD: allows the MAC layer entity to look for the carrier detect signal, in order to detect if the physical medium is free;
- PHY_NL: allows the MAC layer entity to get the floor noise level value present on the power line;
- PHY_SNR: allows the MAC layer entity to get the value of the signal-to-noise ratio, in order to find the appropriate degree of robustness needed for data exchange;
- PHY_ZCT: allows the MAC layer entity to get the zero crossing time of the mains and the time between the last transmission or reception and the zero crossing of the mains.

5.3.2.4 PRIME PHY management plane services

PRIME PHY management plane services are used to manage the physical layer by the MAC layer. See Recommendation ITU-T G.9904:2012, 7.10.4. They are the following:

- PLME_RESET: allows the MAC layer entity to request the PHY layer to reset its present functional state. As a result of this primitive, the PHY should reset all internal states and flush all buffers to clear any queued receive or transmit data;
- PLME_SLEEP: allows the MAC layer entity to request the PHY layer to suspend its present activities including all reception functions. The PHY layer should complete any pending transmission before entering into a sleep state;
- PLME_RESUME: allows the MAC layer entity to request the PHY layer to resume its suspended activities. As a result of this primitive, the PHY layer should start its normal transmission and reception functions;

- PLME_TESTMODE: allows the MAC layer entity to put the PHY layer into some non-default functional modes. Specific functional mode out of the various possible modes is provided as an input parameter. Following the reception of this primitive, the PHY layer should complete any pending transmissions in its buffer before entering the test mode requested;
- PLME_GET: allows the MAC layer entity to query information about a given attribute of the PRIME Information Base.

5.3.3 MAC layer

5.3.3.1 Overview – main features and functions

A subnetwork can be seen as a tree structure with two types of nodes, the base node and service nodes. The base node is at the root of the tree and acts as the master node that provides the subnetwork with connectivity. There is one and only one base node in a subnetwork. Any other subnetwork node is a service node. Service nodes are either leaves or branch points (Switches) of the tree structure

The base node is initially the subnetwork itself and all other nodes should follow a registration process to enrol themselves on the subnetwork.

Service nodes start in a “Disconnected” state and they try to find a base node or a switch node to register themselves to the subnetwork. After this, they become leaves of the tree.

Service nodes may change their state dynamically from “Terminal” functions to “Switch” functions and vice-versa. These changes occur on the basis of certain pre-defined events on the network. Service nodes in “Switch” state become branch points of the tree, capable of switching their neighbours’ data to propagate connectivity.

The three functional states of service nodes are:

- **Disconnected:** all nodes are in this state initially or after a restart. In this state, a node is not capable to participate in the network. The primary function of a service node in this state is to search for an operational network in its proximity and try to register itself on it;
- **Terminal:** In this state a service node is part of the network and is capable of communicating its traffic by establishing connections, but it is not capable of switching the traffic of any other node; and finally:
- **Switch:** In this state a service node is capable of performing all Terminal functions. Additionally, it is capable of forwarding data to and from other devices on the subnetwork.

The events and associated processes that trigger changes from one functional state to another are registration, unregistration, promotion and demotion.

Other functions of the MAC layer are:

- address resolution and broadcast and multicast addressing;
- CSMA/CA algorithm implementation;
- promoting service nodes from “Terminal” state to “Switch” state or demoting them from the “Switch” state to “Terminal” state;
- establishing direct connections from one service node to another;
- packet aggregation;
- security functions, such as encryption and security keys management;
- PHY robustness management in order to select the best modulation schema for a given situation;
- ARQ mechanism.

5.3.3.2 Services used by base node and service nodes

The MAC connection and data services used by base nodes and service nodes are the following (see Recommendation ITU-T G.9904:2012, 8.5.2 and 8.5.4)