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DIN EN 61158-6-12

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Ersatz für
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Siehe Anwendungsbeginn

Industrielle Kommunikationsnetze – Feldbusse – Teil 6-12: Protokollspezifikation des Application Layer (Anwendungsschicht) – Typ 12-Elemente (IEC 61158-6-12:2010); Englische Fassung EN 61158-6-12:2012, nur auf CD-ROM

Industrial communication networks –
Fieldbus specifications –
Part 6-12: Application layer protocol specification – Type 12 elements
(IEC 61158-6-12:2010);
English version EN 61158-6-12:2012, only on CD-ROM

Réseaux de communication industriels –
Spécifications des bus de terrain –
Partie 6-12: Spécification des protocoles des couches d'application – Eléments de type 12
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Anwendungsbeginn

Anwendungsbeginn für die von CENELEC am 2012-03-28 angenommene Europäische Norm als DIN-Norm ist 2013-03-01.

Für DIN EN 61158-6-12:2008-09 gilt eine Übergangsfrist bis zum 2015-03-28.

Nationales Vorwort

Vorausgegangener Norm-Entwurf: E DIN IEC 61158-600:2009-06.

Für dieses Dokument ist das nationale Arbeitsgremium K 956 „Feldbus“ der DKE Deutsche Kommission Elektrotechnik Elektronik Informationstechnik im DIN und VDE (www.dke.de) zuständig.

Die enthaltene IEC-Publikation wurde vom SC 65C „Industrial networks“ erarbeitet.

Das IEC-Komitee hat entschieden, dass der Inhalt dieser Publikation bis zu dem Datum (stability date) unverändert bleiben soll, das auf der IEC-Website unter „http://webstore.iec.ch“ zu dieser Publikation angegeben ist. Zu diesem Zeitpunkt wird entsprechend der Entscheidung des Komitees die Publikation
– bestätigt,
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– geändert.

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

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

Der Zusammenhang der zitierten Normen mit den entsprechenden Deutschen Normen 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 die vorliegende Norm erfüllt.

Da sich die Benutzer der vorliegenden Norm der englischen Sprache als Fachsprache bedienen, wird die englische Fassung der EN 61158-6-12 veröffentlicht. Zu deren Abschnitt 3, der die Begriffe festlegt, wurde eine Übersetzung angefertigt und als informativer Nationaler Anhang NA der vorliegenden Norm hinzugefügt. Für viele der verwendeten Begriffe existieren keine gebräuchlichen deutschen Benennungen, da sich die deutschen Anwender in der Regel ebenfalls der englischen Benennungen bedienen. Diese Norm steht nicht in unmittelbarem Zusammenhang mit Rechtsvorschriften und ist nicht als Sicherheitsnorm anzusehen.

Einführung

Ein Feldbus ist ein digitaler serieller Datenbus für die Kommunikation zwischen Geräten der industriellen Automatisierungstechnik wie beispielsweise Messeinrichtungen, Stellgliedern, Reglern und speicherprogrammierbaren Steuerungen. Die Normen der Reihe DIN EN 61158 legen eine Anzahl von Feldbus-Protokolltypen fest. Die vorliegende Norm legt das Protokoll des Application Layer für Typ 12 fest.

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Änderungen

Gegenüber DIN EN 61158-6-12:2008-09 wurden folgende Änderungen vorgenommen:

a) Fehlerberichtigungen;

b) redaktionelle Verbesserungen.

Frühere Ausgaben

DIN V 19245-1: 1988-01
DIN EN 61158-6: 2005-05
DIN EN 61158-6-12: 2008-09

Nationaler Anhang NA
(informativ)

3.3 Begriffe zur Anwendungsschicht

3.3.1
Anwendung
(en: application)
Funktion oder Datenstruktur, für die Daten verarbeitet oder erzeugt werden

3.3.2
Anwendungsobjekte
(en: application objects)
mehrere Objektklassen, die einen Nachrichtenaustausch über das Netzwerk und innerhalb des Netzwerkgerätes zur Laufzeit verwalten und bereitstellen

3.3.3
Anwendungsprozess
(en: application process)
Teil einer verteilten Anwendung in einem Netzwerk, der sich auf einem Gerät befindet und eindeutig adressiert wird

3.3.4
Anwendungsbeziehung
(en: application relationship)
kooperative Verbindung zwischen zwei oder mehr Aufrufen von Anwendungseinheiten zum Zweck des Informationsaustausches und der Koordination des gemeinsamen Betriebs. Diese Beziehung wird entweder durch den Austausch von Protokolldateneinheiten der Anwendung oder als Ergebnis von Vorkonfigurationsaktivitäten aktiviert.

3.3.5
Attribut
(en: attribute)
Beschreibung eines von außen sichtbaren Merkmals oder einer von außen sichtbaren Eigenschaft eines Objekts

ANMERKUNG Die Attribute eines Objekts enthalten Informationen zu veränderlichen Teilen eines Objekts. Üblicherweise stellen sie Statusinformationen bereit oder steuern den Betrieb eines Objekts. Attribute können auch das Verhalten eines Objekts beeinflussen. Attribute werden in Klassenattribute und Instanzattribute unterteilt.

3.3.6
Basis-Slave
(en: basic slave)
Slave, der nur die physikalische Adressierung von Daten unterstützt

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3.3.7
Verhalten
(en: behavior)
Angabe, wie ein Objekt auf bestimmte Ereignisse reagiert

3.3.8
Bit
(en: bit)
Informationseinheit, die aus einer 0 oder 1 besteht. Ein Bit ist die kleinste Dateneinheit, die übertragen werden kann.

3.3.9
Kanal
(en: channel)
Darstellung eines einzelnen physikalischen oder logischen Verwaltungsobjektes eines Slaves zur Steuerung der Datenübertragung

3.3.10
Client
(en: client)
1) Objekt, das die Dienste eines anderen Objekts (Servers) nutzt, um eine Aufgabe auszuführen
2) Initiator einer Nachricht, auf die ein Server reagiert

3.3.11
Uhrensynchronisation
(en: clock synchroization)
Darstellung einer Abfolge von Interaktionen zur Synchronisation der Uhren aller Zeitempfänger mit einem Zeit-Master

3.3.12
Kommunikationsobjekt
(en: communication object)
Komponente, die einen Austausch von Nachrichten über das Netzwerk zur Laufzeit bereitstellt und verwaltet

3.3.13
Verbindung
(en: connection)
logische Verbindung zwischen zwei Anwendungsobjekten innerhalb eines Gerätes oder in unterschiedlichen Geräten

3.3.14
konsumieren
(en: consume)
Vorgang des Empfangs von Daten von einem Provider

3.3.15
Konsument
(en: consumer)
Knoten oder Senke, der/die Daten von einem Provider empfängt

3.3.16
Übertragungspfad
(en: conveyance path)
unidirektionaler Strom von APDUs über eine Anwendungsbeziehung

3.3.17
zyklisch
(en: cyclic)
Ereignisse, die sich regelmäßig wiederholen

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3.3.18
Daten
(en: data)
allgemeine Bezeichnung für jegliche über einen Feldbus übertragene Informationen

3.3.19
Datenkonsistenz
(en: data consistency)
Mittel für die kohärente Übertragung des Eingabe- oder Ausgabedatenobjekts zwischen Client und Server und für den kohärenten Zugriff auf das Eingabe- oder Ausgabedatenobjekt innerhalb von Client und Server

3.3.20
Datentyp
(en: data type)
Beziehung zwischen den Werten und der Codierung für Daten dieses Typs entsprechend den Definitionen in IEC 61131-3

3.3.21
Datentypobjekt
(en: data type object)
Eintrag im Objektverzeichnis, der einen Datentyp angibt

3.3.22
Standard-Gateway
(en: default gateway)
Gerät mit mindestens zwei Schnittstellen in zwei verschiedenen IP-Subnetzen, das als Router für ein Subnetz agiert

3.3.23
Gerät
(en: device)
mit dem Feldbus verbundene physikalische Einheit, die aus mindestens einem Kommunikationselement (dem Netzwerkelement) besteht und über ein Bedienelement und/oder ein Endelement (Wandler, Aktor usw.) verfügen kann

3.3.24
Geräteprofil
(en: device profile)
Zusammenstellung geräteabhängiger Informationen und Funktionalitäten, um Konsistenz zwischen ähnlichen Geräten desselben Gerätetyps herzustellen

3.3.25
Diagnose-Informationen
(en: diagnosis information)
alle Daten, die serverseitig für Wartungszwecke verfügbar sind

3.3.26
verteilte Uhren
(en: distributed clocks)
Methode zur Synchronisierung von Slaves und zur Unterstützung einer globalen Zeitbasis

3.3.27
Fehler
(en: error)
Nichtübereinstimmung zwischen einem berechneten, beobachteten oder gemessenen Wert oder Zustand und dem festgelegten oder theoretisch richtigen Wert oder Zustand

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3.3.28
Fehlerklasse
(en: error class)
allgemeine Gruppierung für zugehörige Fehlerdefinitionen und entsprechende Fehlercodes

3.3.29
Fehlercode
(en: error code)
Kennzeichnung eines bestimmten Fehlertyps innerhalb einer Fehlerklasse

3.3.30
Ereignis
(en: event)
Instanz einer Änderung von Zuständen

3.3.31
Speicherverwaltungseinheit des Feldbusses
(en: fieldbus memory management unit)
Funktion, die eine oder mehrere Korrespondenzen zwischen logischen Adressen und dem physikalischen Speicher aufbaut

3.3.32
Element der Speicherverwaltungseinheit des Feldbusses
(en: fieldbus memory management unit entity)
einzelnes Element der Speicherverwaltungseinheit des Feldbusses: eine Korrespondenz zwischen einem kohärenten logischen Adressraum und einem kohärenten physikalischen Speicherort

3.3.33
Rahmen
(en: frame)
veraltetes Synonym für DLPDU

3.3.34
Full-Slave
(en: full slave)
Slave-Gerät, das sowohl die physikalische als auch die logische Adressierung von Daten unterstützt

3.3.35
Index
(en: index)
Adresse eines Objektes innerhalb eines Anwendungsprozesses

3.3.36
Schnittstelle
(en: interface)
gemeinsam genutzte Grenze zwischen zwei funktionalen Einheiten, die durch funktionale Merkmale, Signalmerkmale oder entsprechend andere Merkmale festgelegt ist

3.3.37
Little-Endian
(en: little endian)
Datendarstellung von Multi-Oktett-Feldern, wobei das am wenigsten signifikante Oktett zuerst übertragen wird

3.3.38
Master
(en: master)
Gerät, das den Datentransfer im Netzwerk steuert und den Medienzugriff der Slaves durch Senden von Nachrichten initiiert und das die Schnittstelle zum Steuerungssystem bildet

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3.3.39
Zuordnung
(en: mapping)
Verbindung zwischen zwei Objekten in einer Weise, dass ein Objekt ein Teil des anderen Objekts ist

3.3.40
Zuordnungsparameter
(en: mapping parameters)
Satz von Werten, der die Verbindung zwischen Anwendungsobjekten und Prozessdatenobjekten festlegt

3.3.41
Medium
(en: medium)
Kabel, Lichtwellenleiter oder anderes Mittel, über das Kommunikationssignale zwischen zwei oder mehreren Punkten übertragen werden

ANMERKUNG „Medien“ ist der Plural von „Medium“.

3.3.42
Nachricht
(en: message)
geordnete Folge von Oktetten für die Übermittlung von Informationen

ANMERKUNG Nachrichten werden normalerweise für die Übermittlung von Informationen zwischen Peers auf der Anwendungsschicht verwendet.

3.3.43
Netzwerk
(en: network)
Menge von Knoten, die über ein bestimmtes Kommunikationsmedium miteinander verbunden sind, einschließlich zwischengeschalteter Repeater, Bridges, Router und Gateways unterer Schichten

3.3.44
Knoten
(en: node)
a) einzelne DL-Instanz, wie sie auf einem lokalen Verbindungszweig existiert

b) Endpunkt eines Verbindungszweiges in einem Netzwerk oder ein Punkt, an dem zwei oder mehrere Verbindungszweige aufeinandertreffen [abgeleitet von IEC 61158-2]

3.3.45
Objekt
(en: object)
abstrakte Darstellung einer bestimmten Komponente innerhalb eines Gerätes

ANMERKUNG Ein Objekt kann sein:

a) eine abstrakte Darstellung der Fähigkeiten eines Gerätes. Objekte können aus einigen der folgenden Komponenten oder aus allen folgenden Komponenten bestehen:

   1) Daten (Informationen, die sich im Laufe der Zeit ändern);

   2) Konfiguration (Parameter für das Verhalten);

   3) Methoden (Dinge, die mithilfe der Daten und der Konfiguration durchgeführt werden können);

b) eine Zusammenstellung zugehöriger Daten (in Form von Variablen) und Methoden (Prozeduren) für Operationen in Bezug auf diese Daten mit klar definierter Schnittstelle und klar definiertem Verhalten.

3.3.46
Objektverzeichnis
(en: object dictionary)
Datenstruktur, die von Index und Subindex adressiert wird und Beschreibungen von Datentypobjekten, Kommunikationsobjekten und Anwendungsobjekten enthält

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3.3.47
Prozessdaten
(en: process data)
Zusammenstellung von Anwendungsobjekten, die zum Zweck der Messung und Steuerung zyklisch oder azyklisch übertragen werden

3.3.48
Prozessdatenobjekt
(en: process data object)
Struktur, die durch Zuordnungsparameter beschrieben wird und eine oder mehrere Prozessdateneinheiten enthält

3.3.49
Produzent
(en: producer)
Knoten oder Quelle, der/die Daten an einen oder viele Konsumenten sendet

3.3.50
Ressource
(en: resource)
Verarbeitungs- oder Informationsfähigkeit

3.3.51
Segment
(en: segment)
Zusammenstellung von einem realen Master und einem oder mehreren Slaves

3.3.52
Server
(en: server)
Objekt, das einem anderen Objekt (Client) Dienste bereitstellt

3.3.53
Dienst
(en: service)
Operation oder Funktion, die ein Objekt und/oder eine Objektklasse auf Aufforderung eines anderen Objekts und/oder einer anderen Objektklasse ausführt

3.3.54
Slave
(en: slave)
DL-Instanz, die nur nach Initiierung durch den vorausgehenden Slave oder den Master Zugang zum Medium hat

3.3.55
Subindex
(en: subindex)
untergeordnete Adresse eines Objektes innerhalb des Objektverzeichnisses

3.3.56
Sync-Manager
(en: sync manager)
Zusammenstellung von Steuerelementen zur Koordinierung des Zugriffs auf gleichzeitig verwendete Objekte

3.3.57
Sync-Manager-Kanal
(en: sync manager channel)
einzelne Steuerelemente zur Koordinierung des Zugriffs auf gleichzeitig verwendete Objekte

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3.3.58
Switch
(en: switch)
MAC-Bridge, wie in IEEE 802.1D definiert

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EUROPEAN STANDARD

NORME EUROPÉENNE

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Industrial communication networks - Fieldbus specifications - Part 6-12: Application layer protocol specification - Type 12 elements

(IEC 61158-6-12:2010)

Réseaux de communication industriels - Spécifications des bus de terrain - Partie 6-12: Spécification des protocoles des couches d'application - Eléments de type 12 (CEI 61158-6-12:2010)

Industrielle Kommunikationsnetze - Feldbusse - Teil 6-12: Protokollspezifikation des Application Layer (Anwendungsschicht) - Typ 12-Elemente (IEC 61158-6-12:2010)

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Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Management Centre: Avenue Marnix 17, B - 1000 Brussels

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Foreword

The text of document 65C/607/FDIS, future edition 2 of IEC 61158-6-12, prepared by SC 65C, "Industrial networks", of IEC/TC 65, "Industrial-process measurement, control and automation" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 61158-6-12:2012.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2012-12-28
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2015-03-28

This document supersedes EN 61158-6-12:2008.

EN 61158-6-12:2012 includes the following significant technical changes with respect to EN 61158-6-12:2008:

– bug fixes; and

– editorial improvements.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

Endorsement notice

The text of the International Standard IEC 61158-6-12:2010 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 61131-3	NOTE	Harmonized as EN 61131-3.
IEC/TR 61158-1:2010	NOTE	Harmonized as CLC/TR 61158-1:2010 (not modified).
IEC 61158-4-12	NOTE	Harmonized as EN 61158-4-12.

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INTRODUCTION

This part of IEC 61158 is one of a series produced to facilitate the interconnection of automation system components. It is related to other standards in the set as defined by the “three-layer” fieldbus reference model described in IEC/TR 61158-1.

The application protocol provides the application service by making use of the services available from the data-link or other immediately lower layer. The primary aim of this standard is to provide a set of rules for communication expressed in terms of the procedures to be carried out by peer application entities (AEs) at the time of communication. These rules for communication are intended to provide a sound basis for development in order to serve a variety of purposes:

- as a guide for implementors and designers;
- for use in the testing and procurement of equipment;
- as part of an agreement for the admittance of systems into the open systems environment;
- as a refinement to the understanding of time-critical communications within OSI.

This standard is concerned, in particular, with the communication and interworking of sensors, effectors and other automation devices. By using this standard together with other standards positioned within the OSI or fieldbus reference models, otherwise incompatible systems may work together in any combination.

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INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 6-12: Application layer protocol specification – Type 12 elements

1 Scope

1.1 General

The Fieldbus Application Layer (FAL) provides user programs with a means to access the fieldbus communication environment. In this respect, the FAL can be viewed as a “window between corresponding application programs.”

This standard provides common elements for basic time-critical and non-time-critical messaging communications between application programs in an automation environment and material specific to Type 12 fieldbus. The term “time-critical” is used to represent the presence of a time-window, within which one or more specified actions are required to be completed with some defined level of certainty. Failure to complete specified actions within the time window risks failure of the applications requesting the actions, with attendant risk to equipment, plant and possibly human life.

This standard defines in an abstract way the externally visible behavior provided by the different Types of the fieldbus Application Layer in terms of

a) the abstract syntax defining the application layer protocol data units conveyed between communicating application entities,
b) the transfer syntax defining the application layer protocol data units conveyed between communicating application entities,
c) the application context state machine defining the application service behavior visible between communicating application entities; and
d) the application relationship state machines defining the communication behavior visible between communicating application entities; and.

The purpose of this standard is to define the protocol provided to

a) define the wire-representation of the service primitives defined in IEC 61158-5-12, and
b) define the externally visible behavior associated with their transfer.

This standard specifies the protocol of the IEC fieldbus Application Layer, in conformance with the OSI Basic Reference Model (ISO/IEC 7498) and the OSI Application Layer Structure (ISO/IEC 9545).

FAL services and protocols are provided by FAL application-entities (AE) contained within the application processes. The FAL AE is composed of a set of object-oriented Application Service Elements (ASEs) and a Layer Management Entity (LME) that manages the AE. The ASEs provide communication services that operate on a set of related application process object (APO) classes. One of the FAL ASEs is a management ASE that provides a common set of services for the management of the instances of FAL classes.

Although these services specify, from the perspective of applications, how request and responses are issued and delivered, they do not include a specification of what the requesting and responding applications are to do with them. That is, the behavioral aspects of the applications are not specified; only a definition of what requests and responses they can send/receive is specified. This permits greater flexibility to the FAL users in standardizing such object behavior. In addition to these services, some supporting services are also defined in this standard to provide access to the FAL to control certain aspects of its operation.

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1.2 Specifications

The principal objective of this standard is to specify the syntax and behavior of the application layer protocol that conveys the application layer services defined in IEC 61158-5-12.

A secondary objective is to provide migration paths from previously-existing industrial communications protocols. It is this latter objective which gives rise to the diversity of protocols standardized in subparts of IEC 61158-6.

1.3 Conformance

This standard does not specify individual implementations or products, nor does it constrain the implementations of application layer entities within industrial automation systems.

There is no conformance of equipment to the application layer service definition standard. Instead, conformance is achieved through implementation of this application layer protocol specification.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60559, *Binary floating-point arithmetic for microprocessor systems*

IEC 61158-3-12, *Industrial communication networks – Fieldbus specifications – Part 3-12: Data-link layer service definition – Type 12 elements*

IEC 61158-5-12, *Industrial communication networks – Fieldbus specifications – Part 5-12: Application layer service definition – Type 12 elements*

ISO/IEC 7498-1, *Information technology – Open Systems Interconnection – Basic Reference Model: The Basic Model*

ISO/IEC 7498-3, *Information technology – Open Systems Interconnection – Basic Reference Model: Naming and addressing*

ISO/IEC 8802-3, *Information technology – Telecommunications and information exchange between systems - Local and metropolitan area networks – Specific requirements – Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications*

ISO/IEC 9545, *Information technology – Open Systems Interconnection – Application Layer structure*

ISO/IEC 9899, *Programming Languages – C*

ISO/IEC 10731, *Information technology – Open Systems Interconnection – Basic Reference Model – Conventions for the definition of OSI services*

IEEE 802.1D-2004, *IEEE standard for Local and metropolitan area networks – Common specifications – Media access control (MAC) Bridges;* available at <http://www.ieee.org>

IEEE 802.1Q-1998, *IEEE standard for Local and metropolitan area networks – Virtual bridged local area networks Bridges;* available at <http://www.ieee.org>

IETF RFC 768, *User Datagram Protocol*; available at <http://www.ietf.org>

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IETF RFC 791, *Internet Protocol darpa internet program protocol specification*; available at <http://www.ietf.org>

3 Terms, definitions, symbols, abbreviations and conventions

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

3.1 Reference model terms and definitions

This standard is based in part on the concepts developed in ISO/IEC 7498-1 and ISO/IEC 7498-3, and makes use of the following terms defined therein:

3.1.1 correspondent (N)-entities
correspondent AL-entities (N=7) [ISO/IEC 7498-1]

3.1.2 (N)-entity
AL-entity (N=7) [ISO/IEC 7498-1]

3.1.3 (N)-layer
AL-layer (N=7) [ISO/IEC 7498-1]

3.1.4 layer-management [ISO/IEC 7498-1]

3.1.5 peer-entities [ISO/IEC 7498-1]

3.1.6 primitive name [ISO/IEC 7498-3]

3.1.7 AL-protocol [ISO/IEC 7498-1]

3.1.8 AL-protocol-data-unit [ISO/IEC 7498-1]

3.1.9 reset [ISO/IEC 7498-1]

3.1.10 routing [ISO/IEC 7498-1]

3.1.11 segmenting [ISO/IEC 7498-1]

3.1.12 (N)-service
AL-service (N=7) [ISO/IEC 7498-1]

3.1.13 AL-service-data-unit [ISO/IEC 7498-1]

3.1.14 AL-simplex-transmission [ISO/IEC 7498-1]

3.1.15 AL-subsystem [ISO/IEC 7498-1]

3.1.16 systems-management [ISO/IEC 7498-1]

3.1.17 AL-user-data [ISO/IEC 7498-1]

3.2 Service convention terms and definitions

This standard also makes use of the following terms defined in ISO/IEC 10731 as they apply to the data-link layer:

3.2.1 acceptor

3.2.2 asymmetrical service

3.2.3 confirm (primitive);
requestor.deliver (primitive)

3.2.4 deliver (primitive)

3.2.5 AL-service-primitive;
primitive

3.2.6 AL-service-provider

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3.2.7 AL-service-user

3.2.8 indication (primitive); acceptor.deliver (primitive)

3.2.9 request (primitive); requestor.submit (primitive)

3.2.10 requestor

3.2.11 response (primitive); acceptor.submit (primitive)

3.2.12 submit (primitive)

3.2.13 symmetrical service

3.3 Application layer definitions

3.3.1
application
function or data structure for which data is consumed or produced

3.3.2
application objects
multiple object classes that manage and provide a run time exchange of messages across the network and within the network device

3.3.3
application process
part of a distributed application on a network, which is located on one device and unambiguously addressed

3.3.4
application relationship
cooperative association between two or more application-entity-invocations for the purpose of exchange of information and coordination of their joint operation. This relationship is activated either by the exchange of application-protocol-data-units or as a result of preconfiguration activities

3.3.5
attribute
description of an externally visible characteristic or feature of an object

NOTE The attributes of an object contain information about variable portions of an object. Typically, they provide status information or govern the operation of an object. Attributes may also affect the behavior of an object. Attributes are divided into class attributes and instance attributes.

3.3.6
basic slave
slave device that supports only physical addressing of data

3.3.7
behavior
indication of how an object responds to particular events

3.3.8
bit
unit of information consisting of a 1 or a 0. This is the smallest data unit that can be transmitted

3.3.9
channel
representation of a single physical or logical management object of a slave to control conveyance of data

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3.3.10
client
1) object which uses the services of another (server) object to perform a task

2) initiator of a message to which a server reacts

3.3.11
clock synchroization
representation of a sequence of interactions to synchronize the clocks of all time receivers by a time master

3.3.12
communication object
component that manages and provides a run time exchange of messages across the network

3.3.13
connection
logical binding between two application objects within the same or different devices

3.3.14
consume
act of receiving data from a provider

3.3.15
consumer
node or sink receiving data from a provider

3.3.16
conveyance path
unidirectional flow of APDUs across an application relationship

3.3.17
cyclic
events which repeat in a regular and repetitive manner

3.3.18
data
generic term used to refer to any information carried over a fieldbus

3.3.19
data consistency
means for coherent transmission and access of the input- or output-data object between and within client and server

3.3.20
data type
relation between values and encoding for data of that type according to the definitions of IEC 61131-3.

3.3.21
data type object
entry in the object dictionary indicating a data type

3.3.22
default gateway
device with at least two interfaces in two different IP subnets acting as router for a subnet.

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3.3.23
device
physical entity connected to the fieldbus composed of at least one communication element (the network element) and which may have a control element and/or a final element (transducer, actuator, etc.)

3.3.24
device profile
collection of device dependent information and functionality providing consistency between similar devices of the same device type

3.3.25
diagnosis information
all data available at the server for maintenance purposes

3.3.26
distributed clocks
method to synchronize slaves and maintain a global time base

3.3.27
error
discrepancy between a computed, observed or measured value or condition and the specified or theoretically correct value or condition

3.3.28
error class
general grouping for related error definitions and corresponding error codes

3.3.29
error code
identification of a specific type of error within an error class

3.3.30
event
instance of a change of conditions

3.3.31
fieldbus memory management unit
function that establishes one or several correspondences between logical addresses and physical memory

3.3.32
fieldbus memory management unit entity
single element of the fieldbus memory management unit: one correspondence between a coherent logical address space and a coherent physical memory location

3.3.33
frame
denigrated synonym for DLPDU

3.3.34
full slave
slave device that supports both physical and logical addressing of data

3.3.35
index
address of an object within an application process

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3.3.36
interface
shared boundary between two functional units, defined by functional characteristics, signal characteristics, or other characteristics as appropriate

3.3.37
little endian
data representation of multi-octet fields where the least significant octet is transmitted first.

3.3.38
master
device that controls the data transfer on the network and initiates the media access of the slaves by sending messages and that constitutes the interface to the control system

3.3.39
mapping
correspondence between two objects in that way that one object is part of the other object

3.3.40
mapping parameters
set of values defining the correspondence between application objects and process data objects

3.3.41
medium
cable, optical fibre or other means by which communication signals are transmitted between two or more points

NOTE "media" is the plural of medium.

3.3.42
message
ordered series of octets intended to convey information

NOTE Normally used to convey information between peers at the application layer.

3.3.43
network
set of nodes connected by some type of communication medium, including any intervening repeaters, bridges, routers and lower-layer gateways

3.3.44
node
a) single DL-entity as it appears on one local link

b) end-point of a link in a network or a point at which two or more links meet [derived from IEC 61158-2]

3.3.45
object
abstract representation of a particular component within a device

NOTE An object can be

a) an abstract representation of the capabilities of a device. Objects can be composed of any or all of the following components:

1) data (information which changes with time),

2) configuration (parameters for behavior),

3) methods (things that can be done using data and configuration);

b) a collection of related data (in the form of variables) and methods (procedures) for operating on that data that have clearly defined interface and behavior.

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3.3.46
object dictionary
data structure addressed by Index and Sub-index that contains description of data type objects, communication objects and application objects

3.3.47
process data
collection of application objects designated to be transferred cyclically or acyclically for the purpose of measurement and control

3.3.48
process data object
structure described by mapping parameters containing one or several process data entities

3.3.49
producer
node or source sending data to one or many consumers

3.3.50
resource
processing or information capability

3.3.51
segment
collection of one real master with one or more slaves

3.3.52
server
object which provides services to another (client) object

3.3.53
service
operation or function than an object and/or object class performs upon request from another object and/or object class

3.3.54
slave
DL-entity accessing the medium only after being initiated by the preceding slave or

3.3.55
subindex
sub-address of an object within the object dictionary

3.3.56
sync manager
collection of control elements to coordinate access to concurrently used objects.

3.3.57
sync manager channel
single control elements to coordinate access to concurrently used objects.

3.3.58
switch
MAC bridge as defined in IEEE 802.1D

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3.4 Common symbols and abbreviations

AL-	Application layer (as a prefix)
ALE	AL-entity (the local active instance of the application layer)
AL	AL-layer
APDU	AL-protocol-data-unit
ALM	AL-management
ALME	AL-management Entity (the local active instance of AL-management)
ALMS	AL-management service
ALS	AL-service
ALSDU	AL-service-data-unit
DL	Data-link-layer
FIFO	First-in first-out (queuing method)
OSI	Open systems interconnection
PhL	Ph-layer
QoS	Quality of service

3.5 Additional symbols and abbreviations

ASE	Application service element
AR	Application relationship
CAN	Controller Area Network
CiA	CAN in Automation
CoE	CAN application protocol over Type 12 services
CSMA/CD	Carrier sense multiple access with collision detection
DC	Distributed clocks
DNS	Domain name system (server for name resolution in IP networks)
E²PROM	Electrically erasable programmable read only memory
EoE	Ethernet tunneled over Type 12 services

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ESC	Type 12 slave controller
FCS	Frame check sequence
FMMU	Fieldbus memory management unit
FoE	File access with Type 12 services
HDR	Header
ID	Identifier
IETF	Internet engineering rask force
IP	Internet protocol
LAN	Local area network
MAC	Medium access control
OD	Object dictionary
PDI	Physical device internal interface (a set of elements that allows access to DL services from the AL)
PDO	Process data object
RAM	Random access memory
Rx	Receive
SDO	Service data object
SII	slave information interface
SM	Synchronization manager
SoE	Servo drive profile with Type 12 services
SyncM	Synchronization manager
TCP	Transmission control protocol
Tx	Transmit
UDP	User datagram protocol
VoE	Profile specific services
WKC	Working counter

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3.6 Conventions

3.6.1 General concept

The services are specified in IEC 61158-3-12 standard. The service specification defines the services that are provided by the Type 12 DL. The mapping of these services to ISO/IEC 8802-3 is described in this international Standard.

This standard uses the descriptive conventions given in ISO/IEC 10731.

3.6.2 Convention for the encoding of reserved bits and octets

The term "reserved" may be used to describe bits in octets or whole octets. All bits or octets that are reserved should be set to zero at the sending side and shall not be tested at the receiving side except it is explicitly stated or if the reserved bits or octets are checked by a state machine.

The term "reserved" may also be used to indicate that certain values within the range of a parameter are reserved for future extensions. In this case the reserved values should not be used at the sending side and shall not be tested at the receiving side except it is explicitly stated or if the reserved values are check by a state machine.

3.6.3 Conventions for the common codings of specific field octets

APDUs may contain specific fields that carry information in a primitive and condensed way. These fields shall be coded in the order according to Figure 1.

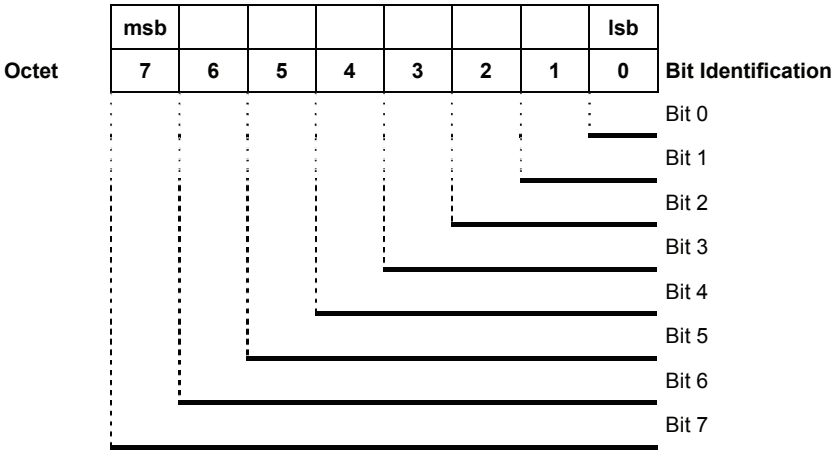

Figure 1 – Common structure of specific fields

Bits may be grouped as group of bits. Each bit or group of bits shall be addressed by its Bit Identification (e.g. Bit 0, Bit 1 to 4). The position within the octet shall be according to the figure above. Alias names may be used for each bit or group of bits or they may be marked as reserved. The grouping of individual bits shall be in ascending order without gaps. The values for a group of bits may be represented as binary, decimal or hexadecimal values. This value shall only be valid for the grouped bits and can only represent the whole octet if all 8 bits are grouped. Decimal or hexadecimal values shall be transferred in binary values so that the bit with the highest number of the group represents the msb concerning the grouped bits.

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EXAMPLE Description and relation for the specific field octet

Bit 0: reserved.

Bit 1-3: Reason_Code The decimal value 2 for the Reason_Code means general error.

Bit 4-7: shall always set to one.

The octet that is constructed according to the description above looks as follows:

(msb) Bit 7 = 1,

Bit 6 = 1,

Bit 5 = 1,

Bit 4 = 1,

Bit 3 = 0,

Bit 2 = 1,

Bit 1 = 0,

(lsb) Bit 0 = 0.

This bit combination has an octet value representation of 0xf4.

3.6.4 Abstract syntax conventions

The AL syntax elements related to PDU structure are described as shown in the example of Table 1.

Frame part denotes the element that will be replaced by this reproduction.

Data field is the name of the elements.

Data Type denotes the type of the terminal symbol.

Value/Description contains the constant value or the meaning of the parameter.

Table 1 – PDU element description example

Frame part	Data Field	Data Type	Value/Description
CoE Header	Number	Unsigned9	0x00
	Reserved	Unsigned3	0x00
	Service	Unsigned4	0x02: SDO Request
SDO	Size Indicator	Unsigned1	0x00: size of Data (1..4) unspecified 0x01: size of Data in Data Set Size specified
	Transfer Type	Unsigned1	0x01: Expedited transfer
	Data Set Size	Unsigned2	0x00: 4 Octet Data 0x01: 3 Octet Data 0x02: 2 Octet Data 0x03: 1 Octet Data
	Complete Access	Unsigned1	0x00
	Command Specifier	Unsigned3	0x01: Initiate Download Request

The informational attribute types are described in C language notations (ISO/IEC 9899) as shown in Figure 2. BYTE and WORD are elements of type unsigned char and unsigned short.

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```
typedef struct
{
  Unsigned8     Type;
  Unsigned8     Revision;
  Unsigned16    Build;
  Unsigned8     NoOfSuppFmmuChannels;
  Unsigned8     NoOfSuppSyncManChannels;
  Unsigned8     RamSize;
  Unsigned8     Reserved1;
  unsigned      FmmuBitOperationNotSupp:  1;
  unsigned      Reserved2:                7;
  unsigned      Reserved3:                8;
} TDLINFORMATION;
```

Figure 2 – Type description example

The attributes of an object are described in a form as shown in Table 2.

Subindex describes a single element of the object.

Description denotes a name string for this attribute.

Data Type denotes the type of this element.

M/O/C indicates whether the attribute is mandatory (M), optional (O) or depends upon setting of other attributes (C).

Access type shows the access right to this element. R means read access right, W means write access right. It can be extended showing the AL state where the access right applies.

PDO Mapping denotes the possibility to map this attribute to TxPDO or RxPDO or to indicate that this parameter is not mappable.

Value contains the constant value and/or the meaning of the parameter.

Table 2 – Example attribute description

Sub-Index	Description	Data type	M/O/C	Access	PDO Mapping	Value
0	Number of entries	UNSIGNED8	M	R	No	4
1	Vendor ID	UNSIGNED32	M	R	No	Assigned uniquely by ETG
2	Product Code	UNSIGNED32	M	R	No	Assigned uniquely by Vendor
3	Revision Number	UNSIGNED32	M	R	No	Assigned uniquely by Vendor Bit 0-15: Minor Revision Number of the device Bit 16-31: Major Revision Number of the device

3.6.5 State machine conventions

The protocol sequences are described by means of State Machines.

In state diagrams states are represented as boxes and state transitions are shown as arrows. Names of states and transitions of the state diagram correspond to the names in the textual listing of the state transitions.

The textual listing of the state transitions is structured as follows, see also Table 3.

The first row contains the name of the transition.

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The second row defines the current state.

The third row contains an optional event followed by Conditions starting with a “/” as first line character and finally followed by the Actions starting with a “=>” as first line character.

The last row contains the next state.

If the event occurs and the conditions are fulfilled the transition fires, i.e. the actions are executed and the next state is entered.

The layout of a Machine description is shown in Table 3. The meaning of the elements of a State Machine Description is shown in Table 4.

Table 3 – State machine description elements

#	Current state	Event /Condition => Action	Next state

Table 4 – Description of state machine elements

Description element	Meaning
Current state Next state	name of the given states.
#	name or number of the state transition.
Event	name or description of the event.
/Condition	boolean expression. The preceding “\” is not part of the condition.
=> Action	list of assignments and service or function invocations. The preceding “=>” is not part of the action.

The conventions used in the state machines are shown in Table 5.

Table 5 – Conventions used in state machines

Convention	Meaning
=	value of an item on the left is replaced by value of an item on the right. If an item on the right is a parameter, it comes from the primitive shown as an input event.
axx	a parameter name if a is a letter. EXAMPLE Identifier = reason means value of a 'reason' parameter is assigned to a parameter called 'Identifier.'
"xxx"	indicates fixed visible string. EXAMPLE Identifier = "abc" means value "abc" is assigned to a parameter named 'Identifier.'
nnn	if all elements are digits, the item represents a numerical constant shown in decimal representation.
0xnn	if all elements nn are digits, the item represents a numerical constant shown in hexadecimal representation.
==	a logical condition to indicate an item on the left is equal to an item on the right.
<	a logical condition to indicate an item on the left is less than the item on the right.
>	a logical condition to indicate an item on the left is greater than the item on the right.
!=	a logical condition to indicate an item on the left is not equal to an item on the right.

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Convention	Meaning
&&	logical "AND"
||	logical "OR"
!	logical "NOT"
+ - * /	arithmetic operators
;	separator of expressions

Readers are strongly recommended to refer to the subclauses for the attribute definitions, the local functions and the FDL-PDU definitions to understand protocol machines. It is assumed that readers have sufficient knowledge of these definitions and they are used without further explanations.

Further constructs as defined in C language notation (ISO/IEC 9899) can be used to describe conditions and actions.

4 Application layer protocol specification

4.1 Operating principle

Type 12 is a Real Time Ethernet technology that aims to maximize the utilization of the full duplex Ethernet bandwidth. Medium access control employs the master/slave principle, where the master node (typically the control system) sends the Ethernet frames to the slave nodes, which extract data from and insert data into these frames.

From an Ethernet point of view, a Type 12 segment is a single Ethernet device, which receives and sends standard ISO/IEC 8802-3 Ethernet frames. However, this Ethernet device is not limited to a single Ethernet controller with a downstream microprocessor, but may consist of a large number of slave devices. These process the incoming frames directly and extract the relevant user data or insert data and transfer the frame to the next slave device. The last slave device within the segment sends the fully processed frame back, so that it is returned by the first slave device to the master as response frame.

This procedure utilizes the full duplex mode of Ethernet: both communication directions are operated independently. Direct communication without a switch between a master device and a Type 12 segment consisting of one or several slave devices may be established.

Industrial communication systems have to meet different requirements in terms of the data transmission characteristics. Parameter data is transferred acyclically and in large quantities, whereby the timing requirements are relatively non-critical, and the transmission is usually triggered by the control system. Diagnostic data is also transferred acyclically and event-driven, but the timing requirements are more demanding, and the transmission is usually triggered by a peripheral device.

Process data, on the other hand, is typically transferred cyclically with different cycle times. The timing requirements are most stringent for process data communication. Type 12 supports a variety of services and protocols to meet these differing requirements.

4.2 Node reference model

4.2.1 Mapping onto OSI basic reference model

Type 12 is described using the principles, methodology and model of ISO/IEC 7498 Information processing systems — Open Systems Interconnection — Basic Reference Model (OSI). The OSI model provides a layered approach to communications standards, whereby the layers can be developed and modified independently. The Type 12 specification defines functionality from top to bottom of a full OSI stack, and some functions for the users of the stack. Functions of the intermediate OSI layers, layers 3 – 6, are consolidated into either the Type 12 Data Link layer or the Type 12 Application layer. Likewise, features common to users of the Fieldbus Application Layer may be provided by the Type 12 Application layer to simplify user operation, as noted in Figure 3.

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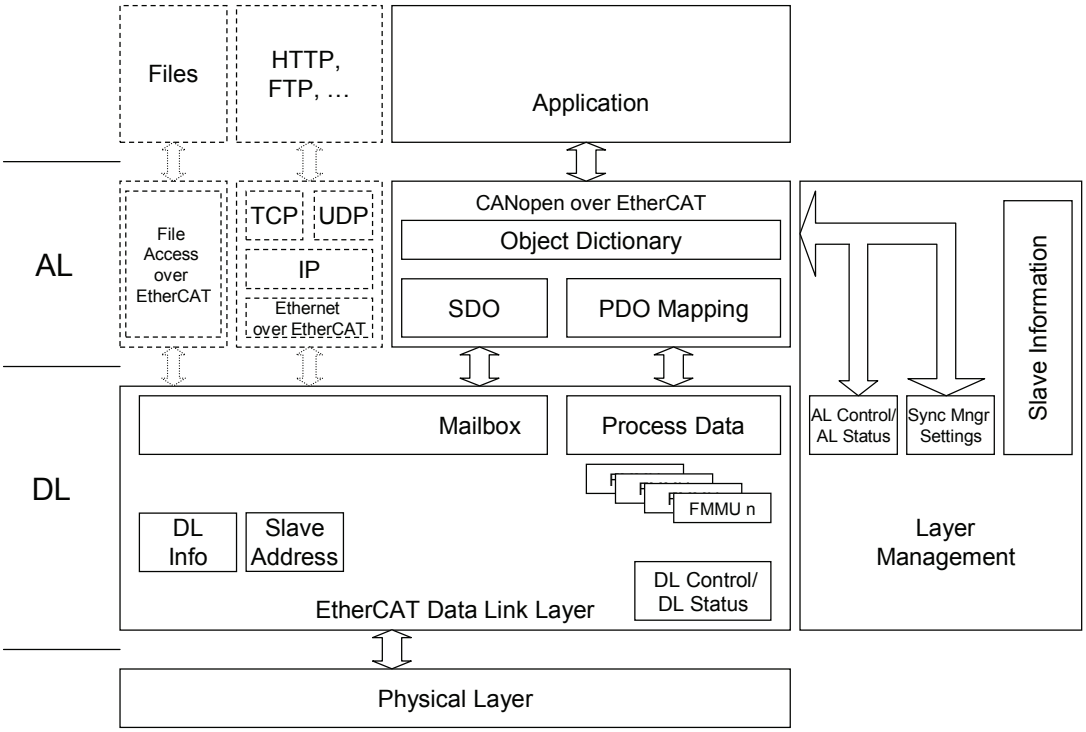

Figure 3 – Slave Node Reference Model

4.2.2 Data Link Layer features

The data link layer provides basic time critical support for data communications among devices. The term “time-critical” is used to describe applications having a time-window, within which one or more specified actions are required to be completed with some defined level of certainty. Failure to complete specified actions within the time window risks failure of the applications requesting the actions, with attendant risk to equipment, plant and possibly human life.

The data link layer has the task to compute, compare and generate the frame check sequence and provide communications by extracting data from and/or including data into the Ethernet frame. This is done depending on the data link layer parameters which are stored at pre-defined memory locations. The application data is made available to the application layer in physical memory, either in a mailbox configuration or within the process data section.

Additionally, some data structures in the Data Link layer will be used to allow a coordination of the interaction between master and slave such as AL Control, Status and Event and Sync manager settings.

4.2.3 Application Layer structure

The Application Layer consists of the following elements.

- A real time entity (mandatory)
- An entity that deals with TCP/UDP/IP and related protocols (optional)
- A file access utility (optional)
- A Management unit (mandatory)

The Application Layer uses the services provided by the Type 12 Data Link Layer to convey the Application Layer service data.

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5 FAL syntax description

5.1 Coding principles

Application layer uses DL objects as defined in IEC 61158-5-12.

5.2 Data types and encoding rules

5.2.1 General description of data types and encoding rules

The format of this data and its meaning have to be known by the producer and consumer(s) to be able to exchange meaningful data. This specification models this by the concept of data types.

The encoding rules define the representation of values of data types and the transfer syntax for the representations. Values are represented as bit sequences. Bit sequences are transferred in sequences of octets (bytes). For numerical data types the encoding is little endian style as shown in Table 6.

The data types and encoding rules shall be valid for the DL services and protocols as well as for the AL services and protocols specified. The encoding rules for the Ethernet frame are specified in ISO/IEC 8802-3. The DLSDU of Ethernet is an octet string. The transmission order within octets depends upon MAC and PhL encoding rules.

5.2.2 Encoding of a Boolean value

a) The encoding of a Boolean value shall be primitive. The ContentsOctets shall consist of a single octet.

b) If the Boolean value is FALSE, the ContentsOctets shall be 0 (zero). If the Boolean value is TRUE, the ContentsOctets shall be 0xff.

5.2.3 Encoding of a Time Of Day with and without date indication value

a) The encoding of a Time Of Day with and without date indication value shall be primitive.

b) The ContentsOctets shall be equal in value to the octets in the data value, as shown in Figure 4.

bits	7	6	5	4	3	2	1	0	
octets									
1	0	0	0	0	227	226	225	224	number of
2	223	222	221	220	219	218	217	216	milliseconds
3	215	214	213	212	211	210	29	28	since
4	27	26	25	24	23	22	21	20	midnight
5	215	214	213	212	211	210	29	28	number of days since 01.01.84
6	27	26	25	24	23	22	21	20	only with date indication
	msb								

Figure 4 – Encoding of Time Of Day value

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5.2.4 Encoding of a Time Difference with and without date indication value

a) The encoding of a Time Difference with and without date indication value shall be primitive.

b) The ContentsOctets shall be equal in value to the octets in the data value, as shown in Figure 5.

bits	7	6	5	4	3	2	1	0	
octets									
1	231	230	229	228	227	226	225	224	
2	223	222	221	220	219	218	217	216	milliseconds
3	215	214	213	212	211	210	29	28	
4	27	26	25	24	23	22	21	20	
5	215	214	213	212	211	210	29	28	days
6	27	26	25	24	23	22	21	20	only with date indication
	msb								

Figure 5 – Encoding of Time Difference value

5.2.5 Transfer syntax for bit sequences

For transmission a bit sequence is reordered into a sequence of octets. Hexadecimal notation is used for octets as specified in ISO/IEC 9899. Let $b = b0...bn\text{-}1$ be a bit sequence. Denote k a non-negative integer such that $8(k - 1) < n \leq 8k$. Then b is transferred in k octets assembled as shown in Table 6. The bits bi, $i \geq n$ of the highest numbered octet are do not care bits.

Octet 1 is transmitted first and octet k is transmitted last. Hence the bit sequence is transferred as follows across the network (transmission order within an octet is determined by ISO/IEC 8802-3):

$b7, b6, ..., b0, b15, ..., b8, ...$

Table 6 – Transfer Syntax for bit sequences

octet number	1.	2.	k.
	b7 .. b0	b15 .. b8	b8k –1 .. b8k -8

EXAMPLE

Bit 9	...	Bit 0
10b	0001b	1100b
0x2	0x1	0xC
		= 0x21C

The bit sequence b = b0 .. b9 = 0011 1000 01_b represents an Unsigned10 with the value 0x21C and is transferred in two octets: First 0x1C and then 0x02.

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5.2.6 Encoding of a Unsigned Integer value

Data of basic data type Unsignedn has values in the non-negative integers. The value range is 0, ..., 2*n*-1. The data is represented as bit sequences of length *n*. The bit sequence

b = *b*0 ...*b*n-1

is assigned the value

Unsignedn(b) = bn-1×2n-1+ ...+ b1×21 + b0×20

The bit sequence starts on the left with the least significant byte (Octet).

EXAMPLE The value 266 = 0x10A with data type Unsigned16 is transferred in two octets, first 0x0A and then 0x01.

The Unsignedn data types are transferred as specified in Table 7. Unsigned data types as Unsigned1 to Unsigned7 and Unsigned 9 to Unsigned15 will be used too. In this case the next element will start at the first free bit position as denoted in 3.6.3.

Table 7 – Transfer syntax for data type Unsignedn

octet number	1.	2.	3.	4.	5.	6.	7.	8.
Unsigned8	b7..b0							
Unsigned16	b7..b0	b15..b8						
Unsigned32	b7..b0	b15..b8	b23..b16	b31..b24				
Unsigned64	b7..b0	b15..b8	b23..b16	b31..b24	b39..b32	b47..b40	b55..b48	b63..b56

5.2.7 Encoding of a Signed Integer value

Data of basic data type Integern has values in the integers. The value range is from -2*n*-1 to 2*n*-1-1. The data is represented as bit sequences of length *n*. The bit sequence

b = *b*0 .. *bn*-1

is assigned the value

Integern(*b*) = *bn*-2×2*n*-2 + ...+ *b*1×21 + *b*0×20 if *bn*-1 = 0

and, performing two's complement arithmetic,

Integern(*b*) = - Integern(^b) - 1 if *bn*-1 = 1

NOTE The bit sequence starts on the left with the least significant bit.

EXAMPLE The value –266 = 0xFEF6 with data type Integer16 is transferred in two octets, first 0xF6 and then 0xFE.

The Integern data types are transferred as specified in Table 8. Integer data types as Integer1 to Integer7 and Integer9 to Integer15 will be used too. In this case the next element will start at the first free bit position as denoted in 3.6.3.

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Table 8 – Transfer syntax for data type Integern

octet number	1.	2.	3.	4.	5.	6.	7.	8.
Integer8	b7..b0							
Integer16	b7..b0	b15..b8						
Integer32	b7..b0	b15..b8	b23..b16	b31..b24				
Integer64	b7..b0	b15..b8	b23..b16	b31..b24	b39..b32	b47..b40	b55..b48	b63..b56

5.2.8 Encoding of a Floating Point value

Float32 ::= OCTET STRING SIZE (4) -- IEC 60559 Single precision

Float64 ::= OCTET STRING SIZE (8) -- IEC 60559 Double precision

5.2.9 Encoding of a Visible String value

a) The encoding of a variable length VisibleString value shall be primitive.

b) There is no Length field and no termination symbol; the length is encoded implicitly.

c) The ContentsOctets shall be a sequence of octets. The leftmost string element is encoded in the first octet, followed by the second octet, followed by each octet in turn up to and including the last octet as rightmost of the ContentsOctets.

5.2.10 Encoding of a Unicode String value

a) The encoding of a variable length UnicodeString value shall be primitive.

b) There is no Length field; the length is encoded implicitly.

c) The ContentsOctets shall be a sequence of unsigned integer. The leftmost string element is encoded in the first unsigned integer, followed by the second unsigned integer, followed by each unsigned integer in turn up to and including the last unsigned integer as rightmost of the ContentsOctets.

5.2.11 Encoding of an Octet String value

a) The encoding of a variable length OctetString value shall be primitive.

b) There is no Length field; the length is encoded implicitly.

c) The ContentsOctets shall be a sequence of octets. The leftmost string element is encoded in the first octet, followed by second octet, followed by each octet in turn up to and including the last octet as rightmost of the ContentsOctets.

5.3 AR coding

5.3.1 AL Control Request (Indication)

The attribute types of AL Control Request are described in Figure 6.

```
typedef struct
{
  unsigned          State:          4;
  unsigned          Acknowledge:    1;
  unsigned          Reserved:       3;
  unsigned          ApplSpecific:   8;
} TALCONTROL;
```

Figure 6 – AL Control Request structure

The AL Control Request is mapped to a DL write service to the DL-user control register object and R2 as specified in IEC 61158-3-12. The AL Control Request coding is specified in Table 9.

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Table 9 – AL Control Description

Parameter	DL-user Register	Data Type	Value
State	R1	Unsigned4	1: Init 2: Pre-Operational 3: Bootstrap 4: Safe-Operational 8: Operational
Acknowledge	R1	Unsigned1	0: Parameter Change of the AL Status Register will be unchanged 1: Parameter Change of the AL Status Register will be reset
Reserved	R1	Unsigned3	shall be zero
Application Specific	R2	Unsigned8	application specific

5.3.2 AL Control Response (Confirmation)

The AL Control Response is mapped to a DL read service to the DL-user status register object and register R4, R5 and R6 as specified in IEC 61158-3-12. The attribute types of AL Control Response are described in Figure 7.

```
typedef struct
{
  unsigned          State:           4;
  unsigned          Change:          1;
  unsigned          Reserved1:       3;
  unsigned          ApplSpecific:    8;
  unsigned          Reserved2:      16;
  unsigned          AlStatusCode:   16;
} TALSTATUSE;
```

Figure 7 – AL Control Response structure

The AL Control Response coding is specified in Table 10.

Table 10 – AL Control Response

Parameter	DL-user Register	Data Type	Value
State	R3	Unsigned4	1: Init 2: Pre-Operational 3: Bootstrap 4: Safe-Operational 8: Operational
Change	R3	Unsigned1	0: State transition successful 1: State transition not successful
Reserved	R3	Unsigned3	shall be zero
Application Specific	R4	Unsigned8	application specific
Reserved	R5	Unsigned16	shall be zero
Application Specific	R6	Unsigned16	see Table 11

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Table 11 – AL Status Codes

Code	Description	Current state (or state change)	Resulting state
0x0000	No error	Any	Current state
0x0001	Unspecified error	Any	Any + E
0x0002	No Memory	Any	Any + E
0x0011	Invalid requested state change	I -> S, I -> O, P -> O O -> B, S -> B, P -> B	Current state + E
0x0012	Unknown requested state	Any	Current state + E
0x0013	Bootstrap not supported	I -> B	I + E
0x0014	No valid firmware	I -> P	I + E
0x0015	Invalid mailbox configuration	I -> B	I + E
0x0016	Invalid mailbox configuration	I -> P	I + E
0x0017	Invalid sync manager configuration	P -> S, S -> O	Current state + E
0x0018	No valid inputs available	O, S -> O	S + E
0x0019	No valid outputs	O, S -> O	S + E
0x001A	Synchronization error	O, S -> O	S + E
0x001B	Sync manager watchdog	O, S	S + E
0x001C	Invalid Sync Manager Types	O, S, P -> S	S + E
0x001D	Invalid Output Configuration	O, S, P -> S	S + E
0x001E	Invalid Input Configuration	O, S, P -> S	P + E
0x001F	Invalid Watchdog Configuration	O, S, P -> S	P + E
0x0020	Slave needs cold start	Any	Current state + E
0x0021	Slave needs INIT	B, P, S, O	Current state + E
0x0022	Slave needs PREOP	S, O	S + E, O + E
0x0023	Slave needs SAFEOP	O	O + E
0x0024	Invalid Input Mapping	P -> S	P + E
0x0025	Invalid Output Mapping	P -> S	P + E
0x0026	Inconsistent Settings	P -> S	P + E
0x0027	FreeRun not supported	P -> S	P + E
0x0028	SyncMode not supported	P -> S	P + E
0x0029	FreeRun needs 3Buffer Mode	P -> S	P + E
0x002A	Background Watchdog	S, O	P + E
0x002B	No Valid Inputs and Outputs	O, S -> O	S + E
0x002C	Fatal Sync Error	O	S + E
0x002D	No Sync Error	O, S, P -> S	S + E
0x0030	Invalid DC SYNCH Configuration	O, S -> O, P -> S	P + E, S + E
0x0031	Invalid DC Latch Configuration	O, S -> O, P -> S	P + E, S + E
0x0032	PLL Error	O, S -> O	S + E
0x0033	DC Sync IO Error	O, S -> O	S + E
0x0034	DC Sync Timeout Error	O, S -> O	S + E
0x0035	DC Invalid Sync Cycle Time	P -> S	P + E

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Code	Description	Current state (or state change)	Resulting state
0x0036	DC Sync0 Cycle Time	P -> S	P + E
0x0037	DC Sync1 Cycle Time	P -> S	P + E
0x0041	MBX_AOE	B, P, S, O	Current state + E
0x0042	MBX_EOE	B, P, S, O	Current state + E
0x0043	MBX_COE	B, P, S, O	Current state + E
0x0044	MBX_FOE	B, P, S, O	Current state + E
0x0045	MBX_SOE	B, P, S, O	Current state + E
0x004F	MBX_VOE	B, P, S, O	Current state + E
0x0050	EEPROM no access	Any	Any + E
0x0051	EEPROM Error	Any	Any + E
0x0060	Slave restarted locally	Any	I
other codes < 0x8000	reserved		
0x8000 – 0xFFFF	Vendor specific		

5.3.3 AL State Changed

The AL State Changed is mapped to a DL read service to the AL Status and AL Status Code object. The attribute types of AL State Changed are described in Figure 8.

```
typedef struct
{
  unsigned          State:            4;
  unsigned          Change:           1;
  unsigned          Reserved1:        3;
  unsigned          ApplSpecific:     8;
  unsigned          Reserved2:       16;
  unsigned          AlStatusCode:    16;
} TALSTATUSE;
```

Figure 8 – AL State Changed structure

The AL State Changed coding is specified in Table 12.

Table 12 – AL State Changed

Parameter	DL-user Register	Data Type	Value
State	R3	Unsigned4	1: Init 2: Pre-Operational 3: Bootstrap 4: Safe-Operational 8: Operational
Change	R3	Unsigned1	shall be one
Reserved	R3	Unsigned3	shall be zero
Application Specific	R4	Unsigned8	application specific
Reserved	R5	Unsigned16	shall be zero
AL Status Code	R6	Unsigned16	see Table 11

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5.3.4 AL AR Attributes

AL AR attributes can be accessed by DL read or write services or by local read write services.

The attribute types of PDI Control are described in Figure 9.

```
typedef struct
{
  unsigned      PDIType:                    8;
  unsigned      StrictALControl:          1;
  unsigned      Reserved:                 7;
} TPDICONTROL;
```

Figure 9 – PDI Control type description

The PDI Control coding is specified in Table 13. PDI Control will be loaded from SII at start-up.

Table 13 – PDI Control

Parameter	DL-user Register	Data Type	Access DL	Access local	Value/Description
PDI Type	R7	Unsigned8	R	R	type specific (see IEC 61158-3-12 DL information parameter)
Strict AL Control	Copy	Unsigned1	R	R	0x00: AL Management will be done by an application Controller 0x01: AL Management will be emulated (AL status follows directly AL control)

The PDI Configuration coding is controller specific as shown in Table 14 and set by SII at start-up.

Table 14 – PDI Configuration

Parameter	DL-user Register	Data Type	Access DL	Access local	Value/Description
Application Specific	R8	unsigned8	R	R	applicatgion specific

The attribute types of Sync Configuration are described in Figure 10.

```
typedef struct
{
  unsigned      SignalCondSync0:          2;
  unsigned      EnableSignalSync0:        1;
  unsigned      EnableInterruptSync0:     1;
  unsigned      SignalCondSync1:          2;
  unsigned      EnableSignalSync1:        1;
  unsigned      EnableInterruptSync1:     1;
} TSYNCCFG;
```

Figure 10 – Sync Configuration type description

The Sync Configuration coding is specified in Table 15. Sync Configuration will be loaded from SII at start-up.

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Table 15 – Sync Configuration

Parameter	DL-user register	Data Type	Access DL	Access local	Value/Description
Signal Conditioning Sync0	R8	unsigned2	R	R	controller specific
Enable Signal Sync0	R8	unsigned1	R	R	0x00: disable 0x01: enable
Enable Interrupt Sync0	R8	unsigned1	R	R	0x00: disable 0x01: enable
Signal Conditioning Sync1	R8	unsigned2	R	R	controller specific
Enable Signal Sync1	R8	unsigned1	R	R	0x00: disable 0x01: enable
Enable Interrupt Sync1	R8	unsigned1	R	R	0x00: disable 0x01: enable

5.4 SII coding

The Slave Information Interface Area coding is specified in Table 16 and Table 17. Address means a word address (e.g. 0 is first word, 1 is second word).

Table 16 – Slave Information Interface Area

Parameter	Address	Data Type	Value/Description
PDI Control	0x0000	Unsigned16	initialization value for PDI Control register (0x140-0x141)
PDI Configuration	0x0001	Unsigned16	initialization value for PDI Configuration register (0x150-0x151)
SyncImpulseLen	0x0002	Unsigned16	sync Impulse in multiples of 10 ns
PDI Configuration2	0x0003	Unsigned16	initialization value for PDI Configuration register R8 most significant word (0x152-0x153)
Configured Station Alias	0x0004	Unsigned16	alias Address
Reserved	0x0005	BYTE[4]	shall be zero
Checksum	0x0007	Unsigned16	low byte contains remainder of division of word 0 to word 6 as unsigned number divided by the polynomial x^8+x^2+x+1(initial value 0xFF)
Vendor ID	0x0008	Unsigned32	CAN-Object 0x1018, Subindex 1
Product Code	0x000A	Unsigned32	CAN-Object 0x1018, Subindex 2
Revision Number	0x000C	Unsigned32	CAN-Object 0x1018, Subindex 3
Serial Number	0x000E	Unsigned32	CAN-Object 0x1018, Subindex 4
Reserved	0x0013	BYTE[8]	chall be zero
Bootstrap Receive Mailbox Offset	0x0014	Unsigned16	receive Mailbox Offset for Bootstrap state (master to slave)
Bootstrap Receive Mailbox Size	0x0015	Unsigned16	receive Mailbox Size for Bootstrap state (master to slave)
Bootstrap Send Mailbox Offset	0x0016	Unsigned16	send Mailbox Offset for Bootstrap state (slave to master)
Bootstrap Send Mailbox Size	0x0017	Unsigned16	send Mailbox Size for Bootstrap state (slave to master)
Standard Receive Mailbox Offset	0x0018	Unsigned16	receive Mailbox Offset for Standard state (master to slave)
Standard Receive Mailbox Size	0x0019	Unsigned16	receive Mailbox Size for Standard state (master to slave)
Standard Send Mailbox Offset	0x001A	Unsigned16	send Mailbox Offset for Standard state (slave to master)

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Parameter	Address	Data Type	Value/Description
Standard Send Mailbox Size	0x001B	Unsigned16	send Mailbox Size for Standard state (slave to master)
Mailbox Protocol	0x001C	Unsigned16	mailbox Protocols Supported as defined in Table 18
Reserved	0x002B	BYTE[66]	shall be zero
Size	0x003E	Unsigned16	size of E^2PROM in KBit-1
Version	0x003F	Unsigned16	this Version is 1

Table 17 – Slave Information Interface Categories

Parameter	Address	Data Type	Value/Description
First Category Header	0x0040	Unsigned15	category Type as defined in Table 19
	0x0040	Unsigned1	vendor Specific
	0x0041	Unsigned16	following Category Word Size x
First Category Data	0x0042	Category dependent	category Data
Second Category Header	0x0042 + x	Unsigned15	category Type as defined in Table 19
	0x0042 + x	Unsigned1	vendor Specific
	0x0043 + x	Unsigned16	following Category Word Size
Second Category Data	0x0044 + x	Category dependent	category Data
…			continuation of the scheme until last category

Table 18 – Mailbox Protocols Supported Types

Protocol	Value	Description
EoE	0x0002	Ethernet over Type 12 (tunnelling of Data Link services)
CoE	0x0004	CAN application protocol over Type 12(access to SDO)
FoE	0x0008	File Access over Type 12
SoE	0x0010	Servo Drive Profile over Type 12
VoE	0x0020	Vendor specific protocol over Type 12

Table 19 – Categories Types

Protocol	Value	Description
NOP	00	no info
STRINGS	10	string repository for other Categories structure of this category data see Table 20
DataTypes	20	data Types for future use
General	30	general information structure of this category data see Table 21
FMMU	40	FMMUs to be used structure of this category data see Table 22
SyncM	41	Sync Manager Configuration structure of this category data see Table 23
TXPDO	50	TxPDO description structure of this category data see Table 24
RXPDO	51	RxPDO description structure of this category data see Table 24
DC	60	Distributed Clock for future use
End	0xffff	

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