



BSI Standards Publication

Industrial communication networks — Fieldbus specifications

Part 5-2: Application layer service definition — Type 2 elements

National foreword

This British Standard is the UK implementation of EN IEC 61158-5-2:2023. It is identical to IEC 61158-5-2:2023. It supersedes BS EN IEC 61158-5-2:2019, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee GEL/65/3, Industrial communications: process measurement and control, including fieldbus.

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

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Date	Text affected
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English Version

Industrial communication networks - Fieldbus specifications -
Part 5-2: Application layer service definition - Type 2 elements
(IEC 61158-5-2:2023)

Réseaux de communication industriels - Spécifications des
bus de terrain - Partie 5-2: Définition des services de la
couche application - Eléments de type 2
(IEC 61158-5-2:2023)

Industrielle Kommunikationsnetze - Feldbusse - Teil 5-2:
Dienstfestlegungen des Application Layer
(Anwendungsschicht) - Typ 2-Elemente
(IEC 61158-5-2:2023)

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European foreword

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The following dates are fixed:

- latest date by which the document has to be implemented at national (dop) 2024-01-28 level by publication of an identical national standard or by endorsement
- latest date by which the national standards conflicting with the (dow) 2026-04-28 document have to be withdrawn

This document supersedes EN IEC 61158-5-2:2019 and all of its amendments and corrigenda (if any).

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Endorsement notice

The text of the International Standard IEC 61158-5-2:2023 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 standard indicated:

IEC 61131-1	NOTE Approved as EN 61131-1
IEC 61131-9	NOTE Approved as EN IEC 61131-9
IEC 61158-2	NOTE Approved as EN IEC 61158-2
IEC 61784-1 (series)	NOTE Approved as EN IEC 61784-1 (series)
IEC 61784-2 (series)	NOTE Approved as EN IEC 61784-2 (series)
IEC 62026-3	NOTE Approved as EN 62026-3

Annex ZA (normative)

Normative references to international publications with their corresponding European publications

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

NOTE 1 Where an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 61131-3	2003	Programmable controllers - Part 3: Programming languages	-	-
IEC 61158-1	2023	Industrial communication networks - Fieldbus specifications - Part 1: Overview and guidance for the IEC 61158 and IEC 61784 series	-	-
IEC 61158-3-2	2023	Industrial communication networks - Fieldbus specifications - Part 3-2: Data-link layer service definition - Type 2 elements	-	-
IEC 61158-4-2	2023	Industrial communication networks - Fieldbus specifications - Part 4-2: Data-link layer protocol specification - Type 2 elements	EN IEC 61158-4-2	2023
IEC 61158-6-2	2023	Industrial communication networks - Fieldbus specifications - Part 6-2: Application layer protocol specification - Type 2 elements	-	-
IEC 61588	2021	Precision Clock Synchronization Protocol for Networked Measurement and Control Systems	-	-
IEC 61784-3-2	-	Industrial communication networks - Profiles - Part 3-2: Functional safety fieldbuses - Additional specifications for CPF 2	EN IEC 61784-3-2	-
IEC 62439-3	2016	Industrial communication networks - High availability automation networks - Part 3: Parallel Redundancy Protocol (PRP) and High-availability Seamless Redundancy (HSR)	EN IEC 62439-3	2018
ISO/IEC 646	-	Information technology - ISO 7-bit coded character set for information interchange	-	-
ISO/IEC 7498-1	-	Information technology - Open Systems Interconnection - Basic reference model: The basic model	-	-
ISO/IEC/IEEE 8802-3	-	Telecommunications and exchange between information technology systems - Requirements for local and metropolitan area networks - Part 3: Standard for Ethernet	-	-

EN IEC 61158-5-2:2023 (E)

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
ISO/IEC 8859-1	-	Information technology - 8-bit single-byte coded graphic character sets - Part-1: Latin alphabet No. 1	-	-
ISO/IEC 9545	-	Information technology - Open Systems Interconnection - Application layer structure	-	-
ISO/IEC 10646	-	Information technology - Universal coded character set (UCS)	-	-
ISO/IEC 10731	-	Information technology - Open Systems Interconnection - Basic Reference Model - Conventions for the definition of OSI services	-	-
ISO/IEC 60559	-	Information technology - Microprocessor Systems - Floating-Point arithmetic	-	-
ISO 639-2	-	Codes for the representation of names of languages - Part-2: Alpha-3 code	-	-
ISO 8601-1	-	Date and time - Representations for information interchange - Part 1: Basic rules	-	-
ISO 8859-1	1987	Information processing - 8-bit single-byte coded graphic character sets - Part 1: Latin alphabet No. 1	-	-
ISO 8859-2	1987	Information processing - 8-bit single byte coded graphic character sets - Part 2: Latin alphabet No. 2	-	-
ISO 8859-3	1988	Information processing - 8-bit single-byte coded graphic character sets - Part-3: Latin alphabet no. 3	-	-
ISO 8859-4	1988	Information processing - 8-bit single-byte coded graphic character sets - Part-4: Latin alphabet no. 4	-	-
ISO/IEC 8859-5	1988	Information processing - 8-bit single-byte coded graphic character sets - Part 5: Latin/Cyrillic alphabet	-	-
ISO 8859-6	1987	Information processing - 8-Bit single-byte coded graphic character sets - Part 6: Latin/Arabic alphabet	-	-
ISO 8859-7	1987	Information processing - 8-bit single-byte coded graphic character sets - Part 7: Latin/Greek alphabet	-	-
ISO 8859-8	1988	Information processing; 8-bit single-byte coded graphic character sets; Part 8: Latin/hebrew alphabet	-	-
ISO/IEC 8859-9	1989	Information processing - 8-bit single-byte coded graphic character sets - Part 9: Latin alphabet No. 5	-	-
ISO 11898-1	2015	Road vehicles - Controller area network (CAN) - Part 1: Data link layer and physical signalling	-	-
IETF RFC 1759	-	Printer MIB	-	-

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**INDUSTRIAL COMMUNICATION NETWORKS –
FIELDBUS SPECIFICATIONS –****Part 5-2: Application layer service definition –
Type 2 elements****FOREWORD**

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Attention is drawn to the fact that the use of the associated protocol type is restricted by its intellectual-property-right holders. In all cases, the commitment to limited release of intellectual-property-rights made by the holders of those rights permits a layer protocol type to be used with other layer protocols of the same type, or in other type combinations explicitly authorized by its intellectual-property-right holders.

NOTE Combinations of protocol types are specified in the IEC 61784-1 series and the IEC 61784-2 series.

IEC 61158-5-2 has been prepared by subcommittee 65C: Industrial networks, of IEC technical committee 65: Industrial-process measurement, control and automation. It is an International Standard.

This fifth edition cancels and replaces the fourth edition published in 2019. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) update of normative and bibliographic references;
- b) new STIME, UTIME and NTIME data types in 5.3.1.5;
- c) updated list of managements objects in 6.1.3;
- d) new attributes and services for the ASE general formal model in 6.2.1.2.1, 6.2.1.3 and 6.5;
- e) clarifications, new attributes and services for the Identity ASE in 6.2.1.2.2;
- f) clarifications, new attributes and other extensions for the Assembly ASE in 6.2.1.2.3;
- g) new attributes and services for the Message Router ASE in 6.2.1.2.4;
- h) addition of missing class attributes for the Acknowledge Handler ASE in 6.2.1.2.5;
- i) clarifications, new attributes and services for the Time Sync ASE in 6.2.1.2.6;
- j) addition of missing class attributes for the Parameter ASE in 6.2.1.2.7;
- k) clarifications of service parameters, status codes and procedures in 6.2.1.3;
- l) addition of a new service for the Message Router ASE in 6.2.1.3;
- m) clarifications and new services for the Connection Manager ASE in 6.2.2;
- n) clarifications and new services for the Connection ASE in 6.2.3;
- o) removal of obsoleted transport options and related services in 6.3.3;
- p) removal of all references to CPF and CPs (material moved to profile documents);
- q) miscellaneous editorial corrections.

The text of this International Standard is based on the following documents:

Draft	Report on voting
65C/1203/FDIS	65C/1244/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts of the IEC 61158 series, published under the general title *Industrial communication networks – Fieldbus specifications*, can be found on the IEC web site.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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 61158-1.

The application service is provided by the application protocol making use of the services available from the data-link or other immediately lower layer. This document defines the application service characteristics that fieldbus applications and/or system management can exploit.

Throughout the set of fieldbus standards, the term "service" refers to the abstract capability provided by one layer of the OSI Basic Reference Model to the layer immediately above. Thus, the application layer service defined in this document is a conceptual architectural service, independent of administrative and implementation divisions.

INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 5-2: Application layer service definition – Type 2 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 part of IEC 61158 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 2 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 document defines in an abstract way the externally visible service provided by the Type 2 fieldbus application layer in terms of:

- an abstract model for defining application resources (objects) capable of being manipulated by users via the use of the FAL service;
- the primitive actions and events of the service;
- the parameters associated with each primitive action and event, and the form which they take; and
- the interrelationship between these actions and events, and their valid sequences.

The purpose of this document is to define the services provided to:

- the FAL user at the boundary between the user and the application layer of the fieldbus reference model; and
- Systems Management at the boundary between the application layer and Systems Management of the fieldbus reference model.

This document specifies the structure and services of the Type 2 fieldbus application layer, in conformance with the OSI Basic Reference Model (ISO/IEC 7498-1) 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 document to provide access to the FAL to control certain aspects of its operation.

1.2 Specifications

The principal objective of this document is to specify the characteristics of conceptual application layer services suitable for time-critical communications, and thus supplement the OSI Basic Reference Model in guiding the development of application layer protocols for time-critical communications.

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 services standardized as the various Types of IEC 61158, and the corresponding protocols standardized in subparts of IEC 61158-6.

This document can be used as the basis for formal application programming interfaces. Nevertheless, it is not a formal programming interface, and any such interface will need to address implementation issues not covered by this specification, including

- a) the sizes and octet ordering of various multi-octet service parameters, and
- b) the correlation of paired request and confirm, or indication and response, primitives.

1.3 Conformance

This document 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 this application layer service definition standard. Instead, conformance is achieved through implementation of conforming application layer protocols that fulfill the Type 2 application layer services as defined in this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

NOTE All parts of the IEC 61158 series, as well as the IEC 61784-1 series and the IEC 61784-2 series are maintained simultaneously. Cross -references to these documents within the text therefore refer to the editions as dated in this list of normative references.

IEC 61131-3:2003¹, *Programmable controllers – Part 3: Programming languages*

IEC 61158-1:2023, *Industrial communication networks – Fieldbus specifications – Part 1: Overview and guidance for the IEC 61158 and IEC 61784 series*

IEC 61158-3-2:2023, *Industrial communication networks – Fieldbus specifications – Part 3-2: Data-link layer service definition – Type 2 elements*

¹ A newer edition of this standard has been published, but only the cited edition applies.

IEC 61158-4-2:2023, *Industrial communication networks – Fieldbus specifications – Part 4-2: Data-link layer protocol specification – Type 2 elements*

IEC 61158-6-2:2023, *Industrial communication networks – Fieldbus specifications – Part 6-2: Application layer protocol specification – Type 2 elements*

IEC 61588:2021, *Precision clock synchronization protocol for networked measurement and control systems*

IEC 61784-3-2, *Industrial communication networks – Profiles – Part 3-2: Functional safety fieldbuses – Additional specifications for CPF 2*

IEC 62439-3:2016, *Industrial communication networks – High availability automation networks – Part 3: Parallel Redundancy Protocol (PRP) and High-availability Seamless Redundancy (HSR)*

ISO/IEC 646, *Information technology – ISO 7-bit coded character set for information interchange*

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

ISO/IEC/IEEE 8802-3, *Telecommunications and exchange between information technology systems – Requirements for local and metropolitan area networks – Part 3: Standard for Ethernet*

ISO/IEC 8859-1, *Information technology – 8-bit single-byte coded graphic character sets – Part 1: Latin alphabet No. 1*

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

ISO/IEC 10646, *Information technology – Universal Coded Character Set (UCS)*

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

ISO/IEC 60559, *Information technology – Microprocessor Systems – Floating-Point arithmetic*

ISO 639-2, *Codes for the representation of names of languages – Part 2: Alpha-3 code*

ISO 8601-1, *Date and time – Representations for information interchange – Part 1: Basic rules*

ISO 8859-1²:1987, *Information processing – 8-bit single-byte coded graphic character sets – Part 1: Latin alphabet No. 1*

ISO 8859-2³:1987, *Information processing – 8-bit single-byte coded graphic character sets – Part 2: Latin alphabet No. 2*

² A newer edition of this standard has been published by ISO/IEC, but the cited edition is the one used in the referenced IETF standards.

³ A newer edition of this standard has been published by ISO/IEC, but the cited edition is the one used in the referenced IETF standards.

ISO 8859-3⁴:1988, *Information processing – 8-bit single-byte coded graphic character sets – Part 3: Latin alphabet No. 3*

ISO 8859-4⁵:1988, *Information processing – 8-bit single-byte coded graphic character sets – Part 4: Latin alphabet No. 4*

ISO 8859-5⁶:1988, *Information processing – 8-bit single-byte coded graphic character sets – Part 5: Latin/Cyrillic alphabet*

ISO 8859-6⁷:1987, *Information processing – 8-bit single-byte coded graphic character sets – Part 6: Latin/Arabic alphabet*

ISO 8859-7⁸:1987, *Information processing – 8-bit single-byte coded graphic character sets – Part 7: Latin/Greek alphabet*

ISO 8859-8⁹:1988, *Information processing – 8-bit single-byte coded graphic character sets – Part 8: Latin/Hebrew alphabet*

ISO 8859-9¹⁰:1989, *Information processing – 8-bit single-byte coded graphic character sets – Part 9: Latin alphabet No. 5*

ISO 11898-1:2015, *Road vehicles – Controller area network (CAN) – Part 1: Data link layer and physical signalling*

IETF RFC 1759, R. Smith, F. Wright, T. Hastings, S. Zilles, J. Gyllenskog, *Printer MIB*, March 1995, available at <https://www.rfc-editor.org/info/rfc1759> [viewed 2022-02-18]

3 Terms, definitions, symbols, abbreviated terms and conventions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <https://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

⁴ A newer edition of this standard has been published by ISO/IEC, but the cited edition is the one used in the referenced IETF standards.

⁵ A newer edition of this standard has been published by ISO/IEC, but the cited edition is the one used in the referenced IETF standards.

⁶ A newer edition of this standard has been published by ISO/IEC, but the cited edition is the one used in the referenced IETF standards.

⁷ A newer edition of this standard has been published by ISO/IEC, but the cited edition is the one used in the referenced IETF standards.

⁸ A newer edition of this standard has been published by ISO/IEC, but the cited edition is the one used in the referenced IETF standards.

⁹ A newer edition of this standard has been published by ISO/IEC, but the cited edition is the one used in the referenced IETF standards.

¹⁰ A newer edition of this standard has been published by ISO/IEC, but the cited edition is the one used in the referenced IETF standards.

3.1 ISO/IEC 7498-1 terms

- a) application entity
- b) application process
- c) application protocol data unit
- d) application service element
- e) application entity invocation
- f) application process invocation
- g) application transaction
- h) real open system
- i) transfer syntax

3.2 ISO/IEC 8822 terms

- a) abstract syntax
- b) presentation context

3.3 ISO/IEC 9545 terms

- a) application-association
- b) application-context
- c) application context name
- d) application-entity-invocation
- e) application-entity-type
- f) application-process-invocation
- g) application-process-type
- h) application-service-element
- i) application control service element

3.4 ISO/IEC 8824-1 terms

- a) object identifier
- b) type

3.5 Type 2 fieldbus data-link layer terms

The following terms, defined in IEC 61158-3-2 and IEC 61158-4-2, apply.

- a) DL-time
- b) DL-scheduling-policy
- c) DLCEP
- d) DLC
- e) DL-connection-oriented mode
- f) DLPDU
- g) DLSDU
- h) DLSAP
- i) fixed tag
- j) generic tag
- k) link
- l) MAC ID
- m) network address

- n) node address
- o) node
- p) tag
- q) scheduled
- r) unscheduled

3.6 Type 2 fieldbus application-layer specific definitions

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

3.6.1

allocate

take a resource from a common area and assign that resource for the exclusive use of a specific entity

3.6.2

application

function or data structure for which data is consumed or produced

3.6.3

application objects

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

3.6.4

application process

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

3.6.5

application process object

component of an application process that is identifiable and accessible through an FAL application relationship

3.6.6

application process object class

class of application process objects defined in terms of the set of their network-accessible attributes and services

3.6.7

application relationship

cooperative association between two or more application-entity-invocations for the purpose of exchange of information and coordination of their joint operation

Note 1 to entry: This relationship is activated either by the exchange of application-protocol-data-units or as a result of preconfiguration activities.

3.6.8

application relationship application service element

application-service-element that provides the exclusive means for establishing and terminating all application relationships

3.6.9**application relationship endpoint**

context and behavior of an application relationship as seen and maintained by one of the application processes involved in the application relationship

Note 1 to entry: Each application process involved in the application relationship maintains its own application relationship endpoint.

3.6.10**attribute**

description of an externally visible characteristic or feature of an object

Note 1 to entry: 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 can also affect the behavior of an object. Attributes are divided into class attributes and instance attributes.

3.6.11**behavior**

indication of how an object responds to particular events

3.6.12**Best Master Clock Algorithm****BMCA**

algorithm performed by each node to determine the clock that will become the master clock on a subnet and the grandmaster clock for the domain

Note 1 to entry: The algorithm primarily compares priority1, clock quality, priority2, and source identity to determine the best master among available candidates.

3.6.13**boundary clock**

clock that has multiple Precision Time Protocol (PTP) ports in a domain and maintains the timescale used in the domain

Note 1 to entry: It may serve as the source of time, i.e., be a master clock, and may synchronize to another clock, i.e., be a slave clock.

[SOURCE: IEC 61588:2009, 3.1.3, modified ¹¹ – second sentence changed to a Note]

3.6.14**class**

set of objects, all of which represent the same kind of system component

Note 1 to entry: A class is a generalization of an object; a template for defining variables and methods. All objects in a class are identical in form and behavior, but usually contain different data in their attributes.

3.6.15**class attribute**

attribute that is shared by all objects within the same class

3.6.16**class code**

unique identifier assigned to each object class

¹¹ This definition and several others are based on the legacy IEC 61588:2009 and not the latest IEC 61588:2021.

3.6.17

class specific service

service defined by a particular object class to perform a required function which is not performed by a common service

Note 1 to entry: A class specific object is unique to the object class which defines it.

3.6.18

client

- a) object which uses the services of another (server) object to perform a task
- b) initiator of a message to which a server reacts

3.6.19

clock

node participating in the Precision Time Protocol (PTP) that is capable of providing a measurement of the passage of time since a defined epoch

Note 1 to entry: There are three types of clocks in IEC 61588:2009, boundary, transparent and ordinary clocks.

[SOURCE: IEC 61588:2009, 3.1.4, modified – different Note]

3.6.20

communication objects

components that manage and provide a run time exchange of messages across the network

EXAMPLES Connection Manager object, Unconnected Message Manager (UCMM) object, and Message Router object.

3.6.21

connection

logical binding between application objects that may be within the same or different devices

Note 1 to entry: Connections may be either point-to-point or multipoint.

3.6.22

connection ID

CID

identifier assigned to a transmission that is associated with a particular connection between producers and consumers, providing a name for a specific piece of application information

3.6.23

connection path

octet stream that defines the application object to which a connection instance applies

3.6.24

connection point

buffer which is represented as a subinstance of an Assembly object

3.6.25

consume

act of receiving data from a producer

3.6.26

consumer

node or sink that is receiving data from a producer

3.6.27

consuming application

application that consumes data

3.6.28**cyclic**

repetitive in a regular manner

3.6.29**device**

physical hardware connected to the link

Note 1 to entry: A device may contain more than one node.

3.6.30**device profile**

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

3.6.31**domain**

logical grouping of clocks that synchronize to each other using the protocol, but that are not necessarily synchronized to clocks in another domain

[SOURCE: IEC 61588:2009, 3.1.7]

3.6.32**end node**

producing or consuming node

3.6.33**endpoint**

one of the communicating entities involved in a connection

3.6.34**epoch**

origin of a time scale

[SOURCE: IEC 61588:2021, 3.1.12]

3.6.35**error**

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

3.6.36**event**

instance of a change of conditions

3.6.37**frame**

denigrated synonym for DLPDU

3.6.38**grandmaster clock**

within a domain, clock that is the ultimate source of time for clock synchronization using the PTP protocol

[SOURCE: IEC 61588:2009, 3.1.13]

3.6.39

group

- a) <general> a general term for a collection of objects. Specific uses:
- b) <addressing> when describing an address, an address that identifies more than one entity

3.6.40

implementation profile

collection of information and functionality supported by a device, independently of its device type

Note 1 to entry: Unlike device profiles, implementation profiles group subsets of Type 2 technologies and characteristics, providing a high-level description of the capabilities of a device.

3.6.41

interface

- a) shared boundary between two functional units, defined by functional characteristics, signal characteristics, or other characteristics as appropriate
- b) collection of FAL class attributes and services that represents a specific view on the FAL class

3.6.42

invocation

act of using a service or other resource of an application process

Note 1 to entry: Each invocation represents a separate thread of control that may be described by its context. Once the service completes, or use of the resource is released, the invocation ceases to exist. For service invocations, a service that has been initiated but not yet completed is referred to as an outstanding service invocation. Also for service invocations, an Invoke ID can be used to unambiguously identify the service invocation and differentiate it from other outstanding service invocations.

3.6.43

instance

actual physical occurrence of an object within a class that identifies one of many objects within the same object class

EXAMPLE California is an instance of the object class state.

Note 1 to entry: The terms object, instance, and object instance are used to refer to a specific instance.

3.6.44

instance attribute

attribute whose value is unique to an object instance and whose definition is shared by all instances of an object

3.6.45

instantiated

object that has been created in a device

3.6.46

logical device

certain FAL class that abstracts a software component or a firmware component as an autonomous self-contained facility of an automation device

3.6.47

Lpacket

Link packet

piece of application information that contains a size, control octet, tag, and link data

Note 1 to entry: Peer data-link layers use Lpackets to send and receive service data units from higher layers in the OSI stack.

3.6.48**management information**

network-accessible information that supports managing the operation of the fieldbus system, including the application layer

Note 1 to entry: Managing includes functions such as controlling, monitoring, and diagnosing.

3.6.49**master clock**

in the context of a single Precision Time Protocol (PTP) communication path, clock that is the source of time to which all other clocks on that path synchronize

[SOURCE: IEC 61588:2009, 3.1.17]

3.6.50**member**

piece of an attribute that is structured as an element of an array

3.6.51**Message Router**

object within a node that distributes messaging requests to appropriate application objects

3.6.52**method**

<object> synonym for an operational service which is provided by the server ASE and invoked by a client

3.6.53**module**

hardware or logical component of a physical device

3.6.54**multipoint connection**

connection from one node to many

Note 1 to entry: Multipoint connections allow messages from a single producer to be received by many consumer nodes.

3.6.55**network**

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

3.6.56**object**

abstract representation of a particular component within a device, usually 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

3.6.57**object specific service**

service unique to the object class which defines it

3.6.58

ordinary clock

clock that has a single Precision Time Protocol (PTP) port in a domain and maintains the timescale used in the domain

Note 1 to entry: It may serve as a source of time, i.e., be a master clock, or may synchronize to another clock, i.e., be a slave clock.

[SOURCE: IEC 61588:2009, 3.1.22, modified – second sentence changed to a Note]

3.6.59

originator

client responsible for establishing a connection path to the target

3.6.60

parent clock

master clock to which a clock is synchronized

[SOURCE: IEC 61588:2009, 3.1.23]

3.6.61

peer

role of an AR endpoint in which it is capable of acting as both client and server

3.6.62

physical device

automation or other network device

3.6.63

point-to-point connection

connection that exists between exactly two application objects

3.6.64

Precision Time Protocol

PTP

protocol defined by IEC 61588:2021

Note 1 to entry: As an adjective, it indicates that the modified noun is specified in or interpreted in the context of IEC 61588:2021.

[SOURCE: IEC 61588:2021, 3.1.48, modified – second sentence changed to a Note, and references to IEEE Std 1588 replaced by IEC 61588:2021]

3.6.65

produce

act of sending data to be received by a consumer

3.6.66

producer

node that is responsible for sending data

3.6.67

property

general term for descriptive information about an object

3.6.68**PTP message**

one of the message defined in IEC 61588:2021

[SOURCE: IEC 61588:2021, 3.1.58, modified – NOTE deleted, and reference to IEEE Std 1588 replaced by IEC 61588:2021]

3.6.69**PTP port**

logical access point of a clock for PTP communications to the communications network

[SOURCE: IEC 61588:2021, 3.1.61, modified – "PTP instance" changed to "clock"]

3.6.70**resource**

processing or information capability of a subsystem

3.6.71**serial number**

unique 32-bit integer value assigned by each manufacturer/vendor to every device having Type 2 communication capabilities

Note 1 to entry: The Vendor ID and serial number jointly form a unique identifier for each device.

3.6.72**server**

- a) role of an AREP in which it returns a confirmed service response APDU to the client that initiated the request
- b) object which provides services to another (client) object

3.6.73**service**

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

3.6.74**synchronized clocks**

(to a specified uncertainty) absent relativistic effects, two clocks which have the same epoch and for which measurements of the time of the same single event at an arbitrary instant differ by no more than the specified uncertainty

[SOURCE: IEC 61588:2021, 3.1.75, modified – reworded according to IEC rules]

3.6.75**System Time**

absolute time value as defined by Type 2 time synchronization in the context of a distributed time system where all devices have a local clock that is synchronized with a common master clock

Note 1 to entry: In the context of Type 2, System Time is a 64-bit integer value in units of nanoseconds with a value of 0 corresponding to the date 1970-01-01.

3.6.76**target**

end-node to which a connection is established

3.6.77

transparent clock

device that measures the time taken for a Precision Time Protocol (PTP) event message to transit the device and provides this information to clocks receiving this PTP event message

[SOURCE: IEC 61588:2009, 3.1.46, modified – truncated]

3.6.78

Unconnected Message Manager

UCMM

component within a node that transmits and receives unconnected explicit messages and sends them directly to the Message Router object

3.6.79

unconnected service

messaging service which does not rely on the set up of a connection between devices before allowing information exchanges

3.6.80

vendor ID

identification of each product manufacturer/vendor by a unique number

Note 1 to entry: Vendor IDs are assigned by the ODVA, Inc. organization (see <www.odva.org>).

3.7 Type 2 abbreviated terms and symbols

AE	Application Entity
AL	Application layer
APO	Application object
AP	Application process
APDU	Application protocol data unit
AR	Application relationship
AREP	Application relationship end point
ASCII	American standard code for information interchange
ASE	Application service element
CAN	Controller Area Network [ISO 11898-1]
CID	Connection ID
CM_API	Actual packet interval
CM_RPI	Requested packet interval
Cnf	Confirmation
CR	Communication relationship
DL-	(as a prefix) data-link-
DLC	Data-link connection
DLCEP	Data-link connection end point
DLL	Data-link layer
DLM	Data-link-management
DLSAP	Data-link service access point
DLSDU	DL-service-data-unit
FAL	Fieldbus application layer
FIFO	First-in first-out
ID	Identifier

IEC	International Electrotechnical Commission
Ind	Indication
IP	Internet protocol
ISO	International Organization for Standardization
I/O	Input/output
LME	Layer management entity
O2T	Originator to target (connection characteristics)
O⇒T	Originator to target (connection characteristics)
OSI	Open systems interconnect
PDU	Protocol data unit
PL	Physical layer
PTP	Precision Time Protocol [IEC 61588]
QoS	Quality of service
REP	Route endpoint
Req	Request
Rsp	Response
SAP	Service access point
SDU	Service data unit
SEM	State event matrix
STD	State transition diagram, used to describe object behavior
T2O	Target to originator (connection characteristics)
T⇒O	Target to originator (connection characteristics)

3.8 Conventions

3.8.1 Overview

The FAL is defined as a set of object-oriented ASEs. Each ASE is specified in a separate subclause. Each ASE specification is composed of two parts, its class specification, and its service specification.

The class specification defines the attributes of the class. The attributes are accessible from instances of the class using the Object Management ASE services specified in Clause 5 of this document. The service specification defines the services that are provided by the ASE.

3.8.2 General conventions

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

Bold font is used in this document to highlight parameter names or important requirement elements from surrounding text.

3.8.3 Conventions for class definitions

Class definitions are described using templates. Each template consists of a list of attributes for the class. The general form of the template is shown below:

FAL ASE:	ASE Name
CLASS:	Class name
CLASS ID:	#
PARENT CLASS:	Parent class name
ATTRIBUTES:	
1 (o) Key Attribute:	numeric identifier
2 (o) Key Attribute:	name
3 (m) Attribute:	attribute name(values)
4 (m) Attribute:	attribute name(values)
4.1 (s) Attribute:	attribute name(values)
4.2 (s) Attribute:	attribute name(values)
4.3 (s) Attribute:	attribute name(values)
5. (c) Constraint:	constraint expression
5.1 (m) Attribute:	attribute name(values)
5.2 (o) Attribute:	attribute name(values)
6 (m) Attribute:	attribute name(values)
6.1 (s) Attribute:	attribute name(values)
6.2 (s) Attribute:	attribute name(values)
SERVICES:	
1 (o) OpsService:	service name
2. (c) Constraint:	constraint expression
2.1 (o) OpsService:	service name
3 (m) MgtService:	service name

- (1) The "FAL ASE:" entry is the name of the FAL ASE that provides the services for the class being specified.
- (2) The "CLASS:" entry is the name of the class being specified. All objects defined using this template will be an instance of this class. The class may be specified by this document, or by a user of this document.
- (3) The "CLASS ID:" entry is a number that identifies the class being specified. This number is unique within the FAL ASE that will provide the services for this class. When qualified by the identity of its FAL ASE, it unambiguously identifies the class within the scope of the FAL. The value "NULL" indicates that the class cannot be instantiated. Class IDs between 1 and 99, 240 and 767 are reserved by this document to identify standardized classes. CLASS IDs between 100 and 199, 768 and 1 279 are allocated for identifying user defined classes.
- (4) The "PARENT CLASS:" entry is the name of the parent class for the class being specified. All attributes defined for the parent class and inherited by it are inherited for the class being defined, and therefore do not have to be redefined in the template for this class.

NOTE The parent-class "TOP" indicates that the class being defined is an initial class definition. The parent class TOP is used as a starting point from which all other classes are defined. The use of TOP is reserved for classes defined by this document.

- (5) The "ATTRIBUTES" label indicate that the following entries are attributes defined for the class.
 - a) Each of the attribute entries contains a line number in column 1, a mandatory (m) / optional (o) / conditional (c) / selector (s) indicator in column 2, an attribute type label in column 3, a name or a conditional expression in column 4, and optionally a list of enumerated values in column 5. In the column following the list of values, the default value for the attribute may be specified.
If an attribute is optional, its default value (specified in IEC 61158-6-2) shall provide the same behavior as if the attribute was not implemented.

- b) Objects are normally identified by a numeric identifier or by an object name, or by both. In the class templates, these key attributes are defined under the key attribute.
 - c) The line number defines the sequence and the level of nesting of the line. Each nesting level is identified by period. Nesting is used to specify
 - i) fields of a structured attribute (4.1, 4.2, 4.3),
 - ii) attributes conditional on a constraint statement (5). Attributes may be mandatory (5.1) or optional (5.2) if the constraint is true. Not all optional attributes require constraint statements as does the attribute defined in (5.2).
 - iii) the selection fields of a choice type attribute (6.1 and 6.2).
- (6) The "SERVICES" label indicates that the following entries are services defined for the class.
- a) An (m) in column 2 indicates that the service is mandatory for the class, while an (o) indicates that it is optional. A (c) in this column indicates that the service is conditional. When all services defined for a class are defined as optional, at least one has to be selected when an instance of the class is defined.
 - b) The label "OpsService" designates an operational service (1).
 - c) The label "MgtService" designates an management service (2).
 - d) The line number defines the sequence and the level of nesting of the line. Each nesting level is identified by period. Nesting within the list of services is used to specify services conditional on a constraint statement.

3.8.4 Conventions for service definitions

3.8.4.1 General

The service model, service primitives, and time-sequence diagrams used are entirely abstract descriptions; they do not represent a specification for implementation.

3.8.4.2 Service parameters

Service primitives are used to represent service user/service provider interactions (ISO/IEC 10731). They convey parameters which indicate information available in the user/provider interaction. In any particular interface, not all parameters need be explicitly stated.

The service specifications of this document uses a tabular format to describe the component parameters of the ASE service primitives. The parameters which apply to each group of service primitives are set out in tables. Each table consists of up to five columns for the

- 1) Parameter name,
- 2) request primitive,
- 3) indication primitive,
- 4) response primitive, and
- 5) confirm primitive.

One parameter (or component of it) is listed in each row of each table. Under the appropriate service primitive columns, a code is used to specify the type of usage of the parameter on the primitive specified in the column:

- M parameter is mandatory for the primitive.
- U parameter is a User option, and can be provided or not depending on dynamic usage of the service user. When not provided, a default value for the parameter is assumed.
- C parameter is conditional upon other parameters or upon the environment of the service user.
- (blank) parameter is never present.
- S parameter is a selected item.

Some entries are further qualified by items in brackets. These may be

- a) a parameter-specific constraint:
"(" indicates that the parameter is semantically equivalent to the parameter in the service primitive to its immediate left in the table.
- b) an indication that some note applies to the entry:
"(n)" indicates that the following note "n" contains additional information pertaining to the parameter and its use.

3.8.4.3 Service procedures

The procedures are defined in terms of

- the interactions between application entities through the exchange of fieldbus Application Protocol Data Units, and
- the interactions between an application layer service provider and an application layer service user in the same system through the invocation of application layer service primitives.

These procedures are applicable to instances of communication between systems which support time-constrained communications services within the fieldbus application layer.

4 Common concepts

The common concepts and templates used to describe the application layer service in this document are detailed in IEC 61158-1, Clause 9.

5 Data type ASE

5.1 General

An overview of the data type ASE and the relationships between data types is provided in IEC 61158-1, 10.2.

5.2 Formal definition of data type objects

The template used to describe the data type class in Clause 5 is detailed in IEC 61158-1, 10.2. This includes the specific ASE structure and the definition of its attributes.

5.3 FAL defined data types

5.3.1 Fixed length types

5.3.1.1 Boolean types

5.3.1.1.1 Boolean

CLASS:	Data type
ATTRIBUTES:	
1 Data type Numeric Identifier	= 1
2 Data type Name	= Boolean
3 Format	= FIXED LENGTH
4.1 Octet Length	= 1

This data type expresses a Boolean data type with the values TRUE and FALSE.

5.3.1.1.2 BOOL

This IEC 61131-3 type is the same as Boolean.

5.3.1.2 Bitstring types**5.3.1.2.1 BitString8**

CLASS:		Data type
ATTRIBUTES:		
1	Data type Numeric Identifier	= 22
2	Data type Name	= Bitstring8
3	Format	= FIXED LENGTH
5.1	Octet Length	= 1

This type contains 1 element of type BitString.

5.3.1.2.2 SWORD

This IEC 61131-3 type is the same as Bitstring8.

5.3.1.2.3 BitString16

CLASS:		Data type
ATTRIBUTES:		
1	Data type Numeric Identifier	= 23
2	Data type Name	= Bitstring16
3	Format	= FIXED LENGTH
5.1	Octet Length	= 2

5.3.1.2.4 WORD

This IEC 61131-3 type is the same as Bitstring16.

5.3.1.2.5 BitString32

CLASS:		Data type
ATTRIBUTES:		
1	Data type Numeric Identifier	= 24
2	Data type Name	= Bitstring32
3	Format	= FIXED LENGTH
5.1	Octet Length	= 4

5.3.1.2.6 DWORD

This IEC 61131-3 type is the same as Bitstring32.

5.3.1.2.7 BitString64

CLASS:		Data type
ATTRIBUTES:		
1	Data type Numeric Identifier	= 57
2	Data type Name	= Bitstring64
3	Format	= FIXED LENGTH
5.1	Octet Length	= 8

5.3.1.2.8 LWORD

This IEC 61131-3 type is the same as Bitstring64.

5.3.1.3 Date types

5.3.1.3.1 DATE

CLASS:		Data type
ATTRIBUTES:		
1	Data type Numeric Identifier	= not used
2	Data type Name	= DATE
3	Format	= FIXED LENGTH
4.1	Octet Length	= 2

This IEC 61131-3 type is a binary number. The most significant bit of the most significant octet is always used as the most significant bit of the binary number; no sign bit is included. This unsigned type has a length of two octets. It expresses the date as a number of days, starting from 1972-01-01 (January 1st, 1972), the start of the Coordinated Universal Time (UTC) era, until 2151-06-06 (June 6th, 2151), i.e. a total range of 65 536 days.

5.3.1.3.2 TimeOfDay

CLASS:		Data type
ATTRIBUTES:		
1	Data type Numeric Identifier	= 12
2	Data type Name	= TimeOfDay
4	Format	= FIXED LENGTH
4.1	Octet Length	= 6

This data type is composed of two elements of unsigned values and expresses the time of day and the date. The first element is an Unsigned32 data type and gives the time after the midnight in milliseconds. The second element is an Unsigned16 data type and gives the date counting the days from 1984-01-01 (January 1st, 1984).

5.3.1.3.3 TimeOfDay without date indication

CLASS:		Data type
ATTRIBUTES:		
1	Data type Numeric Identifier	= 52
2	Data type Name	= TimeOfDay without date indication
4	Format	= FIXED LENGTH
4.1	Octet Length	= 4

This data type is composed of one element of an unsigned value and expresses the time of day. The element is an Unsigned32 data type and gives the time after the midnight in milliseconds.

5.3.1.3.4 TIME_OF_DAY

This IEC 61131-3 type is the same as TimeOfDay without date indication.

5.3.1.4 Numeric types

5.3.1.4.1 Floating Point types

5.3.1.4.1.1 Float32

CLASS:		Data type
ATTRIBUTES:		
1	Data type Numeric Identifier	= 8
2	Data type Name	= Float32
4	Format	= FIXED LENGTH
4.1	Octet Length	= 4

This type has a length of four octets. The format for Float32 is that defined by ISO/IEC 60559 as single precision.

5.3.1.4.1.2 REAL

This IEC 61131-3 type is the same as Float32.

5.3.1.4.1.3 Float64

CLASS:		Data type
ATTRIBUTES:		
1	Data type Numeric Identifier	= 15
2	Data type Name	= Float64
3	Format	= FIXED LENGTH
4.1	Octet Length	= 8

This type has a length of eight octets. The format for Float64 is that defined by ISO/IEC 60559 as double precision.

5.3.1.4.1.4 LREAL

This IEC 61131-3 type is the same as Float64.

5.3.1.4.2 Integer types

5.3.1.4.2.1 Integer8

CLASS:		Data type
ATTRIBUTES:		
1	Data type Numeric Identifier	= 2
2	Data type Name	= Integer8
3	Format	= FIXED LENGTH
4.1	Octet Length	= 1

This integer type is a two's complement binary number with a length of one octet.

5.3.1.4.2.2 SINT

This IEC 61131-3 type is the same as Integer8.

5.3.1.4.2.3 Integer16

CLASS:		Data type
ATTRIBUTES:		
1	Data type Numeric Identifier	= 3
2	Data type Name	= Integer16
3	Format	= FIXED LENGTH
4.1	Octet Length	= 2

This integer type is a two's complement binary number with a length of two octets.

5.3.1.4.2.4 INT

This IEC 61131-3 type is the same as Integer16.

5.3.1.4.2.5 Integer32**CLASS:** Data type**ATTRIBUTES:**

1	Data type Numeric Identifier	=	4
2	Data type Name	=	Integer32
3	Format	=	FIXED LENGTH
4.1	Octet Length	=	4

This integer type is a two's complement binary number with a length of four octets.

5.3.1.4.2.6 DINT

This IEC 61131-3 type is the same as Integer32.

5.3.1.4.2.7 Integer64**CLASS:** Data type**ATTRIBUTES:**

1	Data type Numeric Identifier	=	55
2	Data type Name	=	Integer64
3	Format	=	FIXED LENGTH
4.1	Octet Length	=	8

This integer type is a two's complement binary number with a length of eight octets.

5.3.1.4.2.8 LINT

This IEC 61131-3 type is the same as Integer64.

5.3.1.4.3 Unsigned types**5.3.1.4.3.1 Unsigned8****CLASS:** Data type**ATTRIBUTES:**

1	Data type Numeric Identifier	=	5
2	Data type Name	=	Unsigned8
3	Format	=	FIXED LENGTH
4.1	Octet Length	=	1

This type is a binary number. The most significant bit of the most significant octet is always used as the most significant bit of the binary number; no sign bit is included. This type has a length of one octet.

5.3.1.4.3.2 USINT

This IEC 61131-3 type is the same as Unsigned8.

5.3.1.4.3.3 Unsigned16**CLASS:** Data type**ATTRIBUTES:**

1	Data type Numeric Identifier	=	6
2	Data type Name	=	Unsigned16
3	Format	=	FIXED LENGTH
4.1	Octet Length	=	2

This type is a binary number. The most significant bit of the most significant octet is always used as the most significant bit of the binary number; no sign bit is included. This unsigned type has a length of two octets.

5.3.1.4.3.4 UINT

This IEC 61131-3 type is the same as Unsigned16.

5.3.1.4.3.5 Unsigned32

CLASS:		Data type
ATTRIBUTES:		
1	Data type Numeric Identifier	= 7
2	Data type Name	= Unsigned32
3	Format	= FIXED LENGTH
4.1	Octet Length	= 4

This type is a binary number. The most significant bit of the most significant octet is always used as the most significant bit of the binary number; no sign bit is included. This unsigned type has a length of four octets.

5.3.1.4.3.6 UDINT

This IEC 61131-3 type is the same as Unsigned32.

5.3.1.4.3.7 Unsigned64

CLASS:		Data type
ATTRIBUTES:		
1	Data type Numeric Identifier	= 56
2	Data type Name	= Unsigned64
3	Format	= FIXED LENGTH
4.1	Octet Length	= 8

This type is a binary number. The most significant bit of the most significant octet is always used as the most significant bit of the binary number; no sign bit is included. This unsigned type has a length of eight octets.

5.3.1.4.3.8 ULINT

This IEC 61131-3 type is the same as Unsigned64.

5.3.1.5 Time types**5.3.1.5.1 TIME**

CLASS:		Data type
ATTRIBUTES:		
1	Data type Numeric Identifier	= not used
2	Data type Name	= TIME
3	Format	= FIXED LENGTH
4.1	Octet Length	= 4

This IEC 61131-3 type is a two's complement binary number with a length of four octets. The unit of time for this type is 1 ms.

5.3.1.5.2 STIME

CLASS:		Data type
ATTRIBUTES:		
1	Data type Numeric Identifier	= not used
2	Data type Name	= STIME
3	Format	= FIXED LENGTH
4.1	Octet Length	= 8

This IEC 61131-3 type extension is a binary number. This unsigned type has a length of eight octets. The unit of time for this type is 1 ns. STIME represents the time since 1970-01-01 at 00:00:00 (at the 0th meridian). System Time is adjusted for leap seconds, but not local time zones or daylight savings time. This is the same time base defined for Type 2 Time Synchronization System Time (see 6.2.1.2.6.5, a)).

5.3.1.5.3 UTIME

CLASS:		Data type
ATTRIBUTES:		
1	Data type Numeric Identifier	= not used
2	Data type Name	= UTIME
3	Format	= FIXED LENGTH
4.1	Octet Length	= 8

This IEC 61131-3 type extension is a binary number. This unsigned type has a length of eight octets. The unit of time for this type is 1 μ s. STIME represents the time since 1970-01-01 at 00:00:00 (at the 0th meridian). System Time is adjusted for leap seconds, but not local time zones or daylight savings time. This is the same time base defined for Type 2 Time Synchronization System Time (see 6.2.1.2.6.5, a)).

5.3.1.5.4 ITIME

CLASS:		Data type
ATTRIBUTES:		
1	Data type Numeric Identifier	= not used
2	Data type Name	= ITIME
3	Format	= FIXED LENGTH
4.1	Octet Length	= 2

This IEC 61131-3 type extension is a two's complement binary number with a length of two octets. The unit of time for this type is 1 ms.

5.3.1.5.5 FTIME

CLASS:		Data type
ATTRIBUTES:		
1	Data type Numeric Identifier	= not used
2	Data type Name	= FTIME
3	Format	= FIXED LENGTH
4.1	Octet Length	= 4

This IEC 61131-3 type extension is a two's complement binary number with a length of four octets. The unit of time for this type is 1 μ s.

5.3.1.5.6 LTIME

CLASS:		Data type
ATTRIBUTES:		
1	Data type Numeric Identifier	= not used
2	Data type Name	= LTIME
3	Format	= FIXED LENGTH
4.1	Octet Length	= 8

This IEC 61131-3 type extension is a two's complement binary number with a length of eight octets. The unit of time for this type is 1 μ s.

5.3.1.5.7 NTIME

CLASS:		Data type
ATTRIBUTES:		
1	Data type Numeric Identifier	= not used
2	Data type Name	= NTIME
3	Format	= FIXED LENGTH
4.1	Octet Length	= 8

This IEC 61131-3 type extension is a two's complement binary number with a length of eight octets. The unit of time for this type is 1 ns.

5.3.2 String types**5.3.2.1 BitString**

CLASS:		Data type
ATTRIBUTES:		
1	Data type Numeric Identifier	= 14
2	Data type Name	= Bitstring
3	Format	= STRING
5.1	Octet Length	= 1 to n

This string type is defined as a series of BitString8 elements.

5.3.2.2 OctetString

CLASS:		Data type
ATTRIBUTES:		
1	Data type Numeric Identifier	= 10
2	Data type Name	= OctetString
3	Format	= STRING
4.1	Octet Length	= 1 to n

An OctetString is an ordered sequence of octets, numbered from 1 to n. For the purposes of discussion, octet 1 of the sequence is referred to as the first octet. IEC 61158-6-2 defines the order of transmission.

5.3.2.3 EPATH

CLASS:		Data type
ATTRIBUTES:		
1	Data type Numeric Identifier	= not used
2	Data type Name	= EPATH
3	Format	= STRING
4.1	Octet Length	= 1 to n

An EPATH is an ordered sequence of octets, numbered from 1 to n. Its format is further specified in IEC 61158-6-2, 4.1.9.

5.3.2.4 ETH_MAC_ADDR

CLASS:		Data type
ATTRIBUTES:		
1	Data type Numeric Identifier	= not used
2	Data type Name	= ETH_MAC_ADDR
3	Format	= ARRAY
6.1	Number of array elements	= 6
6.2	Array element data type	= UINT

The Ethernet MAC Address is an array of 6 octets. The recommended display format is "XX-XX-XX-XX-XX", starting with the first octet. The Ethernet MAC Address is assigned by the manufacturer and shall be unique per ISO/IEC/IEEE 8802-3 requirements. The general requirement is that the value of this type shall be Ethernet MAC addresses used in Ethernet frames.

5.3.3 Structure types

5.3.3.1 DATE_AND_TIME

CLASS:		Data type
ATTRIBUTES:		
1	Data type Numeric Identifier	= not used
2	Data type Name	= DATE_AND_TIME
3	Format	= STRUCTURE
5.1	Number of Fields	= 2
5.2.1	Field Name	= Time_Of_Day_Element
5.2.2	Field Data type	= TIME_OF_DAY
5.3.1	Field Name	= Date_Element
5.3.2	Field Data type	= DATE

This IEC 61131-3 type extension is a structure which expresses both the date (as a number of days starting from 1972-01-01 until 2151-06-06), and the time of day as a number of ms starting from midnight.

5.3.3.2 SHORT_STRING

CLASS:		Data type
ATTRIBUTES:		
1	Data type Numeric Identifier	= not used
2	Data type Name	= SHORT_STRING
3	Format	= STRUCTURE
5.1	Number of Fields	= 2
5.2.1	Field Name	= Charcount_Element
5.2.2	Field Data type	= USINT
5.3.1	Field Name	= Stringcontents_Element
5.3.2	Field Data type	= OctetString

This IEC 61131-3 type extension is composed of two elements. Charcount_Element gives the current number of characters in the Stringcontents_Element (one octet per character). Characters shall be as specified in ISO/IEC 8859-1.

5.3.3.3 STRING

CLASS:		Data type
ATTRIBUTES:		
1	Data type Numeric Identifier	= not used
2	Data type Name	= STRING
3	Format	= STRUCTURE
5.1	Number of Fields	= 2
5.2.1	Field Name	= Charcount_Element
5.2.2	Field Data type	= UINT
5.3.1	Field Name	= Stringcontents_Element
5.3.2	Field Data type	= OctetString

This IEC 61131-3 type is composed of two elements. Charcount_Element gives the current number of characters in the Stringcontents_Element (one USINT per character). Characters shall be as specified in ISO/IEC 8859-1.

5.3.3.4 STRING2**CLASS:** Data type**ATTRIBUTES:**

1	Data type Numeric Identifier	=	not used
2	Data type Name	=	STRING2
3	Format	=	STRUCTURE
5.1	Number of Fields	=	2
5.2.1	Field Name	=	Charcount_Element
5.2.2	Field Data type	=	UINT
5.3.1	Field Name	=	String2contents_Element
5.3.2	Field Data type	=	OctetString

This IEC 61131-3 data type extension is composed of two elements. Charcount_Element gives the current number of characters in the String2contents_Element (one UINT per character). Characters shall be as specified in ISO/IEC 10646.

5.3.3.5 STRINGN**CLASS:** Data type**ATTRIBUTES:**

1	Data type Numeric Identifier	=	not used
2	Data type Name	=	STRINGN
3	Format	=	STRUCTURE
5.1	Number of Fields	=	3
5.2.1	Field Name	=	Charsize_Element
5.2.2	Field Data type	=	UINT
5.3.1	Field Name	=	Charcount_Element
5.3.2	Field Data type	=	UINT
5.4.1	Field Name	=	StringNcontents_Element
5.4.2	Field Data type	=	OctetString

This IEC 61131-3 type extension is composed of three elements. Charsize_Element gives the size of a character in StringNcontents_Element (N = number of USINT). Charcount_Element gives the current number of characters in the StringNcontents_Element (N USINT per character). Characters shall be as specified in ISO/IEC 10646.

5.3.3.6 STRINGI**CLASS:** Data type**ATTRIBUTES:**

1	Data type Numeric Identifier	=	not used
2	Data type Name	=	STRINGI
3	Format	=	STRUCTURE
5.1	Number of Fields	=	2
5.2.1	Field Name	=	Stringnum_Element
5.2.2	Field Data type	=	USINT
5.3.1	Field Name	=	International_String_Array
5.3.2	Field Data type	=	STRINGI_ARRAY

This IEC 61131-3 type extension allows for multiple language representation for a single string. It is a structured data type which allocates a USINT variable (Stringnum_Element) containing the number of internationalized character strings and an array of structures (International_String_Array) containing the internationalized character strings.

The international character string structure (STRINGI_ELEMENT) is defined as follows:

- a USINT (Language1_Element) indicating the first ASCII character of the ISO 639-2/T language;
- a USINT (Language2_Element) indicating the second character of the ISO 639-2/T language;
- a USINT (Language3_Element) indicating the third character of the ISO 639-2/T language;
- a USINT (Datatype_Element), limited to the values 0xD0 (STRING), 0xD5 (STRING2), 0xD9 (STRINGN), and 0xDA (SHORT_STRING) indicating the structure of the character string;
- a UINT (Charset_Element) indicating the character set which the character string is based on;
- an array of octet elements which is the actual international character string (which data type is specified in Datatype_Element).

The three characters for the language come from ISO 639-2/T (Alpha-3 Terminology Code), and the character set values come from IANA MIB printer codes (IETF RFC 1759). The character set values are limited to those values that are provided in Table 1.

Table 1 – Valid IANA MIB printer codes for character set selection

Character Set	Value
ISO 8859-1:1987	4
ISO 8859-2:1987	5
ISO 8859-3:1988	6
ISO 8859-4:1988	7
ISO 8859-5:1988	8
ISO 8859-6:1987	9
ISO 8859-7:1987	10
ISO 8859-8:1989	11
ISO 8859-9:1989	12
ISO/IEC 10646-UCS-2	1 000
ISO/IEC 10646-UCS-4	1 001

5.3.3.7 SHORT_STRING

CLASS:

Data type

ATTRIBUTES:

1	Data type Numeric Identifier	=	not used
2	Data type Name	=	SHORT_STRING
3	Format	=	STRUCTURE
5.1	Number of Fields	=	2
5.2.1	Field Name	=	Charcount_Element
5.2.2	Field Data type	=	USINT
5.3.1	Field Name	=	Stringcontents_Element
5.3.2	Field Data type	=	OctetString

This IEC 61131-3 type extension is composed of a single elements. Charcount_Element gives the current number of characters in the Stringcontents_Element (one octet per character). Characters shall be as specified in ISO/IEC 8859-1.

5.3.3.8 STRINGI_ELEMENT

CLASS:		Data type
ATTRIBUTES:		
1	Data type Numeric Identifier	= not used
2	Data type Name	= STRINGI_ELEMENT
3	Format	= STRUCTURE
5.1	Number of Fields	= 6
5.2.1	Field Name	= Language1_Element
5.2.2	Field Data type	= USINT
5.3.1	Field Name	= Language2_Element
5.3.2	Field Data type	= USINT
5.4.1	Field Name	= Language3_Element
5.4.2	Field Data type	= USINT
5.5.1	Field Name	= Datatype_Element
5.5.2	Field Data type	= EPATH
5.6.1	Field Name	= Charset_Element
5.6.2	Field Data type	= UINT
5.7.1	Field Name	= Stringcontents_Element
5.7.2	Field Data type	= SHORT_STRING STRING STRING2 STRINGN

5.4 Data type ASE service specification

There are no operational services defined for the type object.

6 Communication model specification

6.1 Concepts

6.1.1 General

This is a serial communication system for communication between devices that wish to exchange both time critical and messaging type application information. These devices include simple I/O devices, such as sensors/actuators as well as complex control devices such as robots, programmable logic controllers, welders, process controllers.

Unlike some general purpose communication systems that rely on the destination delivery model, this network uses a variant of the publisher/subscriber push model, called the producer/consumer model. The producer/consumer model allows the exchange of time critical application information between a sending device (i.e. the producer) and many receiving devices (i.e. the consumers) without the need to send the data separately to each destination. This is accomplished by attaching a unique identifier to each piece of application information that is being produced onto the network medium. Any device that requires a specific piece of application information simply filters the data on the network medium for the appropriate identifier. Many devices can receive the same piece of application information from a single producing device.

The Type 2 application layer can be associated with different data-link layers, depending on the selected communication profile.

The Type 2 specific data-link layer provides a high degree of protocol efficiency by utilizing an implied token passing mechanism. This mechanism allows all devices equal access to the network without the network overhead associated with passing a "token" to each device granting it permission to send data. The protocol utilizes a time based scheduling mechanism which provides network devices with deterministic and predictable access to the medium while preventing network collisions. This scheduling mechanism allows time critical data, which is required on a periodic, repeatable and predictable basis, to be produced on a predefined schedule without the loss of efficiency associated with continuously requesting or "polling" for the required data. The protocol supports an additional mechanism which allows data that is not time critical in nature or which is only required on an occasional basis to utilize any available network time. This unscheduled data is transmitted after the production of the time critical data has been completed and before the beginning of the next scheduled production of time critical data.

6.1.2 General concepts

Most of the general concepts described in Clause 4 apply, with some restrictions or additions as noted:

- the application layer includes those functionalities from the intermediate layers which are necessary for proper mapping onto the data-link layer,
- Client/Server relationships can be one-to-one, but also one-to-many (see AR model in 6.3.1),
- a variant of the Publisher/Subscriber Push model, the Producer/Consumer model, is used as the base of all AR's (see AR model in 6.3.1),
- an overview of the ASE/APO types and their relationships is provided in 6.1.3,
- AR follow a model which is detailed in 6.3.1,
- specific naming and addressing is specified in 6.1.4,
- common FAL attributes and parameters listed in IEC 61158-1, 9.7 and IEC 61158-1, 9.8 are not used; instead they are specified in relevant subclauses.

6.1.3 Relationships between ASEs

Every node shall contain as a minimum instance one of the following ASE object classes in its application layer.

Object Management ASE:

- Identity (identification and general information about the device)
- Message Router (messaging connection point for communications within the device)

AR ASE:

- Unconnected Message Manager (queued messaging services on a single link)

Depending on the network communication profile, every node shall contain one or several instances of the following ASE object classes in its application layer.

Connection Manager ASE:

- Connection Manager (establishment and maintenance of connections)

and/or Connection ASE:

- Connection (messaging connection point for communications within the device)

Other application layer objects may be implemented in some nodes only.

Object Management ASE:

- Assembly object (binds data from multiple objects to be sent through one connection),
- Acknowledge Handler object (handles acknowledge messages from the application objects),
- Time Sync object (interface to the IEC 61588 precision clock synchronization protocol),
- Parameter object (public interface to device configuration data),
- additional application-specific objects constructed according to the general Type 2 formal model.

AR ASE:

- Transports (connected messaging and data services).

Yet more objects belong to system management, primarily concerned with the data-link layer or other intermediate layers:

- ControlNet object (station management interfaces to lower layers, required in all devices using Type 2 data-link layer),
- Keeper object (holds and distributes attributes of all devices on the link, one required per link, with optional backup(s) – used in conjunction with Type 2 data-link layer),
- Scheduling object (holds information on link schedules, one required in each connection originator – used in conjunction with Type 2 data-link layer),
- TCP/IP Interface object (provides the mechanism to configure the TCP/IP interface of a device, required in all devices with a TCP/IP interface),
- Ethernet Link object (maintains link-specific counters and status information for an Ethernet port, required in all devices with an Ethernet port),
- DeviceNet object (station management interfaces to lower layers, required in all devices using ISO 11898-1:2015 data-link layer),
- Connection Configuration object (interface to create, configure and control connections in a device),
- DLR object (configuration and status information interface for the DLR protocol),
- QoS object (configuration interface for QoS-related behaviors in devices),
- Port object (describes Type 2 ports present on the device),
- PRP/HSR Protocol object (configuration and diagnostic interface for the PRP and HSR protocols),
- PRP/HSR Nodes Table object (record of all PRP or HSR capable nodes detected on the network),
- LLDP Management object (administrative information for the LLDP protocol),
- LLDP Data Table object (record of all adjacent LLDP devices that are currently active).

NOTE These lower layer management objects are described in IEC 61158-4-2.

The ASE and object interactions for a device using both application and data-link Type 2 protocols are illustrated in Figure 1:

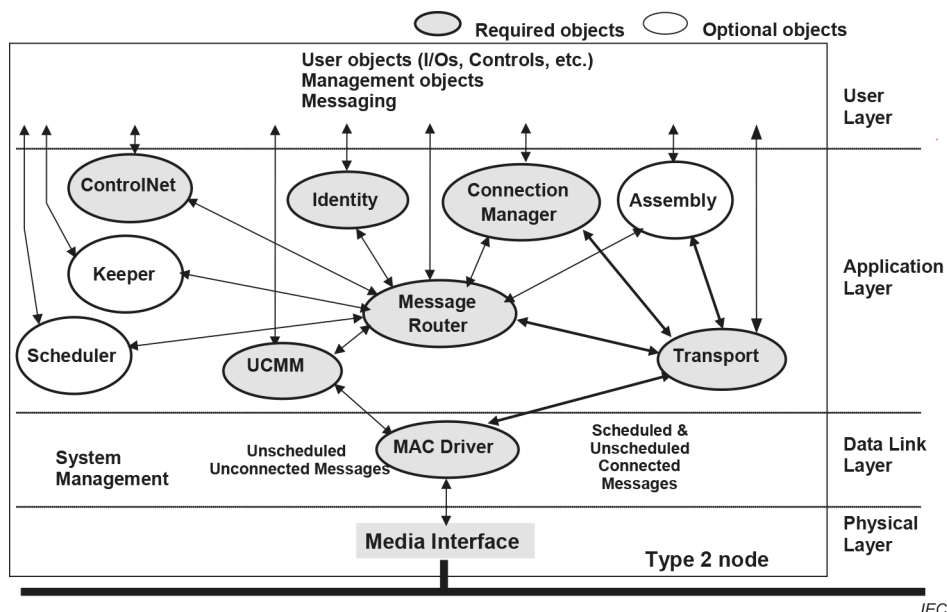


Figure 1 – Overview of ASEs and object classes

6.1.4 Naming and addressing

The information presented here provides a common basis for logically addressing separate physical components across the network. These addressing terms are used in the specifications. Figure 2 should be referenced in the following discussion.

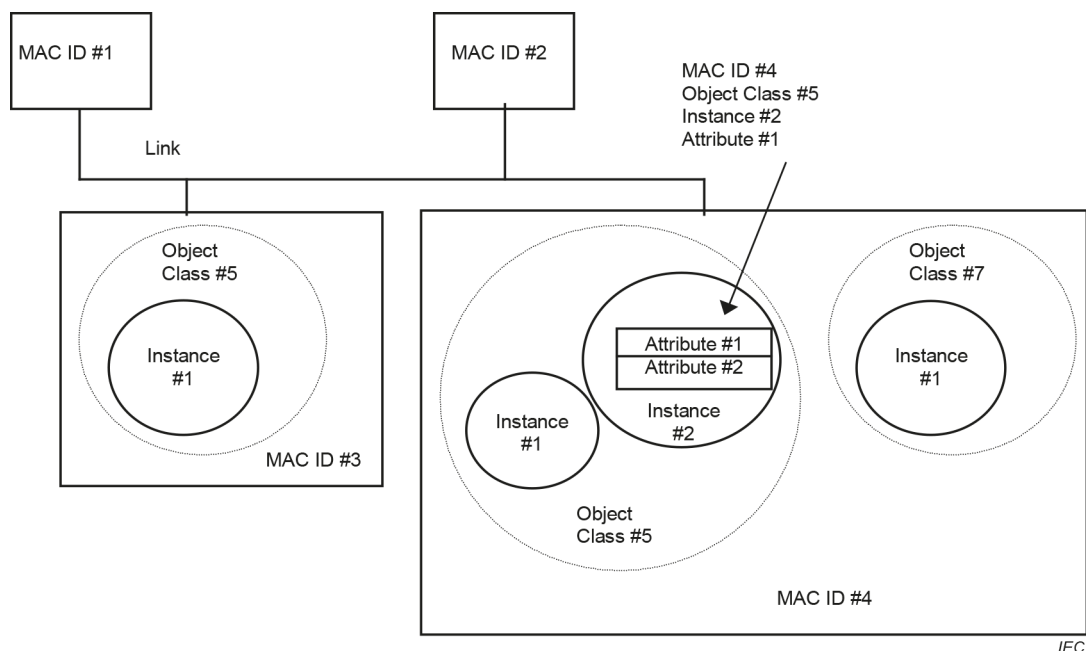


Figure 2 – Addressing format using MAC, class, instance and attribute IDs

The term "node" is used to refer to that portion of a device which contains a link interface and responds to a single MAC ID. The term "device" refers to a complete physical device connecting to the network. A device is able to contain multiple nodes.

NOTE When the Type 2 application layer is used in conjunction with Ethernet, the referenced MAC ID is actually the IP address and not the Ethernet MAC ID.

The Class ID is a unique integer identification value assigned to each object class accessible from the network. The object class can be referenced with this Class ID. In all IEC 61158 specifications for Type 2, class code is synonymous with Class ID.

The Instance ID is an integer identification value assigned to an object instance when it is created that identifies it among all Instances of the same Class. This integer is unique within the <Node:Class> in which it resides.

The Attribute ID is an integer identification value that is unique among all other attributes of that object.

The address of attribute number 1 of instance 2 in class 5 in the node with a MAC ID of 4 is MAC ID#4: Object Class #5: Instance #2: Attribute #1 as shown in Figure 2. This nomenclature is referred to as Class/Instance/Attribute addressing.

Information on how to address an object through multiple links or using a name is provided in IEC 61158-6-2 (Path definition).

6.1.5 Data types

6.1.5.1 Data type general specification

The specification of a data type is comprised of the range of values that variables of the type may take on and the operations performed on these variables.

Data is made up of elementary (primitive) data types. These elementary data types are used to construct derived (constructed) data types.

NOTE 1 Elementary and derived data type specifications correspond to the notation of IEC 61131-3. In addition, since function blocks as defined in IEC 61131-3 have both an associated data structure and a set of defined operations, these elements are also specified below as additional data types.

The derived data types are the following:

- directly derived;
- enumerated;
- subrange;
- structured;
- array.

NOTE 2 These derived data types are defined in IEC 61131-3:2003, 1.3 and 2.3.3. The means of specifying these data types and their default initial values is defined in IEC 61131-3:2003, 2.3.3.1 and 2.3.3.2. The usage of variables of these data types is defined in IEC 61131-3:2003, 2.3.3.3.

6.1.5.2 Supported elementary data types

The following basic data types defined in Clause 5 are supported:

- BOOL
- SINT
- INT
- DINT
- LINT
- USINT
- UINT
- UDINT
- ULINT

REAL
LREAL
TIME
STIME
UTIME
ITIME
FTIME
LTIME
NTIME
DATE
TIME_OF_DAY or TOD
DATE_AND_TIME or DT
STRING
STRING2
STRINGN
STRINGI
SHORT_STRING
SWORD
WORD
DWORD
LWORD
EPATH

6.1.5.3 Compliance with IEC 61131-3

6.1.5.3.1 Compliance statement

NOTE 1 Subclause 6.1.5.3 provides information with respect to only the data types and associated operations defined in this document.

NOTE 2 IEC 61131-3:2003, 1.5.1, defines the requirements which are met by programmable controller systems claiming compliance with IEC 61131-3. This provides the data type-related information to be included in the documentation of functional units which support the data types defined in this document. Subsets or extensions of this documentation are provided as appropriate to the specific compliant functional unit.

An implementation shall comply with the requirements of IEC 61131-3 for language features as specified in Table 2 through Table 4.

Table 2 – Common elements

IEC 61131-3:2003 Table/feature	Feature description
10/1	BOOL data type
10/2	SINT data type
10/3	INT data type
10/4	DINT data type
10/5	LINT data type
10/6	USINT data type
10/7	UINT data type
10/8	UDINT data type
10/9	ULINT data type
10/10	REAL data type
10/11	LREAL data type
10/12	TIME data type
10/13	DATE data type
10/14	TIME_OF_DAY or TOD data type
10/15	DATE_AND_TIME or DT data type
10/16	STRING data type
10/17	SWORD data type
10/18	WORD data type
10/19	DWORD data type
10/20	LWORD data type
12/1	Directly derived data types
12/2	Enumerated data types
12/3	Subrange data types
12/4	Array data types
12/5	Structured data types
13	Standard default initial values
Subclause 2.5.1.3	User-declared functions (no table entry)
22/1	Type conversions (see Table 4)
22/2	TRUNC function
22/3	BCD_TO_** functions
22/4	*_TO_BCD functions
23/1-11	Standard functions of one numeric variable: ABS, SQRT, LN, LOG, EXP, SIN, COS, TAN, ASIN, ACOS, ATAN
24/12n-18n	Standard named arithmetic functions: ADD, MUL, SUB, DIV, MOD, EXPT, MOVE
24/ 12s-15s, 17s,18s	Standard symbolic arithmetic functions: +, *, -, /, **, :=
25/1-4	Standard bit string functions: SHL, SHR, ROR, ROL
26/5s-8s	Standard named bitwise Boolean functions: AND, OR, XOR, NOT
26/5s-7s	Standard symbolic bitwise Boolean functions: &, >=1, =2k+1
27/1-4	Standard selection functions: SEL, MAX, MIN, LIMIT, MUX
28/5n-10n	Standard named comparison functions: GT, GE, EQ, LE, LT, NE
28/5s-10s	Standard symbolic comparison functions: >, >=, =, <=, <, <>

IEC 61131-3:2003 Table/feature	Feature description
29/1-9	Standard character string functions: LEN, LEFT, RIGHT, MID, CONCAT, INSERT, DELETE, REPLACE, FIND
30/1-14	Standard functions of time data types: (see Note) ADD, SUB, MUL, DIV, CONCAT, DATE_AND_TIME_TO_TIME_OF_DAY, TIME_OF_DAY_TO_DATE_AND_TIME
31/1-4	Standard functions of enumerated data types: SEL, MUX, EQ, NE
32	Standard access mechanisms to function block I/O parameters
33/8a,8b,9a,9b	User-defined function blocks per IEC 61131-3:2003, 2.5.2.2, with graphical or textual rising or falling edge input options
34/1-3	Standard bistable function blocks: SR, RS, SEMA
35/1,2	Standard edge detection function blocks: R_EDGE, F_EDGE
36/1-3	Standard counter function blocks: CTU, CTD, CTUD
37/1,2a,3a, 4	Standard timer function blocks: TP, TON, TOF, RTC
55/1-17	Standard operators: (), function evaluation, **,–, NOT, *, /, MOD, +,–, <, >, <=, >=, =, <>, &, AND, XOR, OR
NOTE IEC 61131-3:2003, Table 30, limits the data types to which these operations apply.	

Table 3 – ST language elements

IEC 61131-3:2003 Table/feature	Feature description
55/1-17	Standard operators: (), function evaluation, **,–, NOT, *, /, MOD, +,–, <, >, <=, >=, =, <>, &, AND, XOR, OR
56/2	Function block invocation and output usage

Table 4 – Type conversion operations

Operation	Result	Error conditions
ANY_BIT_TO_ANY_BIT	See Note 4	None
ANY_BIT_TO_ANY_INT	OUTmin + Sbk2k (Note 5)	Result > OUTmax
ANY_BIT_TO_BOOL	FALSE if IN = 0 TRUE otherwise	None
ANY_BIT_TO_STRING	See Note 6	None
ANY_DATE_TO_STRING	See Note 7	None
ANY_INT_TO_BOOL	FALSE if IN = 0 TRUE otherwise	None
ANY_NUM_TO_ANY_INT	IN (Note 8)	(IN > OUTmax) or (IN < OUTmin)
ANY_NUM_TO_ANY_REAL	IN	See Note 9
ANY_NUM_TO_DATE	See Note 10	
ANY_NUM_TO_STRING	See Note 11	
ANY_NUM_TO_TIME	See Note 12	
ANY_NUM_TO_TOD	See Note 13	
ANY_REAL_TO_BOOL	FALSE if IN = 0,0 TRUE otherwise	None
BOOL_TO_ANY_BIT BOOL_TO_ANY_INT	0 if IN = FALSE 1 if IN = TRUE	None
BOOL_TO_ANY_REAL	0,0 if IN = FALSE 1,0 if IN = TRUE	None
BOOL_TO_STRING	'FALSE' if IN = FALSE 'TRUE' if IN = TRUE	None
DATE_TO_ANY_NUM	See Note 14	Result > OUTmax
STRING_TO_ANY	Converted data	See Note 15
TIME_TO_ANY_NUM	See Note 16	Result > OUTmax
TOD_TO_ANY_NUM	See Note 17	Result > OUTmax