

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Industrial communication networks – Fieldbus specifications –
Part 6-18: Application layer protocol specification – Type 18 elements**

**Réseaux de communication industriels – Spécifications des bus de terrain –
Partie 6-18: Spécification des protocoles des couches d'application – Eléments
de type 18**



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ICS 25.04.40; 35.100.70; 35.110

ISBN 978-2-8322-9703-2

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**INDUSTRIAL COMMUNICATION NETWORKS –
FIELDBUS SPECIFICATIONS –****Part 6-18: Application layer protocol specification –
Type 18 elements**

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International Standard IEC 61158-6-18 has been prepared by subcommittee 65C: Industrial networks, of IEC technical committee 65: Industrial-process measurement, control and automation.

This second edition cancels and replaces the first edition published in 2007. This edition constitutes a technical revision.

The main changes with respect to the previous edition are listed below:

- editorial corrections;
- addition of cyclic data segmenting.

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

FDIS	Report on voting
65C/607/FDIS	65C/621/RVD

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

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

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 publication will remain unchanged until the stability date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be:

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- withdrawn;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

NOTE The revision of this standard will be synchronized with the other parts of the IEC 61158 series.

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 implementers 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.

NOTE Use of some of the associated protocol types is restricted by their 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 particular data-link layer protocol type to be used with physical layer and application layer protocols in Type combinations as specified explicitly in the profile parts. Use of the various protocol types in other combinations may require permission from their respective intellectual-property-right holders.

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INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 6-18: Application layer protocol specification – Type 18 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 18 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 specifies interactions between remote applications and defines the externally visible behavior provided by the Type 18 fieldbus application layer in terms of

- a) the formal abstract syntax defining the application layer protocol data units conveyed between communicating application entities;
- b) the transfer syntax defining encoding rules that are applied to the application layer protocol data units;
- c) the application context state machine defining the application service behavior visible between communicating application entities;
- d) the application relationship state machines defining the communication behavior visible between communicating application entities.

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

- a) define the wire-representation of the service primitives defined in IEC 61158-5-18, and
- b) define the externally visible behavior associated with their transfer.

This standard specifies the protocol of the Type 18 fieldbus application layer, in conformance with the OSI Basic Reference Model (ISO/IEC 7498-1) and the OSI application layer structure (ISO/IEC 9545).

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 61158-5-18.

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 the IEC 61158-6 series.

1.3 Conformance

This standard does not specify individual implementations or products, nor do they constrain the implementations of application layer entities within industrial automation systems. 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 61158-5-18:2010 ¹, *Industrial communication networks – Fieldbus specifications – Part 5-18: Application layer service definition – Type 18 elements*

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

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

ISO/IEC 8822, *Information technology – Open Systems Interconnection – Presentation service definition*

ISO/IEC 8824-1, *Information technology – Abstract Syntax Notation One (ASN.1): Specification of basic notation*

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

3 Terms and definitions

3.1 Terms and definitions from other ISO/IEC standards

3.1.1 ISO/IEC 7498-1 terms

For the purposes of this document, the following terms as defined in ISO/IEC 7498-1 apply:

- 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

3.1.2 ISO/IEC 8822 terms

For the purposes of this document, the following terms as defined in ISO/IEC 8822 apply:

¹ o be published.

- a) abstract syntax
- b) presentation context

3.1.3 ISO/IEC 9545 terms

For the purposes of this document, the following terms as defined in ISO/IEC 9545 apply:

- 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

3.1.4 ISO/IEC 8824-1 terms

For the purposes of this document, the following terms as defined in ISO/IEC 8824-1 apply:

- a) object identifier
- b) type

3.2 Other terms and definitions

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

3.2.1

alarm

activation of an event that shows a critical state

3.2.2

alarm ack

acknowledgment of an event that shows a critical state

3.2.3

application

function or data structure for which data is consumed or produced

3.2.4

application layer interoperability

capability of application entities to perform coordinated and cooperative operations using the services of the FAL

3.2.5

application objects

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

3.2.6

application process

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

3.2.7**application process identifier**

distinguishes multiple application processes used in a device

NOTE Application process identifier is assigned by PROFIBUS International (PI).

3.2.8**application process object**

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

NOTE Application process object definitions are composed of a set of values for the attributes of their class (see the definition for Application Process Object Class Definition). Application process object definitions may be accessed remotely using the services of the FAL Object Management ASE. FAL Object Management services can be used to load or update object definitions, to read object definitions, and to dynamically create and delete application objects and their corresponding definitions.

3.2.9**application process object class**

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

3.2.10**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

3.2.11**application relationship application service element**

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

3.2.12**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 Each application process involved in the application relationship maintains its own application relationship endpoint.

3.2.13**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.

3.2.14**backup**

status of the IO AR, which indicates that it, is in the standby state

3.2.15**behavior**

indication of how an object responds to particular events

3.2.16**class**

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

NOTE 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.

3.2.17

class attributes

attribute that is shared by all objects within the same class

3.2.18

class code

unique identifier assigned to each object class

3.2.19

class specific service

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

NOTE A class specific object is unique to the object class which defines it.

3.2.20

clear

status of the IO controller, which indicates that the control algorithm is currently not running

3.2.21

cyclic

repetitive in a regular manner

3.2.22

device

physical hardware connected to the link

NOTE A device may contain more than one node.

3.2.23

device ID

a vendor assigned device type identification

3.2.24

device profile

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

3.2.25

diagnosis data object

object(s) which contains diagnosis information referenced by device/slot/subslot/index

3.2.26

diagnosis information

all data available at the server for maintenance purposes

3.2.27

endpoint

one of the communicating entities involved in a connection

3.2.28

engineering

abstract term that characterizes the client application or device responsible for configuring an automation system via interconnecting data items

3.2.29**error**

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

3.2.30**error class**

general grouping for related error definitions and corresponding error codes

3.2.31**error code**

identification of a specific type of error within an error class

3.2.32**event**

an instance of a change of conditions

3.2.33**frame**

denigrated term for DLPDU, unit of data transfer on a link

3.2.34**identification data object**

object(s) that contain information about device, module and sub-module manufacturer and type referenced by device/slot/subslot/index

3.2.35**implicit AR endpoint**

AR endpoint that is defined locally within a device without use of the create service

3.2.36**index**

address of a record data object within an application process

3.2.37**instance**

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

3.2.38**instance attributes**

attribute that is unique to an object instance and not shared by the object class

3.2.39**instantiated**

object that has been created in a device

3.2.40**interface**

collection of FAL class attributes and services that represents a specific view on the FAL class

3.2.41**invocation**

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

NOTE 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 may be used to unambiguously identify the service invocation and differentiate it from other outstanding service invocations.

3.2.42

IO controller

controlling device, which acts as client for several IO devices (field devices)

NOTE This is usually a programmable controller or a distributed control system.

3.2.43

IO data object

object designated to be transferred cyclically for the purpose of processing and referenced by device/slot/subslot

3.2.44

IO device

field device which acts as server for IO operation

3.2.45

IO supervisor

engineering device which manages commissioning and diagnosis of an IO system

3.2.46

IO system

system composed of all its IO subsystems

NOTE As an example a PLC with more than one IO controller (network interface) controls one IO system composed of an IO subsystems for each IO controller.

3.2.47

logical device

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

3.2.48

member

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

3.2.49

method

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

3.2.50

module

hardware or logical component of a physical device

3.2.51

network

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

3.2.52

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

3.2.53**object specific service**

service unique to the object class which defines it

3.2.54**operate**

status of the IO controller that indicates that the control algorithm is currently running

3.2.55**peer**

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

3.2.56**physical device**

a certain FAL class that abstracts the hardware facilities of an automation device

3.2.57**point-to-point connection**

connection that exists between exactly two application objects

3.2.58**primary**

status of the IO AR that indicates that it is in the operating state

NOTE Besides a primary IO AR a backup IO AR may exist. In example used for redundancy and dynamic reconfiguration of IO data.

3.2.59**property**

a synonym for ASE attributes which are readable or writeable via operational ASE services

NOTE These services are generally named "get_<Attribute Name>" or "set_<Attribute Name>" and correspond with the IDL keywords "propget" and "propput".

3.2.60**provider**

- a) source of a data connection
- b) node or source sending data to one or many consumer

3.2.61**Register X**

register containing bit-oriented cyclic data of type input data that is transmitted from a slave to a master

3.2.62**Register Y**

register containing bit-oriented cyclic data of type output data that is transmitted from a master to a slave

3.2.63**Register Wr**

register containing word-oriented cyclic data of type input data that is transmitted from a slave to a master

3.2.64**Register Ww**

register containing word-oriented cyclic data of type output data that is transmitted from a master to a slave

3.2.65

resource

processing or information capability

3.2.66

run

status of the IO controller which indicates that the control algorithm is currently operating

3.2.67

runtime object model

objects that exist in a device together with their interfaces and methods that are accessible

3.2.68

service

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

3.2.69

slot

address of a structural unit within an IO device

NOTE Within a modular device, a slot typically addresses a physical module. Within compact devices, a slot typically addresses a logical function or virtual module.

3.2.70

stop

status of the IO controller which indicates that the control algorithm is currently not running

3.2.71

vendor ID

central administrative number used as manufacturer identification

NOTE The vendor ID is assigned by PROFIBUS International (PI).

3.3 Abbreviations and symbols

AE	Application entity
AL	Application layer
AP	Application process
APDU	Application protocol data unit
AR	Application relationship
AREP	Application relationship endpoint
ASE	Application service element
DL-	(as a prefix) data-link-
DLL	Data-link layer
DLPDU	Data-link protocol data unit
DLSDU	DL-service data unit
FAL	Fieldbus application layer
ID	Identifier
PDU	Protocol data unit
PL	Physical layer
SDU	Service Data Unit

3.4 Additional abbreviations and symbols for type 18

RX	Register X
RY	Register Y
RWr	Register Wr
RWw	Register Ww

3.5 Conventions

3.5.1 General concept

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 three parts: its class definitions, its services, and its protocol specification. The first two are contained in IEC 61158-5-18. The protocol specification for each of the ASEs is defined in this standard.

The class definitions define the attributes of the classes supported by each ASE. The attributes are accessible from instances of the class using the Management ASE services specified in IEC 61158-5-18 standard. The service specification defines the services that are provided by the ASE.

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

4 Abstract syntax

4.1 M1 device manager PDU abstract syntax

The abstract syntax for attributes belonging to this class is described in Table 1.

Table 1 – M1 device manager attribute format

Attribute	Format	Size (bits)
Management information	Structure of 6 elements:	9 octets
Transmission speed	Unsigned8	8
Number of occupied stations	Unsigned8	8
Station number	Unsigned8	8
Vendor code	Unsigned16	16
Model code	3 octets, bit mapped	24
Software/protocol version	1 octet, bit mapped	8
Connected Slave management information	Array of 64 members:	640 octets
Slave information 1 - 64	Structure of 5 elements:	10 octets
Station number	Unsigned8	8
Vendor code	Unsigned16	16
Model code	3 octets, bit mapped	24
Software/protocol version	1 octet, bit mapped	8
Reserved field	3 octets	24

4.2 M2 device manager PDU abstract syntax

The abstract syntax for attributes belonging to this class is described in Table 2.

Table 2 – M2 device manager attribute format

Attribute	Format	Size (bits)
Slave station information	Array of 64 members:	128 octets
Slave station information 1 - 64	Word	16
Slave station status information	Array of 64 members:	32 octets
Slave station status information 1 - 64	4 Bits	4

4.3 S1 device manager PDU abstract syntax

The abstract syntax for attributes belonging to this class is described in Table 3.

Table 3 – S1 device manager attribute format

Attribute	Format	Size (bits)
Management information	Structure of 5 elements:	10 octets
Station number	Unsigned8	8
Vendor code	Unsigned16	16
Model code	3 octets, bit mapped	24
Software/protocol version	1 octet, bit mapped	8
Reserved field	3 octets	24

4.4 S2 device manager PDU abstract syntax

The abstract syntax for attributes belonging to this class is described in Table 4.

Table 4 – S2 device manager attribute format

Attribute	Format	Size (bits)
Slave station information	Word	16
Slave station status information	4 Bits	4

4.5 M1 connection manager PDU abstract syntax

The abstract syntax for attributes belonging to this class is described in Table 5.

Table 5 – M1 connection manager attribute format

Attribute	Format	Size (bits)
Parameter information	Structure of 14 elements:	452 octets
Number of connected modules	Unsigned16	16
Number of intelligent devices	Unsigned16	16
Station information	Array of 64 members:	128 octets
Station information 1 - 64	Word	16
Number of automatic return modules	Unsigned16	16
Number of retries	Unsigned16	16
Delay time setting	Unsigned16	16
Standby Master station specification	Unsigned16	16
Operation during Master error state	Unsigned16	16

Attribute	Format	Size (bits)
Data-link during Master error state	Unsigned16	16
Scan mode specification	Unsigned16	16
Reserved station specification	Array of 8 members:	8 octets
Reserved station number	Unsigned8	8
Error invalid station specification	Array of 8 members:	8 octets
Invalid station number	Unsigned8	8
Reserved 1	4 Words	8 octets
Reserved 2	78 Words	156 octets
Network status information	Structure of 4 elements:	260 octets
Master status information	Word	16
Slave status information	Array of 64 members:	128 octets
Slave status information 1 - 64	Word	16
Master transmitted status field	Word	16
Slave transmitted status field	Array of 64 members:	128 octets
Slave transmitted status field 1 - 64	Word	16
Network information	Structure of 3 elements:	6 octets
Current link scan time	Unsigned16	16
Minimum link scan time	Unsigned16	16
Maximum link scan time	Unsigned16	16

4.6 M2 connection manager PDU abstract syntax

The abstract syntax for attributes belonging to this class is described in Table 6.

Table 6 – M2 connection manager attribute format

Attribute	Format	Size (bits)
Parameter information	Structure of 4 elements:	15
Transmission speed	2 Bits	2
Last station number	Unsigned8	8
Point mode setting	2 Bits	2
Master station i/o point mode setting	3 Bits	3
Network status information	Structure of 2 elements:	48 octets
Reception status information	Structure of 64 elements:	32 octets
Reception status 1 - 64	4 Bits	4
Slave status information	Structure of 64 elements:	16 octets
Slave status 1 - 64	2 Bits	2

4.7 S1 connection manager PDU abstract syntax

The abstract syntax for attributes belonging to this class is described in Table 7.

Table 7 – S1 connection manager attribute format

Attribute	Format	Size (bits)
Process data support level	2 Bits	2
Network status information	Structure of 1 element:	16
Master transmitted status field	Word	16

4.8 S2 connection manager PDU abstract syntax

The abstract syntax for attributes belonging to this class is described in Table 8.

Table 8 – S2 connection manager attribute format

Attribute	Format	Size (bits)
Parameter information	Structure of 2 elements:	11
Slave station number	Unsigned8	8
Number of occupied slots	3 Bits	3

4.9 M1 cyclic transmission PDU abstract syntax

The abstract syntax for attributes belonging to this class is described in Table 9.

Table 9 – M1 cyclic transmission attribute format

Attribute	Format	Size (bits)
Master status	Word	16
Data out	Structure of 2 elements:	$x + y^a$
RY data	Bit-oriented data structure	x^a
RWw data	Word-oriented data structure	y^a
Data in	Structure of 2 elements	$z + 16^a$
Number of Modules	Unsigned16	16
Slave input data	Array of up to 64 members:	z^a
Station number	Unsigned16	16
Slave status	Word	16
RX data	Bit-oriented data structure	x^a
RWr data	Word-oriented data structure	y^a
^a The values of x, y and z are dependent upon the values of the corresponding configuration settings in the Master status.		

4.10 M2 cyclic transmission PDU abstract syntax

The abstract syntax for attributes belonging to this class is described in Table 10.

Table 10 – M2 cyclic transmission attribute format

Attribute	Format	Size (bits)
RY data	Bit-oriented data structure	64 n ^a
RX data	Bit-oriented data structure	64 n ^a
^a n = the number of points specified by the point-mode-setting value of the M2 connection manager.		

4.11 S1 cyclic transmission PDU abstract syntax

The abstract syntax for attributes belonging to this class is described in Table 11.

Table 11 – S1 cyclic transmission attribute format

Attribute	Format	Size (bits)
Slave status	Word	16
Data out	Structure of 2 elements:	x + y ^a
RY data	Bit-oriented data structure	x ^a
RWw data	Word-oriented data structure	y ^a
Master status	Word	16
Data in	Structure of 2 elements:	x + y ^a
RX data	Bit-oriented data structure	x ^a
RWr data	Word-oriented data structure	y ^a
^a The values of x and y are dependent upon the values of the corresponding configuration settings in the Master status.		

4.12 S2 cyclic transmission PDU abstract syntax

The abstract syntax for attributes belonging to this class is described in Table 12.

Table 12 – S2 cyclic transmission attribute format

Attribute	Format	Size (bits)
RY data	Bit-oriented data structure	n ^a
RX data	Bit-oriented data structure	n ^a
^a n = the number of points specified by the point-mode-setting value of the corresponding M2 connection manager times the number of occupied Slots as specified by the S2 connection manager.		

4.13 Acyclic transmission PDU abstract syntax

The abstract syntax for attributes belonging to this class is described in Table 13.

Table 13 – Acyclic transmission attribute format

Attribute	Format	Size (bits)
Length	Unsigned16	16
Reserved	Octet	8
Type and sequence	Bit-oriented data structure	8
Segment number	Octet	8
Data type	Bit-oriented data structure	8

Attribute	Format	Size (bits)
Destination address	Unsigned8	8
Source address	Unsigned8	8
Destination app type	Unsigned8	8
Source app type	Unsigned8	8
Destination app module	Unsigned8	8
Source app module	Unsigned8	8
Destination network id	Unsigned8	8
Destination address	Unsigned8	8
Destination id	Bit-oriented data structure	16
Source network id	Unsigned8	8
Source address	Unsigned8	8
Source id	Bit-oriented data structure	16
Command header	Octet-oriented data structure	64
Command parameters	Variable length parameter field	0-960 octets

5 Transfer syntax

5.1 M1 device manager PDU encoding

The specific PDU encoding for attributes belonging to this class is described in Table 14.

Table 14 – M1 device manager attribute encoding

Attribute	Encoding			
Management information	Specifies the configuration of the Master device			
Transmission speed	Enumerated list of baud rate values in kbit/s 0 = 156 1 = 625 2 = 2 500 3 = 5 000 4 = 10 000 5 - 255 = reserved			
Number of occupied stations	1 - 4 = allowable range			
Station number	0 = Master 1 - 127 = reserved 128 = Standby Master 129 - 255 = reserved			
Vendor code	The assignment and management of vendor codes is best handled by applicable trade organizations and is therefore beyond the scope of this specification			
Model code	Octet	Bit	Description	Value
	0	1 – 0	Total number of used bit-oriented data bits (both RX and RY combined)	0 = full use 1 = 8 used 2 = 32 used 3 = 16 used
		3 – 2	Distribution of used bit-oriented data bits	0 = RX and RY in equal sizes 1 = RX only 2 = RY only 3 = other RX / RY mix
		5 – 4	Number of occupied station slots	0 = 1 slot 1 = 2 slots 2 = 3 slots 3 = 4 slots
		7 – 6	reserved	(set = 0)
	1	0	FAL-user switch setting	0 = normal 1 = abnormal
		1	FAL-user output upon fault	0 = clear 1 = hold
		5 – 2	reserved	(set = 0)
		7 – 6	DLE support level	0 = level A 1 = level B 2 = level C 3 = reserved
	2	6 – 0	reserved	(set = 0)
		7	Acyclic data format supports messaging type commands.	0 = not supported 1 = supported
Software/protocol version	Bit	Description		Value
	5 - 0	Software version		1 - 63 = allowable range
	7 - 6	Protocol version		0 = Version 1 1 = Version 2 2 = Version 3 3 = Version 4

Attribute	Encoding			
Connected Slave management information	Specifies the configuration of the connected Slaves			
Slave information 1 - 64	Array of 64 elements, each encoded as:			
Station number	1 - 64 = allowable range			
Vendor code	The assignment and management of vendor codes is best handled by applicable trade organizations and is therefore beyond the scope of this specification			
Model code	Octet	Bit	Description	Value
	0	1 – 0	Total number of used bit-oriented data bits (both RX and RY combined)	0 = full use 1 = 8 used 2 = 32 used 3 = 16 used
		3 – 2	Distribution of used bit-oriented data bits	0 = RX and RY in equal sizes 1 = RX only 2 = RY only 3 = other RX / RY mix
		5 – 4	Number of occupied station slots	0 = 1 slot 1 = 2 slots 2 = 3 slots 3 = 4 slots
		7 – 6	reserved	(set = 0)
	1	0	FAL-user switch setting	0 = normal 1 = abnormal
		1	FAL-user output upon fault	0 = clear 1 = hold
		5 – 2	reserved	(set = 0)
		7 – 6	DLE support level	0 = level A 1 = level B 2 = level C 3 = reserved
	2	6 – 0	reserved	(set = 0)
		7	Acyclic data format supports messaging type commands.	0 = not supported 1 = supported
Software/protocol version	Bit	Description	Value	
	5 - 0	Software version	1 - 63 = allowable range	
	7 - 6	Protocol version	0 = Version 1 1 = Version 2 2 = Version 3 3 = Version 4	
Reserved field	Reserved for future specification definition			

5.2 M2 device manager PDU encoding

The specific PDU encoding for attributes belonging to this class is described in Table 15.

Table 15 – M2 device manager attribute encoding

Attribute	Encoding	
Slave station information	Specifies the configuration of the connected Slaves	
Slave station information 1 - 64	Array of 64 Words, each encoded as:	
	Bit	Definition
	2 – 0	0 = 1 i/o point 1 = 2 i/o points 2 = 4 i/o points 3 = 8 i/o points 4 = 16 i/o points 5 = 12 i/o points 6 = reserved 7 = reserved
	3	output i/o type present (0 = false; 1 = true)
	4	input i/o type present (0 = false; 1 = true)
	5	device type: (0 = remote i/o station; 1 = remote device station)
	6	configured as a head station (for number of occupied DLE station slots > 1) (0 = false; 1 = true)
	7	input time constant (0 = normal; 1 = high speed)
	8	output state for abnormal operating states (0 = clear; 1 = hold)
	15 – 9	reserved
Slave station status information	The status fields transmitted from each connected Slave	
Slave station status information 1 - 64	Array of 64, 4-Bit fields, each encoded as:	
	Bit	Definition
	0	Slave status (0 = Normal; 1 = Error)
	1	Configuration data transmitted since connected (0 = false; 1 = true)
	2	Parity (provides even parity for status field)
	3	Reserved (set = 0)

5.3 S1 device manager PDU encoding

The specific PDU encoding for attributes belonging to this class is described in Table 16.

Table 16 – S1 device manager attribute encoding

Attribute	Encoding			
Management information	Specifies the configuration of the Slave device			
Station number	1 - 64 = allowable range			
Vendor code	The assignment and management of vendor codes is FAL user specific and beyond the scope of this specification			
Model code	Octet	Bit	Description	Value
	0	1 – 0	Total number of used bit-oriented data bits (both RX and RY combined)	0 = full use 1 = 8 used 2 = 32 used 3 = 16 used
		3 – 2	Distribution of used bit-oriented data bits	0 = RX and RY in equal sizes 1 = RX only 2 = RY only 3 = other RX / RY mix
		5 – 4	Number of occupied station slots	0 = 1 slot 1 = 2 slots 2 = 3 slots 3 = 4 slots
		7 – 6	reserved	(set = 0)
	1	0	FAL-user switch setting	0 = normal 1 = abnormal
		1	FAL-user output upon fault	0 = clear 1 = hold
		5 – 2	reserved	(set = 0)
		7 – 6	DLE support level	0 = level A 1 = level B 2 = level C 3 = reserved
	2	6 – 0	reserved	(set = 0)
		7	Acyclic data format supports messaging type commands.	0 = not supported 1 = supported
Software/protocol version	Bit	Description		Value
	5 - 0	Software version		1 - 63 = allowable range
	7 - 6	Protocol version		0 = Version 1 1 = Version 2 2 = Version 3 3 = Version 4
Reserved field	Reserved for future specification definition			

5.4 S2 device manager PDU encoding

The specific PDU encoding for attributes belonging to this class is described in Table 17.

Table 17 – S2 device manager attribute encoding

Attribute	Encoding	
Slave station information	Bit	Definition
	2 – 0	0 = 1 i/o point 1 = 2 i/o points 2 = 4 i/o points 3 = 8 i/o points 4 = 16 i/o points 5 = 12 i/o points 6 = reserved 7 = reserved
	3	output i/o type present (0 = false; 1 = true)
	4	input i/o type present (0 = false; 1 = true)
	5	device type: (0 = remote i/o station; 1 = remote device station)
	6	configured as a head station (for number of occupied DLE station slots > 1) (0 = false; 1 = true)
	7	input time constant (0 = normal; 1 = high speed)
	8	output state for abnormal operating states (0 = clear; 1 = hold)
Slave station status information	15 – 9	reserved
	Bit	Definition
	0	Slave status (0 = Normal; 1 = Error)
	1	Configuration data transmitted since connected (0 = false; 1 = true)
	2	Parity (provides even parity for status field)
	3	Reserved (set = 0)

5.5 M1 connection manager PDU encoding

The specific PDU encoding for attributes belonging to this class is described in Table 18.

Table 18 – M1 connection manager attribute encoding

Attribute	Encoding		
Parameter information	Specifies the connection configuration		
Number of connected modules	1 - 64 = allowable range		
Number of intelligent devices	Specifies the number of Slave devices that support process data support level C 0 - 26 = allowable range		
Station information	Indicates the connection configurations of the connected Slave devices.		
Station information 1 - 64	Bit	Description	Value
	7 – 0	Station number	1 - 64 = allowable range
	11 – 8	Number of occupied station slots	1 - 4 = allowable range
	15 – 12	Station type in terms of process data support level	0 = Level A 1 = Level B 2 = Level C 3 = reserved 4 = reserved 5 = Level B 1x cyclic seg 6 = Level C 1x cyclic seg 7 = reserved 8 = Level B 2x cyclic seg 9 = Level C 2x cyclic seg 10 = reserved 11 = Level B 4x cyclic 12 = Level C 4x cyclic 13 = reserved 14 = Level B 8x cyclic 15 = Level C 8x cyclic
Number of automatic return modules	Specifies the number Slave devices that are able to resume connections. 1 - 10 = allowable range		
Number of retries	Specifies the number of times the M1 connection manager object will retry communications scans with consecutive DL errors. 1 - 7 = allowable range		
Delay time setting	Specifies the data-link Scan interval in μ s. 0 - 5000 = allowable range		
Standby Master station specification	0 - 64 = allowable range 0 = no standby Master		
Operation during Master error state	Specifies M1 connection manager object control over the DL during an FAL error state. 0 = Stop Scan 1 = Continue Scan 2 - 65535 = reserved		
Data-link during Master error state	Specifies the state for process data during an FAL error state. 0 = Hold data states 1 = Clear data states 2 - 65535 = reserved		
Scan mode specification	Specifies the scanning behavior. 0 = free-running (continuous loop) 1 = triggered (loop once) 2 - 65535 = reserved		
Reserved station specification	Specifies the reserved Slave station numbers. Although reserved stations are counted as connected stations, a data-link error will not occur for reserved stations not connected.		

Attribute	Encoding		
Reserved station number	1 - 64 = allowable range		
Error invalid station specification	Specifies the error invalid Slave station numbers. Slave station errors (at the Master) will not occur for error invalid Slave stations.		
Invalid station number	1 - 64 = allowable range		
Network status information	Master reception status		
Master status information	Bit	Description	Values
	0	Master frame interval timeout occurred	0 = False 1 = True
	1	Refresh frame reception timeout occurred	0 = False 1 = True
	2	Consecutive transmission timeout occurred	0 = False 1 = True
	3	Consecutive reception timeout occurred	0 = False 1 = True
	4	Transmission route monitor 1 error occurred	0 = False 1 = True
	5	Transmission route monitor 2 error occurred	0 = False 1 = True
	6	Standby Master activation requested	0 = False 1 = True
	15 – 7	reserved	
Slave status information	Scanning results		
Slave status info 1 - 64	Bit	Description	Values
	0	Polling status error occurred	0 = False 1 = True
	1	CRC error occurred	0 = False 1 = True
	2	An abort frame was reported by the DL	0 = False 1 = True
	3	A polling response timeout occurred	0 = False 1 = True
	4	A received data buffer overflow occurred	0 = False 1 = True
	5	An invalid reception address filed was received	0 = False 1 = True
	6	At least one retry has occurred	0 = False 1 = True
	15 – 7	reserved	

Attribute	Encoding		
Master transmitted status field	Bit	Description	Values
	0	FAL-user state	0 = Stop 1 = Run
	1	FAL-user status	0 = Normal 1 = Fault
	2	Cyclic refresh status	0 = Stop 1 = Run
	3	Acyclic status	0 = Normal 1 = Error
	4	Acyclic enabled	0 = Disable 1 = Enable
	6 – 5	reserved	
	7	Master type	0 = Active 1 = Standby
	11 – 8	Size of bit-oriented data fields: RX, RY in Slots. A Slot is 4 octets in length	0 = 0 1 = 8 2 = 16 3 = 24 4 = 32 5 = 40 6 = 48 7 = 56 8 = 64 9 - 15 = reserved
	15 – 12	Size of word-oriented data fields: RWr, RWw in Slots. A Slot is 8 octets in length	0 = 0 1 = 8 2 = 16 3 = 24 4 = 32 5 = 40 6 = 48 7 = 56 8 = 64 9 - 15 = reserved
Slave transmitted status field	Transmitted status fields received from each Slave		
Slave status field 1 - 64	Bit	Description	Values
	0	FAL-user fuse status	0 = Normal 1 = Abnormal
	1	FAL-user status	0 = Normal 1 = Fault
	2	Cyclic refresh status	0 = Complete 1 = Not received
	3	Slave parameter receive status	0 = Complete 1 = Not received
	4	Slave's FAL-user switch status	0 = No change 1 = Changed
	5	Cyclic transmission enabled	0 = Enable 1 = Disable
	6	reserved	
	7	FAL-user watchdog timer error detected	0 = Normal 1 = Error
	8	Acyclic status	0 = Normal 1 = Error
	9	Acyclic enabled	0 = Disabled 1 = Enabled

Attribute	Encoding		
	10	Acyclic type: Master/Slave or Peer/Peer	0 = M/S 1 = P/P
	11	reserved	
	12	Transmission status	0 = Normal 1 = Fault
	13	reserved	1
	15 – 14	Cyclic segmenting configuration	0 = 1x or not supported 1 = 2x 3 = 4x 4 = 8x
Network information	Real time performance parameters		
Current link scan time	ms		
Minimum link scan time	ms		
Maximum link scan time	ms		

5.6 M2 connection manager PDU encoding

The specific PDU encoding for attributes belonging to this class is described in Table 19.

Table 19 – M2 connection manager attribute encoding

Attribute	Encoding		
Parameter information			
Transmission speed	0 = 156 (baud rate in kbit/s) 1 = 625 2 = 2 500 3 = reserved		
Last station number	1 - 64 = allowable range		
Point mode setting	0 = undefined 1 = 4 (points) 2 = 8 3 = 16		
Master station i/o point mode setting	0 = 16 (total points controlled by Master) 1 = 32 2 = 48 3 = 64 4 = 128 5 = 256 6 = 512 7 = 1024		
Network status information	Connection status		
Reception status information	Reception and monitoring timer status		
Reception status 1 - 64	Bit	Description	Values
	0	CRC error occurred	0 = Normal 1 = Error
	1	Parity error occurred	0 = Normal 1 = Error
	2	No response error occurred	0 = Normal 1 = Error
	3	reserved	
Slave status information	Slaves connection status		

Attribute	Encoding		
Slave status 1 - 64	Bit	Description	Values
	0	Slave station connection status	0 = Not connected 1 = Connected
	1	31 or more consecutively received errors including: CRC, parity or timeout	0 = Normal 1 = Fault

5.7 S1 connection manager PDU encoding

The specific PDU encoding for attributes belonging to this class is described in Table 20.

Table 20 – S1 connection manager attribute encoding

Attribute	Encoding
Process data support level	0 = Level A 1 = Level B 2 = Level C 3 = reserved 4 = reserved 5 = Level B 1x cyclic seg 6 = Level C 1x cyclic seg 7 = reserved 8 = Level B 2x cyclic seg 9 = Level C 2x cyclic seg 10 = reserved 11 = Level B 4x cyclic 12 = Level C 4x cyclic 13 = reserved 14 = Level B 8x cyclic 15 = Level C 8x cyclic
Network status information	Status field transmitted by the connected Master.

Attribute	Encoding		
	Bit	Description	Values
Master transmitted status field	0	FAL-user state	0 = Stop 1 = Run
	1	FAL-user status	0 = Normal 1 = Fault
	2	Cyclic refresh status	0 = Stop 1 = Run
	3	Acyclic status	0 = Normal 1 = Error
	4	Acyclic enabled	0 = Disable 1 = Enable
	6 – 5	reserved	
	7	Master type	0 = Active 1 = Standby
	11 – 8	Size of bit-oriented data fields: RX, RY in Slots. A Slot is 4 octets in length	0 = 0 1 = 8 2 = 16 3 = 24 4 = 32 5 = 40 6 = 48 7 = 56 8 = 64 9 - 15 = reserved
	15 – 12	Size of word-oriented data fields: RWr, RWw in Slots. A Slot is 8 octets in length	0 = 0 1 = 8 2 = 16 3 = 24 4 = 32 5 = 40 6 = 48 7 = 56 8 = 64 9 - 15 = reserved

5.8 S2 connection manager PDU encoding

The specific PDU encoding for attributes belonging to this class is described in Table 21.

Table 21 – S2 connection manager attribute encoding

Attribute	Encoding
Parameter information	Specifies the connection configuration of the Slave
Slave station number	1 - 64 = range of allowable values
Number of occupied slots	3 bits encoded as an unsigned integer 1 - 4 = range of allowable values

5.9 M1 cyclic transmission PDU encoding

The specific PDU encoding for attributes belonging to this class is described in Table 22.

Table 22 – M1 cyclic transmission attribute encoding

Attribute	Encoding		
	Bit	Description	Values
Master status	0	FAL-user state	0 = Stop 1 = Run
	1	FAL-user status	0 = Normal 1 = Fault
	2	Cyclic refresh status	0 = Stop 1 = Run
	3	Acyclic status	0 = Normal 1 = Error
	4	Acyclic enabled	0 = Disable 1 = Enable
	6 – 5	reserved	
	7	Master type	0 = Active 1 = Standby
	11 – 8	Size of bit-oriented data fields: RX, RY in Slots. A Slot is 4 octets in length	0 = 0 1 = 8 2 = 16 3 = 24 4 = 32 5 = 40 6 = 48 7 = 56 8 = 64 9 - 15 = reserved
	15 – 12	Size of word-oriented data fields: RWr, RWw in Slots. A Slot is 8 octets in length	0 = 0 1 = 8 2 = 16 3 = 24 4 = 32 5 = 40 6 = 48 7 = 56 8 = 64 9 - 15 = reserved
Data out	Process data registers set by the Master for Slave device output.		
RY data	A position mapped field of bit-oriented output data for all connected Slave devices ordered by Slot with 32 bits per Slot.		
RWw data	A position mapped field of word-oriented output data for all connected Slave devices ordered by Slot with 4 words per Slot.		
Data in	Process data registers read by the Master representing Slave device inputs.		
Number of Modules	1 - 64 = range of allowable values		
Slave input data			
Station number	1 - 64 = range of allowable values		

Attribute	Encoding		
Slave status	Bit	Description	Values
	0	FAL-user fuse status	0 = Normal 1 = Abnormal
	1	FAL-user status	0 = Normal 1 = Fault
	2	Cyclic refresh status	0 = Complete 1 = Not received
	3	Slave parameter receive status	0 = Complete 1 = Not received
	4	Slave's FAL-user switch status	0 = No change 1 = Changed
	5	Cyclic transmission enabled	0 = Enable 1 = Disable
	6	reserved	
	7	FAL-user watchdog timer error detected	0 = Normal 1 = Error
	8	Acyclic status	0 = Normal 1 = Error
	9	Acyclic enabled	0 = Disabled 1 = Enabled
	10	Acyclic type: Master/Slave or Peer/Peer	0 = M/S 1 = P/P
	11	reserved	
	12	Transmission status	0 = Normal 1 = Fault
	13	reserved	1
	15 – 14	Cyclic segmenting configuration	0 = 1x or not supported 1 = 2x 3 = 4x 4 = 8x
RX data	A field containing the bit-oriented input data from Slave device n ordered by Slot with 32 bits per Slot. The number of Slots occupied by the Slave device determines the total length of this field.		
RWr data	A field containing the word-oriented input data from Slave device n ordered by Slot with 4 words per Slot. The number of Slots occupied by the Slave device determines the total length of this field.		

5.10 M2 cyclic transmission PDU encoding

The specific PDU encoding for attributes belonging to this class is described in Table 23.

Table 23 – M2 cyclic transmission attribute encoding

Attribute	Encoding
RY data	A field containing the bit-oriented output data for the Slave devices ordered by Slot with n bits per Slot. Where n = 4, 8 or 16 based upon the point-mode-setting value of the M2 connection manager.
RX data	A field containing the bit-oriented input data from the Slave devices ordered by Slot with n bits per Slot. Where n = 4, 8 or 16 based upon the point-mode-setting value of the M2 connection manager.

5.11 S1 cyclic transmission PDU encoding

The specific PDU encoding for attributes belonging to this class is described in Table 24.

Table 24 – S1 cyclic transmission attribute encoding

Attribute	Encoding		
Slave status	Bit	Description	Values
	0	FAL-user fuse status	0 = Normal 1 = Abnormal
	1	FAL-user status	0 = Normal 1 = Fault
	2	Cyclic refresh status	0 = Complete 1 = Not received
	3	Slave parameter receive status	0 = Complete 1 = Not received
	4	Slave's FAL-user switch status	0 = No change 1 = Changed
	5	Cyclic transmission enabled	0 = Enable 1 = Disable
	6	reserved	
	7	FAL-user watchdog timer error detected	0 = Normal 1 = Error
	8	Acyclic status	0 = Normal 1 = Error
	9	Acyclic enabled	0 = Disabled 1 = Enabled
	10	Acyclic type: Master/Slave or Peer/Peer	0 = M/S 1 = P/P
	11	reserved	
	12	Transmission status	0 = Normal 1 = Fault
	13	reserved	1
	15 – 14	Cyclic segmenting configuration	0 = 1x or not supported 1 = 2x 3 = 4x 4 = 8x
Data out	The process data received from the Master		
RY data	A field containing the bit-oriented input data ordered by Slot with 32 bits per Slot. The number of Slots occupied by the Slave device determines the total length of this field.		

Attribute	Encoding		
RWw data	A field containing the word-oriented input data ordered by Slot with 4 words per Slot. The number of Slots occupied by the Slave device determines the total length of this field.		
Master status	Bit	Description	Values
	0	FAL-user state	0 = Stop 1 = Run
	1	FAL-user status	0 = Normal 1 = Fault
	2	Cyclic refresh status	0 = Stop 1 = Run
	3	Acyclic status	0 = Normal 1 = Error
	4	Acyclic enabled	0 = Disable 1 = Enable
	6 – 5	reserved	
	7	Master type	0 = Active 1 = Standby
	11 – 8	Size of bit-oriented data fields: RX, RY in Slots. A Slot is 4 octets in length	0 = 0 1 = 8 2 = 16 3 = 24 4 = 32 5 = 40 6 = 48 7 = 56 8 = 64 9 - 15 = reserved
	15 – 12	Size of word-oriented data fields: RWr, RWw in Slots. A Slot is 8 octets in length	0 = 0 1 = 8 2 = 16 3 = 24 4 = 32 5 = 40 6 = 48 7 = 56 8 = 64 9 - 15 = reserved
Data in	The process data transmitted to the Master		
RX data	A field containing the bit-oriented input data ordered by Slot with 32 bits per Slot. The number of Slots occupied by the Slave device determines the total length of this field.		
RWr data	A field containing the word-oriented input data ordered by Slot with 4 words per Slot. The number of Slots occupied by the Slave device determines the total length of this field.		

5.12 S2 cyclic transmission PDU encoding

The specific PDU encoding for attributes belonging to this class is described in Table 25.

Table 25 – S2 cyclic transmission attribute encoding

Attribute	Encoding
RY data	A field containing the bit-oriented output data from the Master device ordered by Slot with n bits per Slot. Where n = 4, 8 or 16 based upon the point-mode-setting value of the associated M2 connection manager. The total length of this field is determined by n times the number Slots occupied by the Slave device as specified by the S2 connection manager object.
RX data	A field containing the bit-oriented input data for the Master device ordered by Slot with n bits per Slot. Where n = 4, 8 or 16 based upon the point-mode-setting value of the associated M2 connection manager. The total length of this field is determined by n times the number Slots occupied by the Slave device as specified by the S2 connection manager object.

5.13 Acyclic transmission PDU encoding

5.13.1 Acyclic message encoding

The specific PDU encoding for acyclic messages is specified in Table 26.

Table 26 – Acyclic transmission – message data encoding

Field	Size (octets)	Value
Length	2	Length of message (in octets) not including the first 4 octets. (i.e., set to a value four less than the total length of the message)
reserved	1	for future use (set = 0)
Type and sequence	1	bits 3 – 0 = type (set = 0) <u>M2 type:</u> bits 7 – 4 = sequence number in the range 1-7. FAL user increments this field by 1 upon each successive request, rolling back to 1 after 7. <u>S2 type:</u> bits 6 – 4 = reserved field – used by DL-protocol for segmenting and reassembly Bit 7 = sequence flag, alternating 0 and 1. FAL user toggles this bit on each successive request
Segment number	1	reserved field – used by DL-protocol for segmenting and reassembly
Data type	1	b7 = priority (0 = low; 1 = high) b6 = response required (0 = true; 1 = false) b5 – b0 = reserved
Destination address	1	Station number of the intended destination AREP
Source address	1	Station number of the originating device.
Destination app type	1	FAL user target application type (set = 33)
Source app type	1	FAL user source application type (set = 33)
Destination app module	1	FAL-user target application handler module (0 = network, 1-255 = FAL user specific)
Source app module	1	DLS-user source application handler module (0 = network, 1-255 = FAL user specific)
Destination network id	1	for future extension (set = 0)
Destination address	1	for future extension (set = 0)