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Edition 2.0 2023-03

INTERNATIONAL STANDARD

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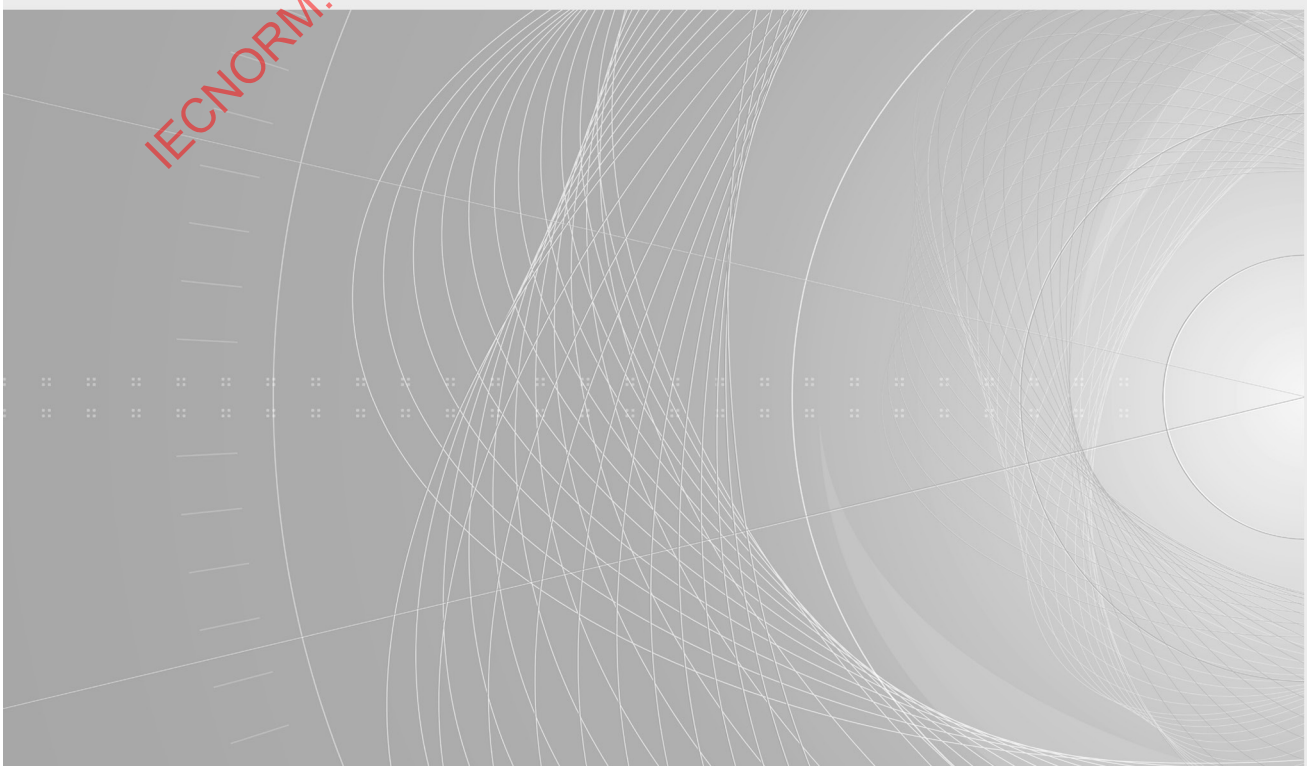
Industrial communication networks – Fieldbus specifications – Part 3-24: Data-link layer service definition – Type 24 elements



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Part 3-24: Data-link layer service definition – Type 24 elements

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

IEC 61158-3-24 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 second edition cancels and replaces the first edition published in 2014. This edition constitutes a technical revision.

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

- addition of a new cyclic transmission mode which called "no time slot type" in Clause 4;
- addition of some parameters for Table 14 and Table 15 in Clause 5.3.2.2;
- in Subclause 5.3.5.2, addition of some parameters for Table 31 and addition of a new Table 32.

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

Draft	Report on voting
65C/1201/FDIS	65C/1242/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 the parts of the IEC 61158 series, 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.

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INTRODUCTION

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

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 data-link layer service defined in this document is a conceptual architectural service, independent of administrative and implementation divisions.

INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 3-24: Data-link layer service definition – Type 24 elements

1 Scope

1.1 General

This part of IEC 61158 provides common elements for basic time-critical messaging communications between devices in an automation environment. 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 24 fieldbus data-link layer in terms of

- the primitive actions and events of the service;
- the interrelationship between these actions and events, and their valid sequences;
- the parameters associated with each primitive action and event, and the form which they take.

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

- the Type 24 fieldbus application layer at the boundary between the application and data-link layers of the fieldbus reference model;
- systems management at the boundary between the data-link layer and systems management of the fieldbus reference model.

1.2 Specifications

The principal objective of this document is to specify the characteristics of conceptual data-link layer services suitable for time-critical communications, and thus supplement the OSI Basic Reference Model in guiding the development of data-link protocols for time-critical communications. A secondary objective is to provide migration paths from previously-existing industrial communications protocols.

This document can be used as the basis for formal DL-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

- the sizes and octet ordering of various multi-octet service parameters, and
- 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 data-link entities within industrial automation systems.

There is no conformance of equipment to this data-link layer service definition standard. Instead, conformance is achieved through implementation of the corresponding data-link protocol that fulfills the Type 24 data-link layer services 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.

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

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

ISO/IEC 10731:2005, *Information technology – Open Systems Interconnection – Basic Reference Model – Conventions for the definition of OSI services*

ISO/IEC 19501:2005, *Information technology – Open Distributed Processing – Unified Modeling Language (UML) Version 1.4.2*

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

3.1 Reference model terms and definitions

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

3.1.1 acknowledgement [ISO/IEC 7498-1]

3.1.2 correspondent (N)-entities
correspondent DL-entities (N=2)
correspondent Ph-entities (N=1) [ISO/IEC 7498-1]

3.1.3 DL-address [ISO/IEC 7498-3]

3.1.4 DL-protocol [ISO/IEC 7498-1]

3.1.5 DL-protocol-data-unit [ISO/IEC 7498-1]

3.1.6 DL-service-data-unit [ISO/IEC 7498-1]

3.1.7 DLS-user [ISO/IEC 7498-1]

3.1.8 DLS-user-data [ISO/IEC 7498-1]

3.1.9 event [ISO/IEC 19501]

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

3.1.11 primitive name [ISO/IEC 7498-1]

3.1.12 reset [ISO/IEC 7498-1]

3.1.13 segmenting [ISO/IEC 7498-1]

3.1.14 state [ISO/IEC 19501]

3.1.15 state machine [ISO/IEC 19501]

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

3.1.17 transition [ISO/IEC 19501]

3.1.18 (N)-entity [ISO/IEC 7498-1]
DL-entity (N=2)
Ph-entity (N=1)

3.1.19 (N)-layer [ISO/IEC 7498-1]
DL-layer (N=2)
Ph-layer (N=1)

3.1.20 (N)-service [ISO/IEC 7498-1]
DL-service (N=2)
Ph-service (N=1)

3.1.21 (N)-service-access-point [ISO/IEC 7498-1]
DL-service-access-point (N=2)
Ph-service-access-point (N=1)

3.2 Service convention terms and definitions

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

3.2.1 confirm (primitive)

3.2.2 DL-service-primitive; primitive

3.2.3 DL-service-provider

3.2.4 DL-service-user

3.2.5 indication (primitive)

3.2.6 request (primitive)

3.2.7 requestor

3.2.8 response (primitive)

3.3 Additional Type 24 data-link specific definitions

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

3.3.1
acknowledge
acknowledgement

3.3.2
acyclic transmission
non-periodic exchange of telegrams

3.3.3
C1 master
one of the network device type that initiates and control cyclic transmission

3.3.4
C1 message
message communication that C1 master operates as initiator to exchange messages with slave or C2 master

3.3.5
C2 master
one of the network device types that has the function of monitoring all process data transmitted through the network and initiate message communication

3.3.6
C2 message
message communication that C2 master operates as initiator to exchange messages with slave or C1 master

3.3.7
cyclic transmission
periodic exchange of telegrams

3.3.8
data
generic term used to refer to any information carried over a fieldbus

3.3.9
device
physical entity connected to the fieldbus composed of at least one communication element (the network element) and which has a control element and/or a final element (transducer, actuator, etc.)

3.3.10
event driven mode
transmission mode for the application layer protocol of the communication type 24 in which a transaction of command-response-exchanging arises as user's demands

3.3.11
frame
synonym for DLPDU

3.3.12
initiator
network device that initiates the exchange of process data or message

3.3.13
interface
shared boundary between two functional units, defined by functional characteristics, signal characteristics, or other characteristics as appropriate

3.3.14
input data
process data sent by the slave and received by the C1 master

3.3.15
message
ordered series of octets intended to convey information

Note 1 to entry: Normally used to convey information between peers at the application layer.

3.3.16
monitor slave
slave that has the function of monitoring all process data transmitted through the network

3.3.17
network
set of nodes connected by some type of communication medium, including any intervening repeaters, bridges, routers and lower-layer gateways

3.3.18
node
- single DL-entity as it appears on one local link
- end-point of a link in a network or a point at which two or more links meet

3.3.19
output data
process data sent by the C1 master and received by the slaves

3.3.20
protocol
convention about the data formats, time sequences, and error correction in the data exchange of communication systems

3.3.21
real-time communication
transfer of data in real-time

3.3.22
receiving DLS-user
DL-service user that acts as a recipient of DL-user-data

Note 1 to entry: A DL-service user can be concurrently both a sending and receiving DLS-user.

3.3.23
responder
network device that responds process data or message after it has been initiated by initiator

3.3.24
send data with acknowledge
data transfer service with acknowledge of reception from corresponding DLE

3.3.25
send data with no-acknowledge
data transfer service without acknowledgement of reception from corresponding DLE

3.3.26
slave
one of the network device types that accesses the medium only after it has been initiated by C1-Maser or C2 Master

3.3.27
sending DLS-user
DL-service user that acts as a source of DL-user-data

3.3.28
station
network device embodying one node

3.3.29
topology
physical network architecture with respect to the connection between the network devices of the communication system

3.3.30
transmission cycle
fixed time period of cyclic transmission

3.3.31
time slot
time period reserved so that initiator and responder can exchange one frame respectively

3.4 Common symbols and abbreviations

DA	Destination address
DL-	Data-link layer (as a prefix)
DLE	DL-entity (the local active instance of the data-link layer)
DLL	DL-layer
DLM	DL-management
DLMS	DL-management service
DLPDU	DL-protocol-data-unit
DLS	DL-service
DLSAP	DL-service-access-point
DLSDU	DL-service-data-unit
FIFO	First-in-first-out (queuing method)
ID	Identifier
OSI	Open systems interconnection
PDU	Protocol data unit
Ph-	Physical layer (as a prefix)
PhE	Ph-entity (the local active instance of the physical layer)
PhL	Ph-layer
PHY	Physical layer device (specified in ISO/IEC 8802-3)
QoS	Quality of service
RT	Real-time
SAP	Service access point
SDU	Service data unit

3.5 Additional type 24 symbols and abbreviations

ACK	Acknowledge
C1MSG	C1 message
C2MSG	C2 message
I/O	Input and/or output
MSG	Message
Rx	Receive
SDA	Send data with acknowledge
SDN	Send data with no-acknowledge
SM	State machine
T_{cycle}	Transmission cycle
T_{slot}	Time slot
Tx	Transmit

3.6 Common conventions

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

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

Service primitives, used to represent service user/service provider interactions (see ISO/IEC 10731), convey parameters that indicate information available in the user/provider interaction.

This document uses a tabular format to describe the component parameters of the DLS primitives. The parameters that apply to each group of DLS primitives are set out in tables throughout the remainder of this document. Each table consists of up to six columns, containing the name of the service parameter, and a column each for those primitives and parameter-transfer directions used by the DLS:

- the request primitive's input parameters;
- the indication primitive's output parameters;
- the response primitive's input parameters; and
- the confirm primitive's output parameters.

NOTE The request, indication, response and confirm primitives are also known as requestor.submit acceptor.deliver, acceptor.submit, and requestor.deliver primitives, respectively (see ISO/IEC 10731).

One parameter (or part 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 and parameter direction 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 the dynamic usage of the DLS-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 DLS-user.

(blank) parameter is never present.

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

In any particular interface, not all parameters need to be explicitly stated. Some may be implicitly associated with the primitive.

In the diagrams which illustrate these interfaces, dashed lines indicate cause-and-effect or time-sequence relationships, and wavy lines indicate that events are roughly contemporaneous.

3.7 Additional Type 24 conventions

The following notation, a shortened form of the primitive classes defined in 3.2, is used in the figures.

req	request primitive
ind	indication primitive
cnf	confirm primitive (confirmation)

4 Data-link service and concepts

4.1 Overview

The services provided by this interface are used to utilize the following functions which are required in factory automation system, especially in motion control system.

- Exchange I/O data between the controller and the device.
- Transfer message between the controller and the device, or between the equipment for engineering and them.
- Exactly synchronize the controller with the device.

This interface provides the data exchange service for the above usage. For the data exchange, this service classifies the stations into three types of C1 master, C2 master and slave. The data exchange is executed between one master station (C1 master or C2 master) and N slave stations. There are two types of transmission modes, cyclic transmission and acyclic transmission.

In cyclic transmission mode, transmission is executed cyclically with an accurate period. The transmission cycle is set by the C1 master and slave and C2 master follow it. The transmission cycle has I/O data exchange band to transmit process data and message communication band to transmit message. In I/O data exchange band, C1 master transmits output data to all slaves and the slaves transmit input data to C1 master. This transmission is executed once to each slave, to provide real-time transmission service to DLS-user. In message communication band, transmission is executed only when DLS-user requests.

The DLE in C1 master controls transmission sequence in cyclic transmission mode. The time period for a master station to exchange with one slave station is called time slot. There are two types of communication sequence, one is "fixed-width time slot type" whose time slot width is same for all stations and the other is "configurable time slot type" whose time slot can be defined for each station. All stations shall use the same-data-length frame when the DLE adopts fixed-width time slot type. The width of the time slot is static in both types, and it is set by DL-management during initialization. Once cyclic communication starts, it shall not be changed.

There is "no time slot type" which does not use time slot, as another cyclic transmission mode.

Acyclic transmission mode is used by DLS-user that operates in event driven mode. In acyclic transmission mode, transmissions are executed sporadically. The same transmission sequence and message communication can be executed in acyclic transmission, as in cyclic transmission mode without fixing the transmission cycle. Though C2 message communication is also possible, the DLS-user shall execute the arbitration of the transmission timing. In acyclic transmission mode, the data length is fixed at 64 octets.

In acyclic transmission mode, slaves execute processing of the output data sent by the master and processing of the data to send the input data at its own timing. Slaves do not operate simultaneously.

This interface provides the maintenance service besides the transmission of data. The maintenance service is described in the next clause.

4.2 DLS-user services

4.2.1 General

This clause describes notional model for data transfer service between DLE and DLS user. Information is exchanged by DLS primitives and related parameters between DLE and DLS user. The following services are provided to DLS user.

- Write data
- Read data
- Send data with acknowledge service (SDA)
- Send data with no-acknowledge service (SDN)
- Cyclic event
- Get Status

4.2.2 Write data

This service is used to transmit process data. This service is available in cyclic transmission mode. This service transfers DLSDU that contains process data to DLE. The DLE stores the passed DLSDU within the DLE itself and transmits at the scheduled timing. The previous DLSDU will be overwritten by new DLSDU when the DLS-user issues a new request to the identical SAP before the DLE transmits the previous DLSDU.

4.2.3 Read data

This service is used to receive process data. This service is available in cyclic transmission mode. This service retrieves the DLSDU that DLE has been received during I/O data exchange. DLE stores the DLSDU that has been assembled from received DLPDU into the DLE itself. DLE has an independent storage area of DLSDU of each SAP. And it holds only the newest DLSDU. DLSDU will be overwritten by new DLSDU when the DLE assembles a new DLSDU from a newly received DLPDU before the DLS-user issues this service request.

4.2.4 Send data with acknowledge service (SDA)

This service is used for message communication in cyclic transmission mode. This service permits the local DLS-user to send a DLSDU to a single remote station. The DLSDU is delivered to remote DLS-user by the remote DLE. If the size of the DLSDU is too large to transfer with one DLPDU, local DLE divides the DLSDU before transmitting it, and then remote DLE will assemble them into the original DLSDU.

Remote DLE returns acknowledge to the local station to notify of the receipt status of each DLPDU. If an error occurred during the transmission, the local DLE repeats to transmit the

DLPDU. The local DLS-user receives a confirmation concerning the receipt or non-receipt of the DLSDU by the remote DLE.

4.2.5 Send data with no-acknowledge service (SDN)

This service is used for both I/O data exchange and message communication in acyclic transmission mode. This service permits a local DLS-user to transfer a DLSDU to a single remote station (unicast), or to all other remote stations (broadcast) at the same time. In this service, DLE does not operate segmentation of the DLSDU passed by DLS user. Confirmation of this service is issued by local DLE, therefore it does not include any information indicating whether remote DLE has received the DLSDU requested by DLS user or not.

4.2.6 Event

DLS primitive employs this service to inform the DLS-user about certain events in the DLL.

4.2.7 Get status

This service permits the local DLS-user to read current status of the local DLE.

4.3 Overview of interactions

Table 1 shows the list of service primitives and parameters for DLS-user.

Table 1 – The list of DLS service primitives and parameters

Service	primitive	Parameter	function
Set data	DL-WRITE-DATA.req	SAP_ID, DLSDU	Request for writing send data
	DL-WRITE-DATA.cnf	Result	
Read data	DL-READ-DATA.req	SAP_ID	Request for reading received data
	DL-READ-DATA.cnf	Result, DLSDU	
Send data with acknowledge service	DL-SDA.req	SAP_ID, Node_ID, Length, DLSDU	Request for sending message
	DL-SDA.cnf	Result	
	DL-SDA.ind	SAP_ID, Node_ID, Length, DLSDU	
Send data with no acknowledge service	DL-SDN.req	SAP_ID, Node_ID, Length, DLSDU	Request for asynchronous communication
	DL-SDN.cnf	Result	
	DL-SDN.ind	SAP_ID, Node_ID, Length, DLSDU	
Cyclic Event	DL-EVENT.ind	Event_ID	Event notification

The sequences of primitives are shown in Figure 1 to Figure 4.

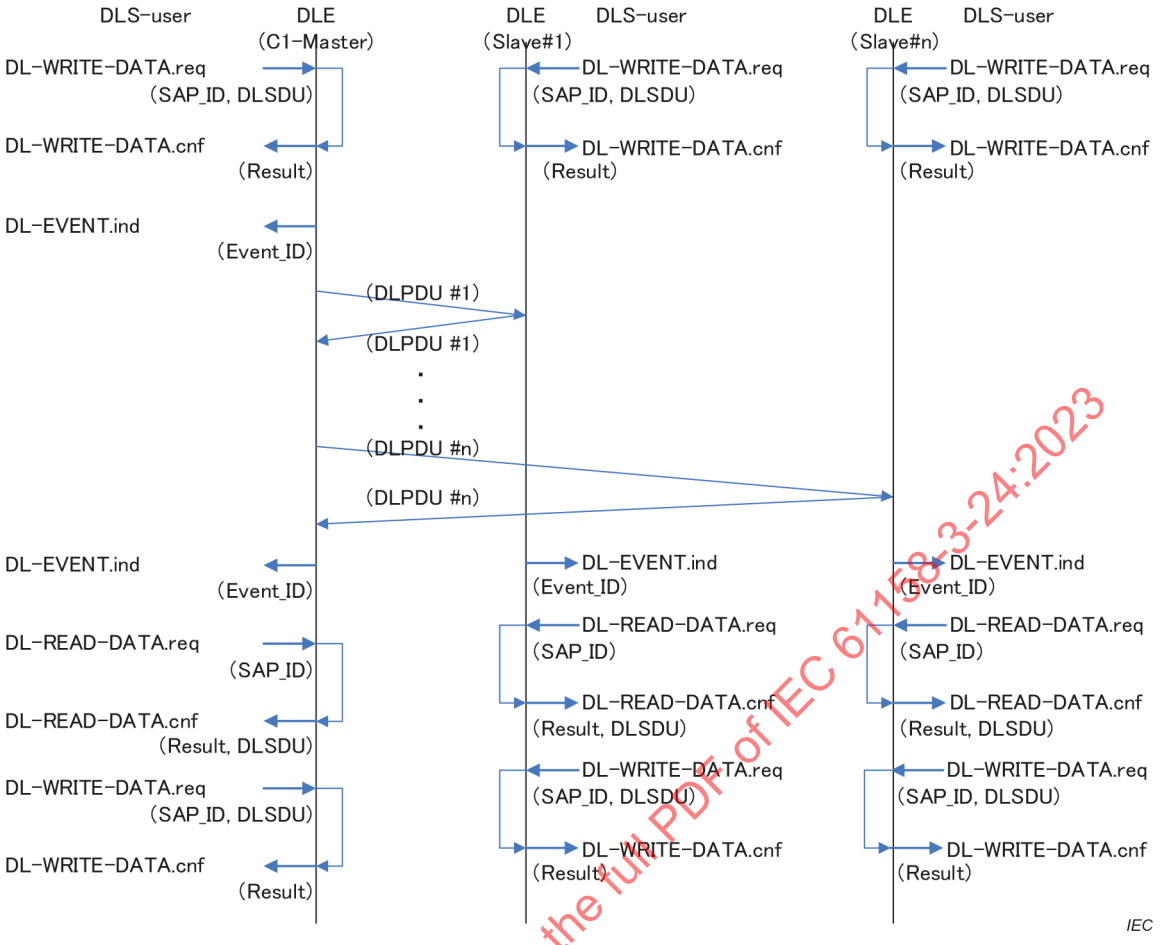

Figure 1 – Sequence of primitive for set data and read data service

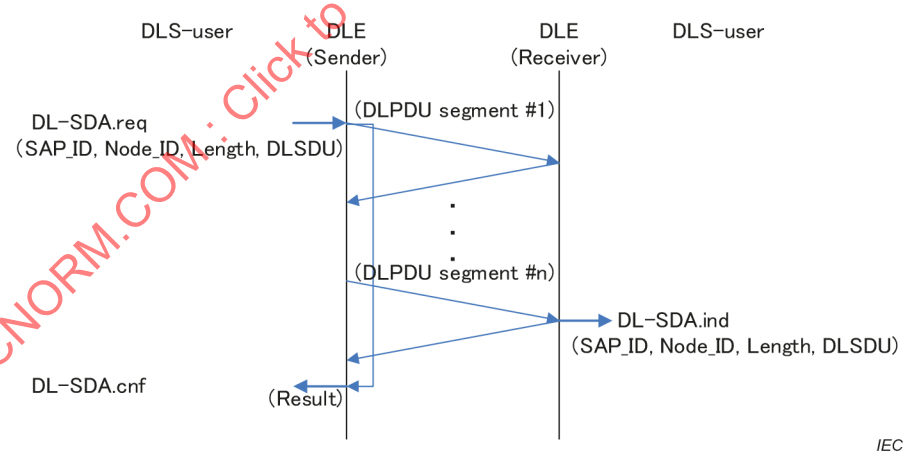

Figure 2 – Sequence of primitive for send data with acknowledge service

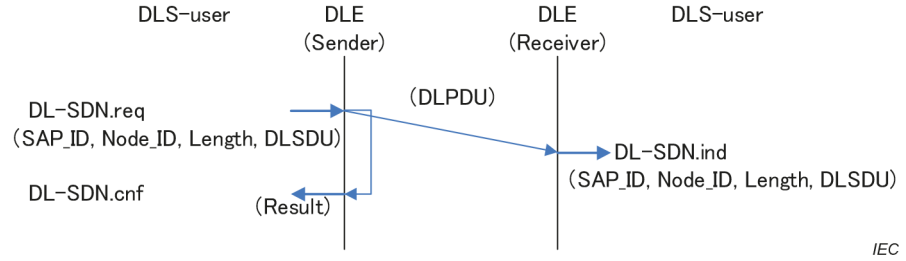

Figure 3 – Sequence of primitive for send data with no-acknowledge service

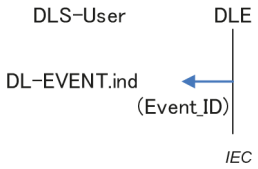

Figure 4 – Sequence of primitives for event service

4.4 Detailed specification of services and interactions

4.4.1 Write data

4.4.1.1 Function

The DLS-user uses this service to write the data directly to the internal buffer of DLE. The service is locally processed after the DL-WRITE-DATA request primitive has arrived. The DLE communicates the successful processing of the service to the DLS-user by means of a DL-WRITE-DATA confirmation primitive (immediate confirmation).

4.4.1.2 Type of parameters

4.4.1.2.1 General

Table 2 indicates the primitives and parameters of write data service. Details of these parameters are shown in the following sections.

Table 2 – Write data primitives and parameters

DL-WRITE-DATA Parameter name	Request Input	Confirm Output
SAP_ID	M	
DLSDU	M	
Result		M

4.4.1.2.2 SAP_ID

This parameter designates ID of service access point. SAP_ID is different by the DLSDU to be accessed is process data or the message data. SAP_ID for process data is different between input data and output data. Slave has a pair of SAP_ID's for both of the output data and input data. C1 master and C2 master have a SAP_ID of the pair for the number of slaves.

4.4.1.2.3 DLSDU

This parameter specifies the DLS-user data which is to be written to the local DLE and shall be sent to remote station.

4.4.1.2.4 Result

This parameter indicates the success or failure of the associated write data service request. Permitted values for this parameter are specified in Table 3.

Table 3 – Values of result for write data service

Value	Definition
OK	The write data function was carried out successfully
NG	The write data function was not carried out successfully

4.4.2 Read data

4.4.2.1 Function

The DLS-user uses this service to read the data directly from the internal buffer of DLE. The service is locally processed after the DL-READ-DATA request primitive has arrived. The DLE communicates the successful processing of the service to the DLS-user by means of a DL-READ-DATA confirmation primitive (immediate confirmation).

4.4.2.2 Type of parameters

4.4.2.2.1 General

Table 4 indicates the primitives and parameters of read data service. Details of these parameters will be shown in the following sections.

Table 4 – Read data primitives and parameters

DL-READ-DATA	Request	Confirm
Parameter name	Input	Output
SAP_ID	M	
DLSDU		M
Result		M

4.4.2.2.2 SAP_ID

See 4.4.1.2.2.

4.4.2.2.3 DLSDU

This parameter specifies the DLS-user data that has been received by the local DLE.

4.4.2.2.4 Result

This parameter indicates the success or failure of the associated read data service request. Permitted values for this parameter are specified in Table 5.

Table 5 – Values of result for read data service

Value	Definition
OK	The read data function was carried out successfully
NG	The read data function was not carried out successfully

4.4.3 Send data with acknowledge

4.4.3.1 Function

This service is applicable when the DLE operates in the cyclic transmission mode. The DLS-user requests to start data transfer to remote DLS-user by DL-SDA request primitive. DLE executes requested data transfer within the message communication band. The maximum data length which is sent in one frame shall be defined by DLM, when the communication is initialized. If data length exceeds maximum length, DLSDU shall be divided and sent by DLE. Data shall be restored by DLE of receiver.

4.4.3.2 Types of parameters

4.4.3.2.1 General

Table 6 indicates the primitives and parameters of DL-SDA service.

Table 6 – SDA primitives and parameters

DL-SDA	Request	Confirm
Parameter name	Input	Output
SAP_ID	M	
Node_ID	M	
Length	M	
DLSDU	M	
Result		M

4.4.3.2.2 SAP_ID

This parameter specifies service access port ID that is used for message communication. The DLE has two SAP_ID's. One is for C1 message and another is C2 message.

4.4.3.2.3 Node_ID

This parameter specifies the destination address of DLSDU. If DLSDU is basic format, extended address shall be specified.

4.4.3.2.4 Length

This parameter specifies the length of DLSDU.

4.4.3.2.5 Result

This parameter indicates the success or failure of the associated SDA service request. Permitted values for this parameter are specified in Table 7.

Table 7 – Values of result for SDA service

Value	Definition
OK	The send data with acknowledge function was carried out successfully
NG	The send data with acknowledge function was carried out successfully

4.4.4 Send data with no-acknowledge (SDN)

4.4.4.1 Function

This service is applicable when the DLE operates in acyclic transmission mode. The DLS-user requests remote DLS-user to start data transfer with DL-SDN request primitive. This service permits a local DLS-user to transfer a DLSDU to a single remote station (unicast), or to transfer it to all other remote stations at the same time (broadcast). Confirmation of this service is issued by local DLE, therefore it does not include any information indicating whether remote DLE has received DLSDU that is requested by DLS user or not.

4.4.4.2 Types of parameters

4.4.4.2.1 General

Table 8 indicates the primitives and parameters of send data with no-acknowledge service.

Table 8 – SDN primitives and parameters

DL-SDA	Request	Confirm
Parameter name	Input	Output
SAP_ID	M	
Node_ID	M	
Length	M	
DLSDU	M	
Result		M

4.4.4.2.2 SAP_ID

This parameter specifies service access port ID that is used in acyclic transmission mode.

4.4.4.2.3 Node_ID

See 4.4.3.2.3.

4.4.4.2.4 Length

See 4.4.3.2.4.

4.4.4.2.5 Result

This parameter indicates the success or failure of the associated SDN service request. Permitted values for this parameter are specified in Table 9.

Table 9 – Values of result for SDN service

Value	Definition
OK	The send data with no-acknowledge function was carried out successfully
NG	The send data with no-acknowledge function was not carried out successfully

4.4.5 Cyclic Event

4.4.5.1 Function

This service informs the DLS-user about certain events in DLE.

4.4.5.2 Types of parameters

4.4.5.2.1 General

Table 10 indicates the primitives and parameters of event service and Table 11 indicates the parameter Event_ID.

Table 10 – Event primitives and parameters

DL-EVENT	Indication
Parameter name	Output
Event_ID	M

4.4.5.2.2 Event_ID

Table 11 – Values of Event_ID for event service

Event_ID	Name	Definition
DL_Ev_Tcycle	Transmission start event	This is the event to notify of start timing of transmission cycle. DLE continues to issue this event after staring cyclic transmission until it is reset.

5 DL-management service

5.1 Overview

5.1.1 General

DL-management provides the following services to the DLMS-user:

- Reset
- Set value
- Get value
- Evaluate delay (See Note)
- Set communication mode request to remote station (See Note)
- Start communication request to local station (See Note)
- Clear error status
- DLM Event

NOTE DLMS-user can use this service only when the DLE adopts configurable time slot.

5.1.2 Reset

The DLMS-user employs this service to make DL-management to reset the DLE. A reset is equivalent to power on. The DLMS-user receives a confirmation that is issued immediately by DLE.

5.1.3 Set value

The DLMS-user employs this service to assign new value to the parameters of the DLE. The DLMS-user receives a confirmation whether the specified parameters have been set to the new value.

5.1.4 Get value

The DLMS-user employs this service to read the value of parameters of the DLE. DLMS-user receives a confirmation that contains the current value of the specified parameter.

5.1.5 Evaluate delay

DLMS-user uses this service to measure the transmission delay from C1 master to slave and C1 master to C2 master. Only DLMS-user in C1 master can use this service.

5.1.6 Set communication mode

DLMS-user uses this service to send a request to configure the communication mode to the remote station. Only DLMS-user in C1 master can use this service.

5.1.7 Start communication

DLMS-user uses this service to request the local DLE to start communication.

5.1.8 Clear error status

The DLMS-user employs this service to clear the error status of the DLE. DLMS-user passes DLM-CLR-ERR request primitive to DL-management to clear the error status of DLE. DL-management passes the confirm primitive to the DLS-user to indicate the success or failure of the corresponding service.

5.1.9 DLM Event

DL-management employs this service to inform the DLMS-user about certain events or errors in the DLL.

5.2 Overview of interactions

Table 12 shows the list of service primitives and parameters.

Table 12 – The list of DLMS service primitives and parameters

Service	Primitive	Parameter	function
Reset	DLM-RESET.req		Request for DL reset
	DLM-RESET.cnf	Result	
Set value	DLM-SET-VALUE.req	Var_ID, Val	Request for DL variables setting
	DLM-SET-VALUE.cnf	Result	
Get value	DLM-GET-VALUE.req	Var_ID	Request for referring DL variables
	DLM-GET-VALUE.cnf	Result, Val	
Evaluate delay	DLM-MEAS-DELAY.req		Request for measuring transmission delay
	DLM-MEAS-DELAY.cnf	Result	
	DLM-MEAS-DELAY.ind	Delay_time	

Service	Primitive	Parameter	function
Set communication	DLM-SET-COMMODE.req		Request remote station to start communication
Mode	DLM-SET-COMMODE.cnf	Result	
Start communication	DLM-START.req		Request local station to start communication
	DLM-START.cnf	Result	
	DLM-START.ind	Com_Mode, Cycle_time, C2_stime, Max_Delay, T_{M_unit}	
Clear error	DLM-CLR-ERR.req	Err_Status	Request for clearing error factor
	DLM-CLR-ERR.cnf	Result	
DLM error event	DLM-EVENT.ind	Event_ID	Event notification

The sequences of DL-management primitives are shown in Figure 5 to Figure 9.

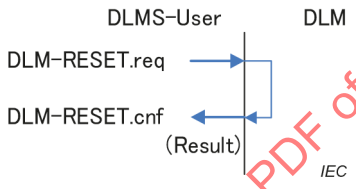

Figure 5 – Sequence of primitives for Reset service

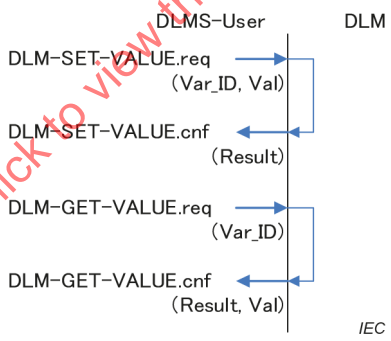

Figure 6 – Sequence of primitives for Set/get value service

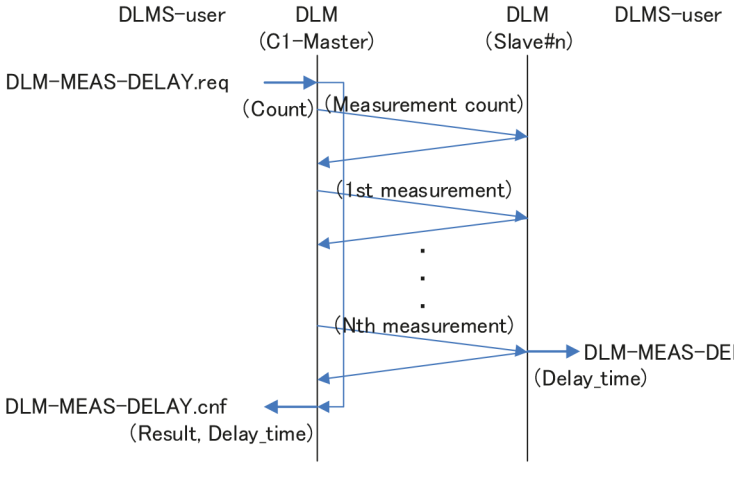

Figure 7 – Sequence of primitives for Evaluate delay service

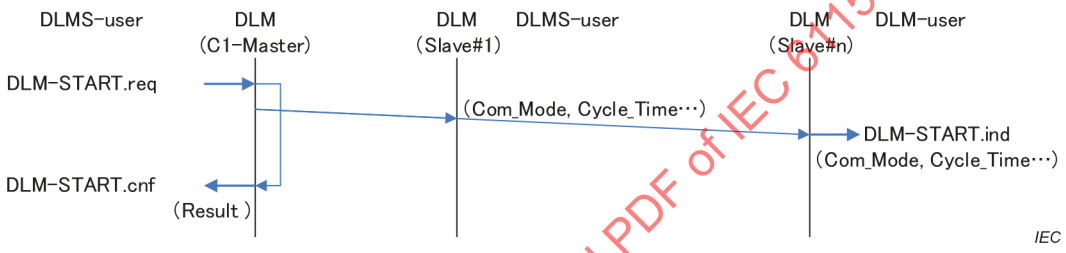

Figure 8 – Sequence of primitives for Start communication service

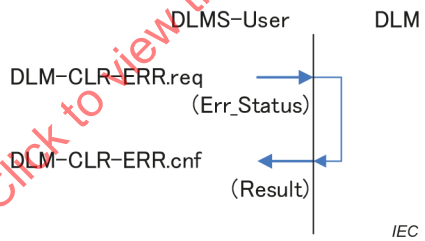

Figure 9 – Sequence of primitives for Event and Clear error status service

5.3 Detailed specification of services and interactions

5.3.1 Reset

5.3.1.1 Function

This service is used to reset all sublayers in the DLE.

The DLMS-user passes a DLM-RESET request primitive to DL-management to reset the DLE. After receipt of DLM-RESET request primitive DL-management issues the confirm primitive to the DLMS-user immediately and then issues the reset request to all sublayers and resets itself.

5.3.1.2 Types of parameters

None

5.3.2 Set value

5.3.2.1 Function

The DLMS-user uses this service to assign the new value of variables of the DLE.

The DLMS-user passes a DLM-SET-VALUE request primitive to DL-management to assign a desired value to one or more specified variables of the DLE. After receipt of DLM-SET-VALUE request primitive, DL-management selects the specified variables and sets the new values. If the requested service was executed, DL-management passes a DLM-SET-VALUE confirm primitive to the DLMS-user to indicate the success or failure of the corresponding service request.

5.3.2.2 Types of parameters

5.3.2.2.1 General

Table 13 indicates the primitives and parameters of Set value service.

Table 13 – Set value primitive and parameters

DLM-SET-VALUE	Request	Confirm
Parameter name	Input	Output
Var_ID	M	
Val	M	
Result		M

5.3.2.2.2 Var_ID

5.3.2.2.2.1 General

Var_ID is the parameter to specify the DLE variable, when the DLMS-user requests to read or to write it. Table 14 shows the list of Var_ID and Table 15 shows the data type and range of the value.

Table 14 – The list of parameter Var_ID of Set value request

Var_ID	Definition	Requirement
MA	Station address of this station	M
Nmax_slaves	Number of connectable slave stations	C[a]
Cyc_sel	Transmission type selector	C[a]
Nmax_dly_cnt	Transmission delay time measuring count	C[b]
IO_sz	I/O data size of cyclic communication	C
Pkt_sz	Message communication packet size	C[c]
Nmax_retry	Maximum number of retries for I/O data exchange	C[d]
T_{cycle}	Cyclic transmission period	M
T_{slot}	Time slot period	C[b]
T_{unit}	Unit of time	C[e]
T_{idly}	Event delay time in transmission period	C[b]
T_{c2_dly}	C2 master transmission start delay	C[b]
IO_MAP	I/O map	C[c]

Var_ID	Definition	Requirement
Line_code	Transmission line code	C[f]
Baud_rate	Baud rate	C[f]
T_{latch}	Time for C1 master to cyclically latch the INPUT data	C[f]
T_{cc_mul}	Individual transmission cycle multiple	C[f]
T_{cc_pos}	Individual transmission position number	C[f]

[a] The set value has no affection when the DLE is slave station.

[b] The set value has affection when the DLE is C1 master which adopts configurable time slot.

[c] The set value shall be same as IO_sz when the DLE adopts fixed-width time slot.

[d] The set value has affection only when the DLE is C1 master.

[e] The set value has affection when the DLE adopts configurable time slot.

[f] The set value is used when the cyclic transmission mode adopts no time slot type

Table 15 – Data type and range of variables

Var_ID	Min	Max
MA	1	2^{16}-1
Nmax_slaves	1	62
Cyc_sel	0	1
Nmax_dly_cnt	1	31
IO_sz	8	64
Pkt_sz	4	500
Nmax_retry	0	62
T_{cycle}	a	[a]
T_{slot}	[b]	[b]
T_{unit}	0	[b]
T_{idly}	0	[c]
T_{c2_dly}	0	[c]
IO_MAP	See 5.3.2.2.2.14	
Line_code	See 5.3.2.2.2.15	
Baud_rate	See 5.3.2.2.2.16	
T_{latch}	See 5.3.2.2.2.17	
T_{cc_mul}	See 5.3.2.2.2.18	
T_{cc_pos}	See 5.3.2.2.2.19	

[a] The value shall be set within the range from 31,25 µs to 64 ms by the unit specified by the value of T_{unit}.

[b] The value shall be set within the range from 0 to less than the value of T_{cycle} by the unit specified by the value of T_{unit}.

[c] The value shall be set below the value of T_{cycle} by the unit specified by the value of T_{unit} .

5.3.2.2.2.2 MA

This variable is used to specify the DL address of the local station. When DLE adopts short format DLPDU, only the lower 16 bits are effective.

5.3.2.2.2.3 Nmax_slaves

This variable is used to specify the maximum number of connectable slaves.

5.3.2.2.2.4 Cyc_sel

This variable is used to specify the selection of transmission mode, which is cyclic or acyclic. The value is listed at Table 16.

Table 16 – List of the values of variable Cyc_sel

Value	Symbol	Description
0	CMode_Cyclic	Cyclic transmission mode
1	CMode_Acyclic	Acyclic transmission mode

5.3.2.2.2.5 Nmax_dly_cnt

This variable is used to specify the execution times of the transmission delay measurement.

5.3.2.2.2.6 IO_sz

This variable is used to specify the I/O data size and message packet size of cyclic communication instead of I/O map, when DLE adopt fixed-width time slot. When DLE adopt configurable time slot, this variable is not effective.

5.3.2.2.2.7 Pkt_sz

This variable is used to specify the message packet size of cyclic communication, when DLE adopts configurable time slot. When DLE adopts fixed-width time slot, IO_sz is used instead of this variable.

5.3.2.2.2.8 Nmax_retry

This variable is used to specify the maximum-retry-count, which limits the number of retries in the I/O data exchange retry bandwidth.

5.3.2.2.2.9 T_{cycle}

This variable is used to specify the period of the cycle communication. The range that can be set is from 15,625 µs to 64 ms. A set value depends on the value that is specified by the variable T_{unit}.

5.3.2.2.2.10 T_{slot}

This variable is used to specify the time period that is secured to execute the exchange of command and response once between master and slave. The minimum value is from 31,25 µs and the maximum value is equal to Tcycle. A set value depends on the value that is specified by the variable T_{unit}.

5.3.2.2.2.11 T_{unit}

This variable is used to specify the unit of a set value of the variable concerning time, when the DLE adopts configurable time slot. Table 17 shows the list of the values that can be selected. The values are valid when the DLE adopts configurable time slot type. When the DLE adopts fixed-width time slot type, regardless of these values, 250 ns is used as the unit for all variables concerning time. When the DLE adopts no time slot type, 1 ns is used.

Table 17 – List of the values of variable T_{unit}

Value	Definition	T_{cycle}
0	10 ns	15,625 µs to 500 µs
1	100 ns	More than 500 µs to 4 ms
2	1 µs	More than 4 ms to 64 ms

5.3.2.2.2.12 T_{idly}

This variable is used to specify the timing of the event that the DLE issues to the DLS-user every cycle synchronizing with a cyclic communication. After the time specified by this variable passes from the beginning of the communication cycle, the event is generated.

5.3.2.2.2.13 T_{c2_dly}

This variable is used to specify the start time of C2 message communication within the transmission cycle. The minimum value is from 0 µs and the maximum value is equal to T_{cycle}. A set value depends on the value that is specified by the variable T_{unit}.

5.3.2.2.2.14 IO_Map

This is the set of the variables which are required for I/O data exchange of cyclic communication, when DLE adopts configurable time slot. See 5.3.2.2.2.6 when DLE adopts fixed-width time slot.

This variable has an array of structures with the number of elements that set with Nmax_slaves. Table 18 and Table 19 show the structure example of each element of this variable. Table 18 shows the minimum members of IO_Map. The order and alignment of these members depends on the implementation.

Table 18 – Structure example of each element of variable IO_Map

Member name	Definition	Requirement
axis_adr	Station address	M
t_rsp	Response watch time	M
cd_len	Command or output data length [octets]	M
rd_len	Response or input data length [octets]	M
T_{tr_dly}	Transmission delay	M

Table 19 – Data type and range of each element

Member name	Min	Max	Source
axis_adr	(See 5.3.2.2.2.2)		DLMS-user
t_rsp	0	$2^{16}-1$	DLMS-user
cd_len	8	64	DLMS-user
rd_len	8	64	DLMS-user
T_{tr_dly}	–	–	DL-management

5.3.2.2.2.15 Line code

This variable specifies the transmission line code of no time slot type. Table 20 shows the list of the values.

Table 20 – List of the values of variable Line code

Value	Symbol	Description
0	MAN	Manchester code
1	NRZI	Non-return-to-zero-inverted code

5.3.2.2.2.16 Baud rate

This variable specifies the Baud rate of no time slot type. Table 21 shows the list of the values.

Table 21 – List of the values of variable Baud rate

Value	Definition
0	4 Mbit/s
1	8 Mbit/s
2	16 Mbit/s
3	24 Mbit/s
4	32 Mbit/s

Transmission line code and Baud rate of no time slot type are used in combination. Table 22 shows the list of combinations.

Table 22 – List of the values of variable Line code and Baud rate

Line code symbol	Baud rate				
	4 Mbit/s	8 Mbit/s	16 Mbit/s	24 Mbit/s	32 Mbit/s
MAN	M	M			
NRZI			M	M	M

5.3.2.2.2.17 T_{latch}

This variable specifies time for C1 master of no time slot type to cyclically latch the INPUT data. The value that is smaller than the value of T_{cycle} is set.

5.3.2.2.2.18 T_{cc_mul}

In the transmission cycle that can be set for each slave of no time slot type this value is set as the value of integer multiple of the basic transmission cycle. The range is from 1 to 256.

5.3.2.2.2.19 T_{cc_pos}

This variable specifies the position number within the transmission cycle where the no time slot type slave updates the data and is set as the value equal to or is less than the setting of T_{cc_mul} (see 5.3.2.2.2.18).

5.3.2.2.3 Val

See 5.3.2.2.2.

5.3.2.2.4 Result

This parameter indicates the success or failure of the associated Set value service request. Permitted values for this parameter are specified in Table 23.

Table 23 – Values of result for Set value service

Value	Definition
OK	The Set value function was carried out successfully
NG	The Set value function was not carried out successfully

5.3.3 Get value

5.3.3.1 Function

The DLMS-user uses this service to read the variables of the DLE. The DLMS-user passes a DLM-GET-VALUE request primitive to DL-management to read the current value of one or more specified variables of the DLE. After receipt of DLM-GET-VALUE request primitive, DL-management selects the specified variables and gets their current values. And then DL-management passes a DLM-GET-VALUE confirm primitive to the DLMS-user to deliver the current value and to indicate the success or failure of the corresponding service request. This primitive returns as a variable one or more of the requested variable values.

5.3.3.2 Types of parameters

5.3.3.2.1 General

Table 24 indicates the primitives and parameters of Get value service.

Table 24 – Get value primitive and parameters

DLM-GET-VALUE	Request	Confirm
Parameter name	Input	Output
Var_ID	M	
Val		M
Result		M

5.3.3.2.2 Var_ID

5.3.3.2.2.1 General

The values listed in Table 25 can be specified to the parameter Var_ID as well as the Var_IDs listed in Table 26.

Table 25 –The list of parameter Var_ID of Get value request

Var_ID	Definition	Requirement
Sts_STI	Status of connection	C (See Note)
Sts_ORcv	Receive status of output data	C (See Note)
Sts_IRcv	Receive status of input data	C (See Note)
Sts_Err	Error status	M
NOTE This is applicable when DL layer is configurable time slot type.		

Table 26 – Data type and range of variables

Var_ID	Min	Max
Sts_STI	0	$2^{64}-1$
Sts_ORcv	0	$2^{64}-1$
Sts_IRcv	0	$2^{64}-1$
Sts_Err	0	(See Note)
NOTE It depends on the implementation.		

5.3.3.2.2.2 Sts_STI

This is used to check the status of slaves and C2 master. It can be used when DLE adopts configurable time slot type. This variable is 64-bit-width data, and each bit is allocated to a station. Bit 0 is allocated to C12 master, bits 1 to 62 are to slaves which order is registered in the I/O map, and bit 63 is to C2 master. In each bit, the value zero means unconnected or the transmission delay measurement uncompleted, and the value one means the transmission delay measurement completed.

5.3.3.2.2.3 Sts_ORcv

This is used to read the receive status of output data. It can be used when DLE adopts configurable time slot type. This variable is 64-bit-width data, and each bit is allocated to a station. Bit 0 is allocated to C1 master, bits 1 to 62 are to slaves which order is registered in the I/O map, and bit 63 is to C2 Master. In each bit, the value zero means receive fault or no received, and the value one means the normally received data.

5.3.3.2.2.4 Sts_IRcv

This is used to read the receive status of input data. It can be used when DLE adopts configurable time slot type. This variable is 64-bit-width data, and each bit is allocated to a station. Bit 0 is allocated to C1 master, bits 1 to 62 are to slaves which order is registered in the I/O map, and bit 63 is to C2 Master. In each bit, the value zero means receive fault or no received, and the value one means the normally received data.