

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Industrial communication networks – Fieldbus specifications –
Part 4-25: Data-link layer protocol specification – Type 25 elements**

**Réseaux de communication industriels – Spécifications des bus de terrain –
Partie 4-25: Spécification du protocole de la couche liaison de données –
Éléments de type 25**



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Type 25 elements****FOREWORD**

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

FDIS	Report on voting
65C/946/FDIS	65C/955/RVD

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

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

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

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- withdrawn,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.

INTRODUCTION

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

The data-link protocol provides the data-link service by making use of the services available from the physical layer. The primary aim of this document is to provide a set of rules for communication expressed in terms of the procedures to be carried out by peer data-link entities (DLEs) 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:

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

This document is concerned, in particular, with the communication and interworking of sensors, effectors and other automation devices. By using this document 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.

The International Electrotechnical Commission (IEC) draws attention to the fact that it is claimed that compliance with this document may involve the use of a patent concerning Type 25 elements and possibly other types given in this document as follows:

JP4074631 [HI]	Transmission line system, frame transmitter therein, and transmission line switching method
JP4653800 [HI]	Transmission line system, frame transmission apparatus, method and program for switching transmission line in transmission line system
JP4944986 [HI]	Transmission line system and transmission line construction method
CN1964307 [HI]	Transfer path system and frame transfer device in same system, transfer path handover method and system
CN101515887 [HI]	Transmission line system, frame transmitter therein, transmission line switching method and program

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INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 4-25: Data-link layer protocol specification – Type 25 elements

1 Scope

1.1 General

The data-link layer provides basic time-critical messaging communications between devices in an automation environment.

This protocol provides communication opportunities to all participating data-link entities

- a) in a synchronously-starting cyclic manner, according to a pre-established schedule, and
- b) in a cyclic or acyclic asynchronous manner, as requested each cycle by each of those data-link entities.

Thus this protocol can be characterized as one which provides cyclic and acyclic access asynchronously but with a synchronous restart of each cycle.

1.2 Specifications

This document specifies

- a) procedures for the timely transfer of data and control information from one data-link user entity to a peer user entity, and among the data-link entities forming the distributed datalink service provider;
- b) procedures for giving communications opportunities to all participating DL-entities, sequentially and in a cyclic manner for deterministic and synchronized transfer at cyclic intervals up to one millisecond;
- c) procedures for giving communication opportunities available for time-critical data transmission together with non-time-critical data transmission without prejudice to the time-critical data transmission;
- d) procedures for giving cyclic and acyclic communication opportunities for time-critical data transmission with prioritized access;
- e) procedures for giving communication opportunities based on ISO/IEC/IEEE 8802-3 medium access control, with provisions for nodes to be added or removed during normal operation;
- f) the structure of the fieldbus DLPDUs used for the transfer of data and control information by the protocol of this document, and their representation as physical interface data units.

1.3 Procedures

The procedures are defined in terms of

- a) the interactions between peer DL-entities (DLEs) through the exchange of fieldbus DLPDUs;
- b) the interactions between a DL-service (DLS) provider and a DLS-user in the same system through the exchange of DLS primitives;
- c) the interactions between a DLS-provider and a Ph-service provider in the same system through the exchange of Ph-service primitives.

1.4 Applicability

These procedures are applicable to instances of communication between systems which support time-critical communications services within the data-link layer of the OSI or fieldbus reference models, and which require the ability to interconnect in an open systems interconnection environment.

Profiles provide a simple multi-attribute means of summarizing an implementation's capability, and thus its applicability to various time-critical communications needs.

1.5 Conformance

This document also specifies conformance requirements for systems implementing these procedures. This document does not contain tests to demonstrate compliance with such requirements.

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 IEC 61784-1 and IEC 61784-2 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/IEEE 8802-3:2017, *Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 3: Standard for Ethernet*

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

IEEE Std 802.1D, *IEEE Standard for Local and metropolitan area networks – Media access Control (MAC) Bridges*, available at <http://www.ieee.org> [viewed 2018-09-17]

IEEE Std 802.1Q, *IEEE Standard for Local and metropolitan area networks – Bridges and Bridged Networks*, available at <http://www.ieee.org> [viewed 2018-09-17]

3 Terms, definitions, symbols, abbreviations and conventions

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

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

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://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 DL-address	[ISO/IEC 7498-3]
3.1.2 DL-address-mapping	[ISO/IEC 7498-1]
3.1.3 called-DL-address	[ISO/IEC 7498-3]
3.1.4 calling-DL-address	[ISO/IEC 7498-3]
3.1.5 centralized multi-end-point-connection	[ISO/IEC 7498-1]
3.1.6 DL-connection	[ISO/IEC 7498-1]
3.1.7 DL-connection-end-point	[ISO/IEC 7498-1]
3.1.8 DL-connection-end-point-identifier	[ISO/IEC 7498-1]
3.1.9 DL-connection-mode transmission	[ISO/IEC 7498-1]
3.1.10 DL-connectionless-mode transmission	[ISO/IEC 7498-1]
3.1.11 correspondent (N)-entities correspondent DL-entities (N=2) correspondent Ph-entities (N=1)	[ISO/IEC 7498-1]
3.1.12 DL-duplex-transmission	[ISO/IEC 7498-1]
3.1.13 (N)-entity DL-entity (N=2) Ph-entity (N=1)	[ISO/IEC 7498-1]
3.1.14 DL-facility	[ISO/IEC 7498-1]
3.1.15 flow control	[ISO/IEC 7498-1]
3.1.16 (N)-layer DL-layer (N=2) Ph-layer (N=1)	[ISO/IEC 7498-1]
3.1.17 layer-management	[ISO/IEC 7498-1]
3.1.18 DL-local-view	[ISO/IEC 7498-3]
3.1.19 DL-name	[ISO/IEC 7498-3]
3.1.20 naming-(addressing)-domain	[ISO/IEC 7498-3]
3.1.21 peer-entities	[ISO/IEC 7498-1]
3.1.22 primitive name	[ISO/IEC 7498-3]
3.1.23 DL-protocol	[ISO/IEC 7498-1]
3.1.24 DL-protocol-connection-identifier	[ISO/IEC 7498-1]
3.1.25 DL-protocol-data-unit	[ISO/IEC 7498-1]
3.1.26 DL-relay	[ISO/IEC 7498-1]
3.1.27 reset	[ISO/IEC 7498-1]
3.1.28 responding-DL-address	[ISO/IEC 7498-3]
3.1.29 routing	[ISO/IEC 7498-1]
3.1.30 segmenting	[ISO/IEC 7498-1]
3.1.31 (N)-service DL-service (N=2) Ph-service (N=1)	[ISO/IEC 7498-1]
3.1.32 (N)-service-access-point DL-service-access-point (N=2) Ph-service-access-point (N=1)	[ISO/IEC 7498-1]

3.1.33 DL-service-access-point-address	[ISO/IEC 7498-3]
3.1.34 DL-service-connection-identifier	[ISO/IEC 7498-1]
3.1.35 DL-service-data-unit	[ISO/IEC 7498-1]
3.1.36 DL-simplex-transmission	[ISO/IEC 7498-1]
3.1.37 DL-subsystem	[ISO/IEC 7498-1]
3.1.38 systems-management	[ISO/IEC 7498-1]
3.1.39 DLS-user-data	[ISO/IEC 7498-1]

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 acceptor**
- 3.2.2 asymmetrical service**
- 3.2.3 confirm (primitive);**
requestor.deliver (primitive)
- 3.2.4 deliver (primitive)**
- 3.2.5 DL-confirmed-facility**
- 3.2.6 DL-facility**
- 3.2.7 DL-local-view**
- 3.2.8 DL-mandatory-facility**
- 3.2.9 DL-non-confirmed-facility**
- 3.2.10 DL-provider-initiated-facility**
- 3.2.11 DL-provider-optional-facility**
- 3.2.12 DL-service-primitive;**
primitive
- 3.2.13 DL-service-provider**
- 3.2.14 DL-service-user**
- 3.2.15 DLS-user-optional-facility**
- 3.2.16 indication (primitive);**
acceptor.deliver (primitive)
- 3.2.17 multi-peer**
- 3.2.18 request (primitive);**
requestor.submit (primitive)
- 3.2.19 requestor**
- 3.2.20 response (primitive);**
acceptor.submit (primitive)
- 3.2.21 submit (primitive)**
- 3.2.22 symmetrical service**
- 3.3 Terms and definitions**

3.3.1

blocking

port state which does not participate in frame communication

3.3.2

class

identifiers that designate communication range of the RCL frame and the other frames

3.3.3

control communication

non-real-time acyclic data communication for higher priority applications and node control communication

3.3.4

cyclic communication

periodic data communication for real-time communication

3.3.5

DLCEP-address

DL-address which designates either

- a) one peer DL-connection-end-point, or
- b) one multi-peer publisher DL-connection-end-point and implicitly the corresponding set of subscriber DL-connection-end-points where each DL-connection-end-point exists within a distinct DLSAP and is associated with a corresponding distinct DLSAP-address.

3.3.6

DLSAP

distinctive point at which DL-services are provided by a single DL-entity to a single higher-layer entity

3.3.7

DL(SAP)-address

either an individual DLSAP-address, designating a single DLSAP of a single DLS-user, or a group DL-address potentially designating multiple DLSAPs, each of a single DLS-user

Note 1 to entry: This terminology is chosen because ISO/IEC 7498-3 does not permit the use of the term DLSAP-address to designate more than a single DLSAP at a single DLS-user.

3.3.8

(individual) DLSAP-address

DL-address that designates only one DLSAP within the extended link

Note 1 to entry: A single DL-entity may have multiple DLSAP-addresses associated with a single DLSAP.

3.3.9

extended link

DL-subnetwork, consisting of the maximal set of links interconnected by DL-relays, sharing a single DL-name (DL-address) space, in which any of the connected DL-entities may communicate, one with another, either directly or with the assistance of one or more of those intervening DL-relay entities

3.3.10

frame

denigrated synonym for DLPDU

3.3.11

group DL-address

DL-address that potentially designates more than one DLSAP within the extended link

Note 1 to entry: A single DL-entity may have multiple group DL-addresses associated with a single DLSAP. A single DL-entity also may have a single group DL-address associated with more than one DLSAP.

3.3.12

information communication

non-real-time acyclic data communication for low priority applications

3.3.13**logical link down**

link status at which the port is in a blocking state and does not communicate all kinds of frames except RCL frames

3.3.14**logical link up**

link status at which the port communicates all kinds of frames

3.3.15**node**

single DL-entity as it appears on one local link

3.3.16**physical link down**

link status at which the port does not communicate the frames due to link down status defined in ISO/IEC/IEEE 8802-3

3.3.17**receiving DLS-user**

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

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

3.3.18**ring control (RCL) communication**

control communication of Type 25 DLL ring network using RCL frames and non-real-time

3.3.19**sending DLS-user**

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

3.3.20**station**

synonym for node

3.3.21**station address**

identifier address that designates the node of Type 25 network

3.4 Symbols and abbreviations

NOTE Many symbols and abbreviations are common to more than one protocol Type; they are not necessarily used by all protocol Types.

DL-	Data-link layer (as a prefix)
DLC	DL-connection
DLCEP	DL-connection-end-point
DLE	DL-entity (the local active instance of the data-link layer)
DLL	DL-layer
DLM	DL-management
DLME	DL-management Entity (the local active instance of DL-management)
DLMS	DL-management service
DLPCI	DL-protocol-control-information
DLPDU	DL-protocol-data-unit
DLS	DL-service

DLSAP	DL-service-access-point
DLSDU	DL-service-data-unit
EGA	Edge-A node
EGB	Edge-B node
FIFO	First-in first-out (queuing method)
ISL	Isolate node
ITM	Intermediate node
LCA	Loop condition alert (Type 25 frame type)
LCC	Loop condition check (Type 25 frame type)
LCN	Loop condition notify (Type 25 frame type)
LLD	Logical link down
LLU	Logical link up
LNA	Loop notify answer (Type 25 frame type)
NNB	No neighborhood state
OSI	Open systems interconnection
Ph-	Physical layer (as a prefix)
PhE	Ph-entity (the local active instance of the Physical layer)
PhL	Ph-layer
PhS	Ph-service
PLD	Physical link down
PLU	Port A (B) link up state
QoS	Quality-of-service
RCL	Ring control
RCLC	RCL communication control
RHE	Rapid hello (Type 25 frame type)
RT	Real time
RTC	RT communication control
SCR	Station condition report (Type 25 frame type)
TRC	Transmit/Receive control
WLU	Wait link up state

3.5 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 request primitive's output parameters;
- the indication primitive's output parameters;
- the response primitive's input parameters;
- 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 may or may not be provided 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) a parameter-specific constraint

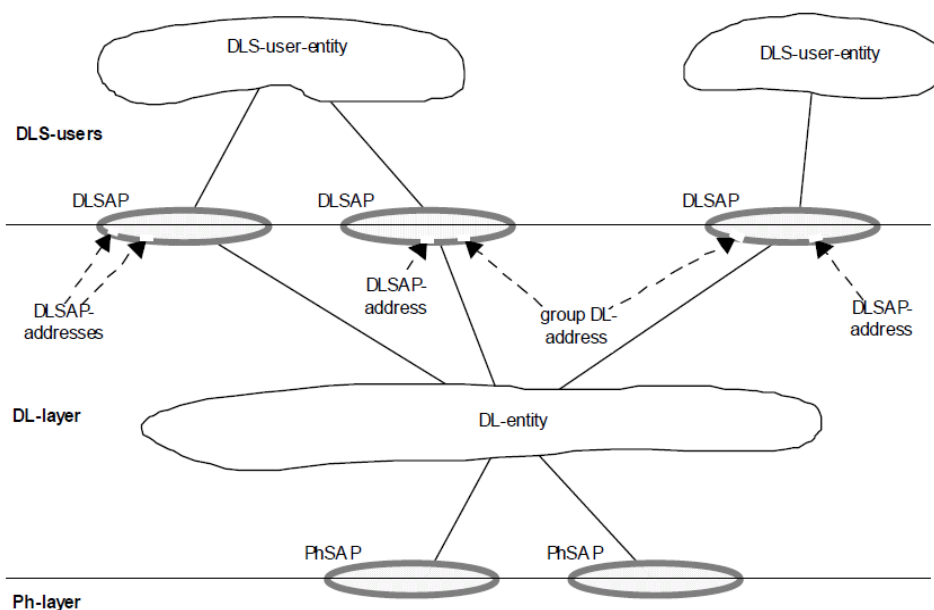
(=) indicates that the parameter is semantically equivalent to the parameter in the service primitive to its immediate left in the table;

b) an indication that some note applies to the entry

(n) indicates that the following note n contains additional information pertaining to the parameter and its use.

In any particular interface, not all parameters need be explicitly stated. Some may be implicitly associated with the DLSAP at which the primitive is issued.

Figure 1 shows the relationships of DLSAPs, DLSAP-addresses and group DL-addresses.



NOTE 1 DLSAPs and PhSAPs are depicted as ovals spanning the boundary between two adjacent layers.

NOTE 2 DL-addresses are depicted as designating small gaps (points of access) in the DLL portion of a DLSAP.

NOTE 3 A single DL-entity can have multiple DLSAP-addresses and group DL-addresses associated with a single DLSAP.

Figure 1 – Relationships of DLSAPs, DLSAP-addresses and group DL-addresses

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.

3.6 Additional Type 25 conventions

3.6.1 Primitive 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)
rsp response primitive

3.6.2 State machine conventions

The protocol sequences are described by means of state machines.

In state diagrams, states are represented as boxes and state transitions are shown as arrows.

Names of states and transitions of the state diagram correspond to the names in the state table. The textual listing of the state transitions is structured as shown in Table 1.

Table 1 – State transition descriptions

#	Current state	Event /condition => actions	Next state
---	---------------	--------------------------------	------------

Table 2 – Descriptions of state machine elements

Description element	Meaning
#	Number of the transition.
Current state, Next state	Names of the originating state and the target state of transition.
Event	Name or description of the trigger event that fire the transition.
/conditions	Boolean expression, which shall be true for the transition to be fired.
=>actions	List of assignments and service or function invocations. The action should be atomic. The preceding "=>" is not part of the action.
"/ conditions" may be omitted	

The conventions used in the state machines are shown in Table 3.

Table 3 – Conventions used in state machine

Convention	Meaning
=	Substitution of the right side for the left side
==	A logical condition to indicate an item on the left is equal to an item on the right.
!=	A logical condition to indicate an item on the left is not equal to an item on the right
<	A logical condition to indicate an item on the left is less than the item on the right
>	A logical condition to indicate an item on the left is greater than the item on the right
&&	Logical "AND"
	Logical "OR"
!	Negation operator
+ - * /	Arithmetic operator
++	Increment operator
--	Decrement operator
;	Breakpoint

4 Overview of the DL-protocol

4.1 General

A Type 25 fieldbus is based on the ISO/IEC/EEE 8802-3 but extended towards real-time Ethernet. Type 25 network controls the data traffic and assigns frame priorities with IEEE 802.1Q VLAN.

NOTE Any standard Ethernet silicon, infrastructure component or test and measurement equipment such as a network analyzer is applicable to Type 25 network.

4.2 Overview of the medium access control

4.2.1 General

Type 25 network provides mechanisms to achieve the following.

- It assigns priorities to four types of frames (RCL/Cyclic/Control/Information).
- The frames in Type 25 network are guaranteed real-time of cyclic communication to control the data traffic.

- c) It uses ISO/IEC/IEEE 8802-3 communication without needs for special functions for RTE communication such as time sharing or node synchronization.
- d) The ring topology is only permitted in Type 25 network. In order to control the network, it categorizes the frames into three classes according to their communication ranges.

4.2.2 Network topology

The ring topology shall be used in Type 25 network. The network shall be controled and reconfigured by RCL frames. Type 25 ring network does not need concept of master/slave model because each node in Type 25 network reconfigures autonomously. To prevent frame loop, one section in the ring network is in the blocking state (see IEEE 802.1D) and the blocked section terminates all kinds of frames except RCL frame (as illustrated in Table 2).

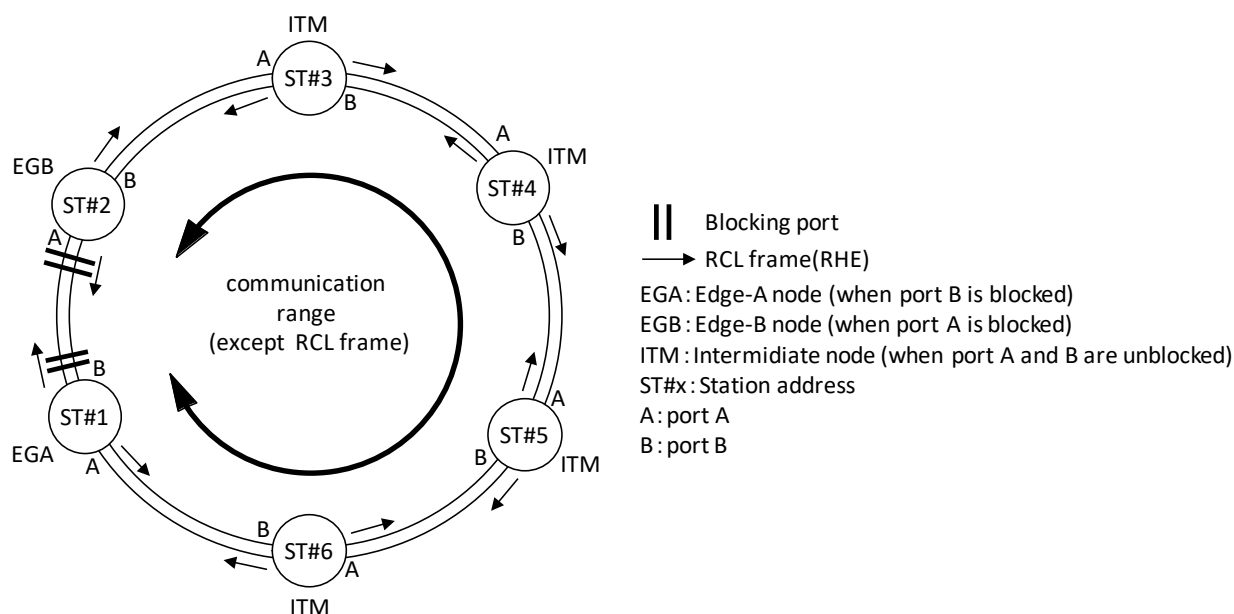


Figure 2 – Ring control in Type 25 network

Each node in the ring network has two ports A and B to connect to the neighboring nodes. Each node has its own station address. In Type 25 network, each node has four different node states depending on the blocking status of their ports. Table 4 shows the characteristics of the node states.

Table 4 – Characteristics of the node states

Node states	Abbreviation	Description
Isolated node	ISL	Both port A and B are blocked in this state (e.g. not connect cables to other nodes) and the node is isolated from the Type 25 network.
Edge-A node (when port B is blocked)	EGA	Port B is blocked, port A is unblocked. The node works with Edge-A. There is only one node in a Type 25 network.
Edge-B node (when port A is blocked)	EGB	Port A is blocked, port B is unblocked. The node works with Edge-B. There is only one node in a Type 25 network.
Intermediate node (when port A, B are unblocked)	ITM	Both port A and B are unblocked. The node works with Edge-A and Edge-B. In a Type 25 network, there are an Edge-A node and an Edge-B node. The other nodes are this state.

RCL frames are based on general ISO/IEC/IEEE 8802-3 frames. These frames have different ranges of communication which are given by “class”. Table 5 shows the characteristics of the frame class and Figure 3 shows the communication ranges in Type 25 network.

Table 5 – Characteristic of the frame classes

Frame class	Description
Class 1	This frame is used to communicate with the neighboring node only. It passes through blocking ports. RHE frame are RCL frames in this class.
Class 2	This frame is used to communicate around the network. This frame is able to pass through blocking ports and the Edge-A node terminates the frames. LCC, LCA, LCN, LNA, and SCR frames are RCL frames in this class.
Class 3	This frame is general Ethernet frame and terminated by blocking ports. The RT frames (Cyclic, Control, Information frames) are in this class.

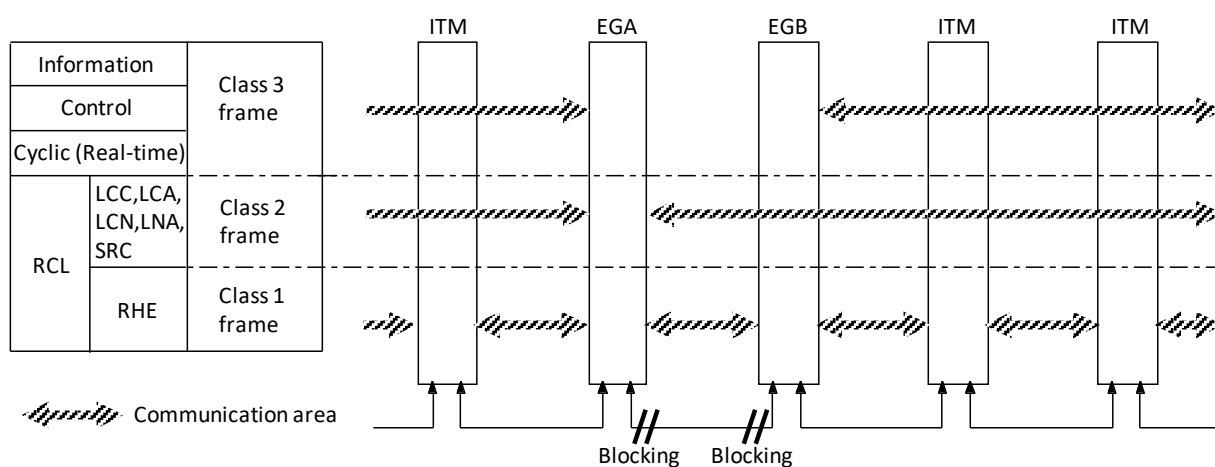


Figure 3 – Communication ranges of Type 25 frames

4.2.3 Priority control with VLAN

Table 6 shows the VLAN priority mapping of the Type 25 network. Type 25 network maps VLAN priority to four types communication, Ring control, Cyclic, Control, and Information communication. Ring control communication, Type 25 ring network reconfiguration frame is the highest priority. Cyclic communication, real-time communication frame is the second highest priority. Control communication is the third priority and Information is the lowest priority.

Table 6 – VLAN priority mapping of Type 25 network

VLAN	Usage	VLAN priority
VLAN-1	Ring control communication	7 (Highest)
VLAN-2	Cyclic communication	5 (High)
VLAN-3	Control communication	3 (Low)
VLAN-4	Information communication	1 (Lowest)

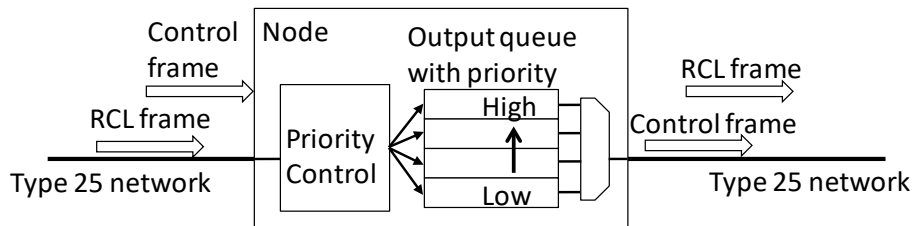


Figure 4 – Priority control with VLAN of Type 25 network

Each node has output queues with priority. The receiving frames are put into the output queues based on their frame priorities. The frame with higher priority will be forwarded neighboring node. In this mechanism, Type 25 network guarantees real-time cyclic communication.

4.2.4 The maximum delivery delay in Type 25 network

Type 25 network limits data traffic in the network to ensure real time communication. This maintains the communication delay of frames at an acceptable level. The traffic restriction of each node is determined by the total number of nodes in the network and cycle time using the node.

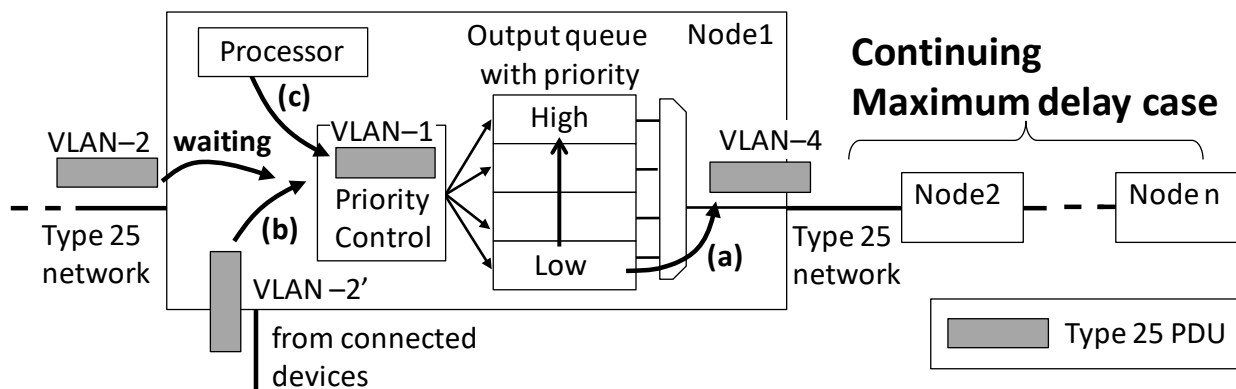


Figure 5 – The mechanism of transmission delay in a node

There are three causes of the delay regarding VLAN-2 (cyclic communication) frame in Type 25 network.

- VLAN-2 frame arrives at the time when the node is sending another frame. The VLAN-2 frame is forced to wait until the transmission is finished. This delay is caused by any priority frames.
- Before receiving a VLAN-2 frame, the node receives another VLAN-2 frame (VLAN-2' in Figure 5) from other ports. In this case, at the priority queue, the VLAN2 frame is put after the VLAN-2' frame.
- When the VLAN-2 frame is waiting for transmission due to the causes a) and b), the node receives higher priority frames (VLAN-1 frame). Since the node will transmit the highest priority frames first, the VLAN-2 frame is forced to wait until the transmission of higher priority frames is finished.

When three causes happen all at once in a node, the maximum delay occurs. The delivery time could be calculated in the case of the maximum delay occurring at all nodes in a Type 25 network.

4.2.5 Traffic control for real-time communication

Delivery time in Type 25 network is calculated based on the maximum delay time per node, the number of nodes, and the length of ring network.

The maximum delay of real-time communication (cyclic communication) between two nodes is calculated by taking into account to the four delay causes shown in Figure 6.

1) Stacking delay in sending node:

The delay caused by the transmission process. It depends on the implementation of the hardware and software.

2) Cable segment delay:

The delay caused by transmission cable constructing ring network. It is proportional to the cable length.

3) Transmission delay in transit node

The delay caused by transmission delay per transit node. It is proportional to the number of nodes in the transmission path. The detail is shown in 4.2.4.

4) Stacking delay in receiving node:

The delay caused by the receiving process. It depends on the implementation of the hardware and software.

The delivery time is calculated by the following equation.

$$(\text{delivery time}) = (1) + (2) \times \text{cable length} + (3) \times (\text{the number of nodes} - 2) + (4)$$

The cycle time of cyclic communication shall be set to larger than the delivery time to guarantee real-time communication of cyclic communication frames in Type 25 network.

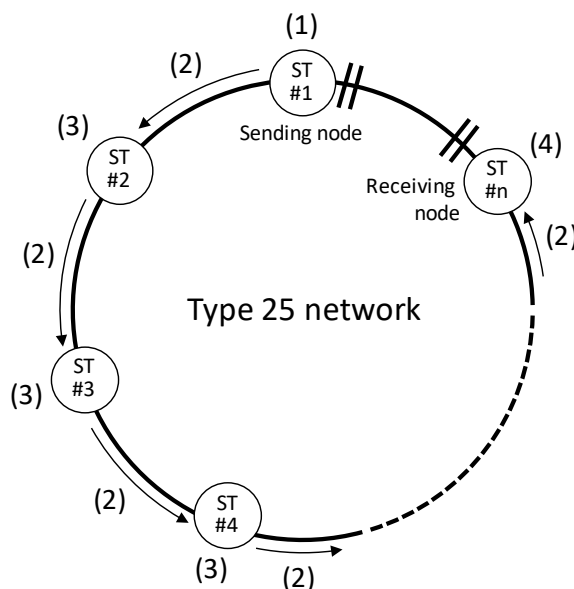


Figure 6 – The maximum delay in Type 25 network

4.3 Service assumed from PhL

Subclause 4.3 describes the assumed physical service (PhS) and the constraints used by the DLE. The Physical Service is assumed to provide the following service primitives specified by ISO/IEC/IEEE 8802-3:2017, Clause 6.

The assumed primitives of PhS are

- PhS-A_DATA.req;
- PhS-A_DATA.ind;
- PhS-B_DATA.req;
- PhS-B_DATA.ind.

4.4 DL Layer architecture

The Type 25 fieldbus DLL is modeled as a combination of control components of RCL communication control (RCLC), Real-time communication control (RTC), Transmit/Receive control (TRC) and DL-management (DLM).

The data-link layer is comprised of the components shown in Table 7.

Table 7 – Data-link layer components

Components	Description
RCL communication control (RCLC)	At RCLC, DLSDU for the ring control (RCL) data is stored and transferred between the DLS-user and the TRC.
Real-time communication control (RTC)	At RTC, control data/information data is stored and transferred between DLS-user and the TRC.
Transmit/Receive control (TRC)	At TRC, DLSDU is stored and transferred from the RCLC/RTC to Ph-Layer. DLPDU is stored and transferred from Ph-Layer to the RCLC/RTC.
DL-management (DLM)	The DL-management interface holds the station management variables that belong to the DLL, and manages synchronized changes of the link parameters.

The internal arrangement of these components, and their interfaces, is shown in Figure 7. The arrowheads illustrate the primary direction of the flow of data and control.

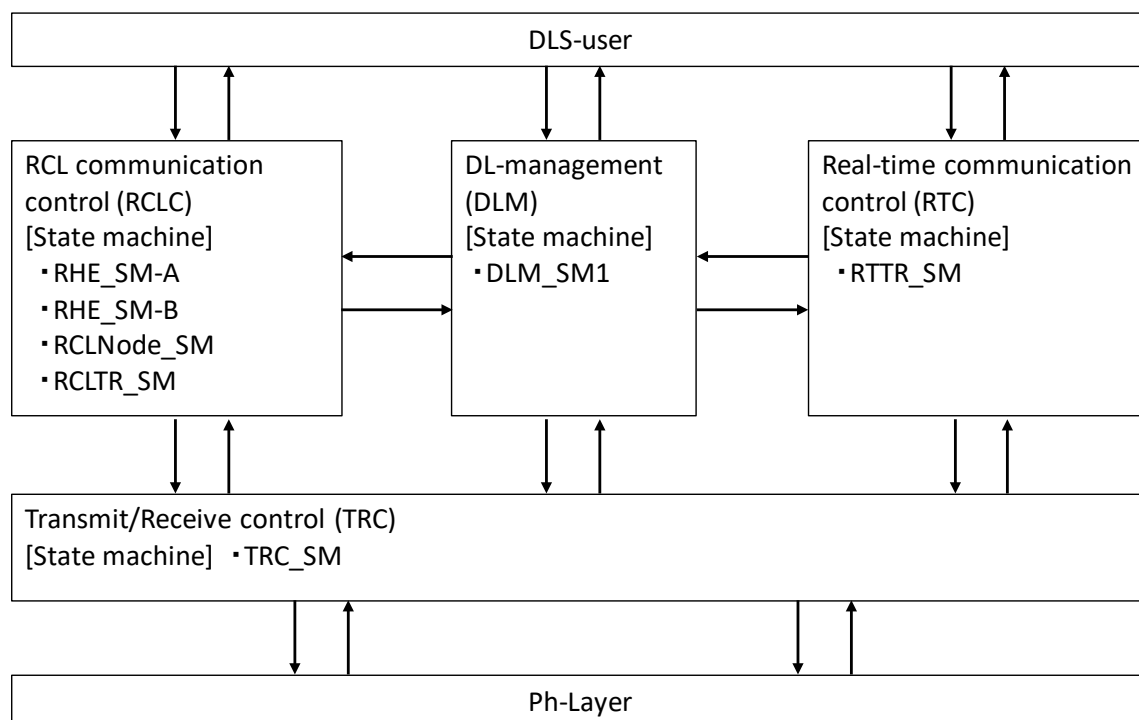


Figure 7 – Data-Link layer internal architecture

4.5 Local parameters and variables

4.5.1 Overview

This specification uses DLS-user request parameters $P(\dots)$ and local variables $V(\dots)$ as a means of clarifying the effect of certain actions and the conditions under which those actions are valid, local timers $T(\dots)$ as a means of monitoring actions of the distributed DLS-provider and of ensuring a local DLE response to the absence of those actions, and local counters $C(\dots)$ for performing rate measurement functions.

Unless otherwise specified, at the moment of their creation or of DLE activation:

- a) all variables shall be initialized to their default value, or to their minimum permitted value if no default is specified;
- b) all counters shall be initialized to zero;
- c) all timers shall be initialized to inactive;

DL-management may change the values of configuration variables.

4.5.2 Variables, parameter, counter and timer

4.5.2.1 $P(\text{RHE_RxCK_NUM})$

This parameter indicates the expiration time of not receiving RHE frames.

4.5.2.2 $P(\text{RHE_LKUP_NUM})$

This parameter indicates the number of receiving RHE frames for logical linkup.

4.5.2.3 $P(\text{LCC_STOP_NUM})$

This parameter indicates the threshold number to stop the LCC frame transmission.

4.5.2.4 $C(\text{PA_RHE_LKUP}), C(\text{PB_RHE_LKUP})$

These counters indicate the count of continuously receiving RHE frames at port A and port B, respectively.

4.5.2.5 $C(\text{PA_RHE_RxCK}), C(\text{PB_RHE_RxCK})$

These counters are used to check whether continuously received or dropped RHE frames. Each value is decreased in $T(\text{PA_RHE_TIME})$ or $T(\text{PB_RHE_TIME})$.

4.5.2.6 $C(\text{PA_Rx-RHE_NotMatch}), C(\text{PB_Rx-RHE_NotMatch})$

These counters are used to detect the change from neighborhood node to another node.

4.5.2.7 $C(\text{Rx_Counter})$

This counter indicates the number of receiving LCC frames by own node.

4.5.2.8 $T(\text{PA_RHE_TIME}), T(\text{PB_RHE_TIME})$

$T(\text{PA_RHE_TIME})$ and $T(\text{PB_RHE_TIME})$ are used for fixed cycle to do RHE operation.

4.5.2.9 $V(\text{PA_Blocking}), V(\text{PB_Blocking})$

These variables hold and designate the blocking status at the ports respectively. When the port is blocked, these variables are set to "True", otherwise "False".

4.5.2.10 V(LCN_Pri)

This variable is a unique value used to decide an Edge-A node in the network. This variable is used when the node sends LCN frames.

4.5.2.11 V(LNA_Pri)

This variable is a unique value used to decide an Edge-A node in the network. This variable is used when the node sends LNA frames.

4.5.2.12 V(PA_NBST_LKST), V(PB_NBST_LKST)

These variables hold and designate the link status of a neighborhood node. It takes three types value (NNB, WLU, and PLU). These values are updated by receiving the RHE frames.

4.5.2.13 V(PA_NBST_NDST), V(PB_NBST_NDST)

This variable holds and designates the node status of a neighborhood node. It takes four types value (ISL, EGA, EGB, and ITM) and updates the value by receiving the RHE frames.

4.5.2.14 V(PA_NBST_RCLADD), V(PB_NBST_RCLADD)

These variables hold and designate the address of a neighborhood node. These values are updated by receiving the RHE frames.

4.5.2.15 V(PA_RHE_CYCLE), V(PB_RHE_CYCLE)

These variables hold and designate the cycle time to do RHE operation.

4.5.2.16 V(PA_RHE_RxSeq), V(PB_RHE_RxSeq)

These variables hold and designate the sequence number of receiving RHE frames. If RHE frames from neighborhood node are received continuously, these values increase.

4.5.2.17 V(PA_STATUS), V(PB_STATUS)

These variables hold and designate the port link status of own node. They take three values (NNB, WLU, and PLU).

5 General structure and encoding of PhPDUs and DLPDU and related elements of procedure

5.1 Overview

The DLL and its procedures are necessary to provide the services offered to the DLS user by using the services available from the PhL. Clause 5 describes the structure and semantics of DLPDU and the procedure, commonly used in this specification.

5.2 Common MAC frame structure, encoding and elements of procedure

5.2.1 MAC frame structure

Figure 8 shows the Type 25 fieldbus DLPDU.

Preamble (7)	SFD (1)	Destination address (6)	Source address (6)	VLAN tag (4)	Length/ Type (2)	DLS-user data	Padding	FCS (4)
-----------------	------------	----------------------------	-----------------------	-----------------	---------------------	---------------	---------	------------

(*)the number in parenthesis indicates length of the field in octets

Figure 8 – Type 25 fieldbus DLPDU frame format

5.2.2 Elements of the MAC frame

5.2.2.1 Preamble

The preamble field is identical to ISO/IEC/IEEE 8802-3:2017, Clause 3. The preamble field is a 56-bit field that is used to allow the physical signaling part circuitry to reach its steady state synchronization with the receiving frame timing.

The preamble pattern is:

“10101010 10101010 10101010 10101010 10101010 10101010 10101010.”

5.2.2.2 Start frame delimiter (SFD)

The Start Frame Delimiter (SFD) is identical to ISO/IEC/IEEE 8802-3:2017, Clause 3. The SFD field is the sequence of bit pattern “10101011”. It immediately follows the preamble pattern and indicates the start of a frame.

5.2.2.3 Destination address

The Destination address is identical to ISO/IEC/IEEE 8802-3:2017, Clause 3. This address field is a 48-bit in length. The frames received and sent at each node are classified into three classes (class 1, 2, and 3) based on the communication range. The detail of the class is shown in 4.2.2.

The frame class is distinguished by destination address. Table 8 shows the destination address of three types of classes.

Table 8 – Destination address format

Frame class	Frame type	Destination address
Class 1	RCL (RHE)	01-80-C2-00-00-0F
Class 2	RCL (LCC/LCA/LCN/LNA/SCR)	01-80-C2-00-00-0E
Class 3	Cyclic/Control/Information	Destination MAC address of the DLSDU

5.2.2.4 Source address

Source address shall contain the node address of the source DLE.

5.2.2.5 VLAN tag

VLAN tag uses IEEE 802.1Q VLAN tag, and indicates frame type (RCL, cyclic, control, and information) designated VID and frame priority designated PCP. Table 9 shows the VLAN tag format.

Table 9 – VLAN tag format

Frame type	TPID (2 octets)	TCI (2 octets)		
		PCP (3 bit)	CFI (1 bit)	VID (12 bit)
RCL	0x8100	111	0	0xFFB
Cyclic	0x8100	101	0	0xFFC
Control	0x8100	011	0	0xFFD
Information	0x8100	001	0	0xFFE(*)

(*): Information frames may use other VID than 0xFFE(4094) from 1 to 50 and designate multiple VIDs.

5.2.2.6 Length/Type

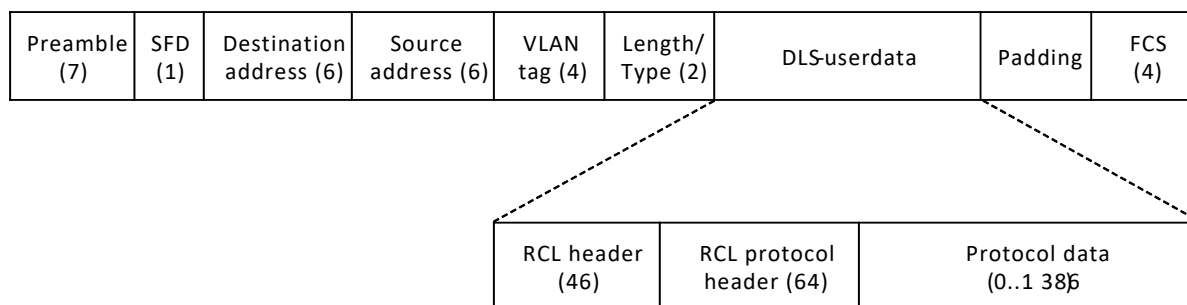
The Length/type is different for frame types.

- RCL frame is set to the frame length. It is different for the RCL_type.
- Cyclic frame is set to 0x0800 (designated IP frame).
- Control and information frames are set to protocol ID that corresponds to PDU data.

5.2.2.7 DLS-user data field

5.2.2.7.1 RCL frame

Figure 9 shows the RCL frame format. RCL frame has three segments, RCL header, RCL protocol header, and Protocol data in DLS-user data. Each segment contains information which is used to control the ring network. The information differs according to RCL frame types.



Key: (#) the number in parenthesis indicates length of the field in octets

Figure 9 – RCL frame format

5.2.2.7.2 RT frame

The RT frames are identical to the ISO/IEC/IEEE 8802-3.

5.2.2.8 Padding

Padding is inserted into the frame so that the data length is always a multiple of 32 bits.

5.2.2.9 Field check sequence (FCS)

The frame check sequence (FCS) construction, polynomial and expected residual are identical to ISO/IEC/IEEE 8802-3:2017, Clause 3.

6 DLPDU-specific structure, encoding and elements of procedure

6.1 General

Clause 6 defines the structure, contents and encoding of each type and format of the RCL communication DLPDU, and specifies elements of procedure for the DLPDU. The RT communication DLPDU is not described in Clause 6 since its frame is identical to the ISO/IEC/IEEE 8802-3.

6.2 Structure of the RCL DLPDU

Frame of class 1 is used to communicate to the neighboring node. Frame of class 2 is used to communicate between nodes around the network. For the RCL frame, there are one kind of class 1 frame and five kinds of class 2 frame. Table 10 shows the types and classes of RCL frames.

Table 10 – Types and classes of RCL frames

Frame class	Frame name	Description
Class 1	RHE (Rapid Hello)	The RHE frame confirms the neighboring node and transmission path.
Class 2	LCC (*) (Loop Condition Check)	The LCC frame is used to determine autonomously the single Edge-A node, which exists in the normal ring network.
Class 2	LCA (*) (Loop Condition Alert)	If a node's port B is physical or logical link down, the node's LCA frame declares that it has higher priority to be Edge-A node.
Class 2	LCN (*) (Loop Condition Notify)	A node's LCN frame declares that its own port B changes to physical link down state.
Class 2	LNA (*) (Loop Notify Answer)	The LNA frame is sent to the node which sent LNA frame. Only Edge-B node sends this frame.
Class 2	SCR (Station Condition Report)	The SCR frame notifies the event of change in network topology to all nodes in the ring network.
(*)LCC, LCA, LCN, and LNA have different priority to select an Edge-A node: LCN > LCA > LCC (high priority) > LCC (low priority)		

6.2.1 RCL header

6.2.1.1 General

The structure of RCL DLPDU is shown in Table 11.

Table 11 – Structure of RCL header

RCL header field		Size (Octet)
Class		2
Destination address	Priority	1
	Station address	1
	MAC address	6
Source address	Priority	1
	Station address	1
	MAC address	6
CMD		4
Sequence number		4
Reserved		20

6.2.1.2 Class

There are two kinds of class in RCL frame as shown in Table 12.

- Class 1: used to communicate to the neighboring node;
- Class 2: used to communicate between nodes around the network.

Table 12 – Class field format

Frame class	Value(2 octets)
Class 1	0x0001
Class 2	0x0002

6.2.1.3 Destination address

Table 13 shows the destination address field format. Set value of priority, station address, MAC address, depending on RCL_type.

Table 13 – Destination address field format

Item	RCL_type	
	RHE/LCC/LCN/SCR	LCA/LNA
Priority	0x00	Set to the source address that receives RCL frame (LCA: received LCC frame, LNA: received LCN frame)
Station address	0xFF	
MAC address	FF-FF-FF-FF-FF-FF	

6.2.1.4 Source address

All RCL frames are set to the data shown in Table 14.

Table 14 – Source address field format

Item	Value
Priority	0x00
Station address	Station address of the node
MAC address	MAC address of the node

6.2.1.5 CMD

The CMD is used to identify the RCL frame. This area is different according to the frame type (RCL_type) as shown in Table 15.

Table 15 – CMD field format

Bit	Item	Value					
		RHE	LCC	LCA	LCN	LNA	SCR
[3..0]	Reserved	1					
[7..4]	Unique number 1	0	0	1	2	3	0
[11..8]	Unique number 2	0	1	1	1	1	3
[15..12]	Reserved	0					
[23..16]	Frame class	1	2	2	2	2	2
[31..24]	Reserved	0					

6.2.1.6 Sequence number

Sequence number is used to detect loss and duplication of received frames. Its value ranges from 0x00000000 to 0xFFFFFFFF with an increment of 1.

7 DLE elements of procedure

7.1 Overview

In Subclause 7.2, the operation of RCLC, RTC, TRC, and DLM are described.

7.2 RCL communication control (RCLC)

7.2.1 General

RCLC provides the following functions.

- Control link status of communication with neighboring node using RHE frame;
- Control node status using class 2 RCL frames;
- Send and receive RCL frames.

7.2.2 Primitive definitions

7.2.2.1 Primitive definitions between RCLC and DLS-user

Table 16 summarizes all primitives exchanged between the RCLC and the DLS-user.

Table 16 – The primitives and parameters for DLS-user interface

Primitive name	Source	Associated parameters	Description
DL-RCL.req	DLS-user	(in S_add, PortNum Frame_pri, RCL_type, DLSDU)	Transmits a RCL frame from the DLS-user. The RCL frame is carried to TRC with the class parameter.
DL-RCL.cnf	RCLC	(out Status)	Responds to complete DLSDU transmission and reports the status to DLS-user.
DL-RCL.ind	RCLC	(out S_add, PortNum Frame_pri, RCL_type, DLSDU)	Carries forward a received RCL frame to the DLS-user.

The parameters used with the primitives exchange between the RCLC and the DLS-user are described in Table 17.

Table 17 – Parameters used with primitives exchanged between RCLC and DLS-user

Parameter name	Description
S_add	The S_add parameter specifies the DL-address of the publisher.
PortNum	This parameter specifies the transmit/receive port of the publisher.
Frame_pri	This parameter specifies the priority with VLAN of the ring network.
RCL_type	This parameter specifies the RCL type of the RCL frame.
DLSDU	This parameter specifies the information of the RCL frame.
Status	This parameter allows DLMS-user to determine whether the requested DLS was provided successfully, or failed due to a particular reason. The value conveyed in this parameter is as follows: “OK – successfully completed”; “Failure – terminated before completion”.

7.2.2.2 Primitive definitions between RCLC and TRC

Table 18 summarizes all primitives exchanged between the RCLC and the TRC.

Table 18 – The primitives and parameters for TRC interface

Primitive name	Source	Associated parameters	Description
RCLC-Tx.req	RCLC	D_add, S_add, Tx_port, Frame_pri, RCL_type, DLSDU	Transmits a RCL frame to TRC with associated parameters. The RCLC attaches the Tx_port parameter (port A, B or both).
RCLC-Rx.ind	TRC	D_add, S_add, Rx_port, Frame_pri, RCL_type, DLSDU	Carries forward a received RCL frame from the TRC.
RCLC-SetPT.req	RCLC	BLKport, Blocking	Requests to change the blocking status of a port to the TRC.

The parameters used with the primitives exchange between the RCLC and the TRC are described in Table 19.

Table 19 – Parameters used with primitives exchanged between RCLC and TRC

Parameter name	Description
D_add	The D_add parameter specifies the DL-address of the subscriber.
S_add	The S_add parameter specifies the DL-address of the publisher.
Tx_port	This parameter specifies the transmit port of the publisher.
Rx_port	This parameter specifies the receive port of the publisher.
Frame_pri	This parameter specifies the priority with VLAN of the ring network.
RCL_type	This parameter specifies the RCL type of the RCL frame.
DLSDU	This parameter specifies the information of the RCL frame.
BLKport	This parameter specifies the blocking port in itself.
Blocking	This parameter specifies the blocking status in itself.

7.2.2.3 Primitive definitions between RCLC and DLM

Table 20 summarizes all primitives exchanged between the RCLC and the DLM.

Table 20 – The primitives and parameters for DLM interface

Primitive name	Source	Associated parameters	Description
RCL_STOP.ind	RCLC	RCL_Indtype	Indicates a stop of the RCL frame to DLM based on the ring control state machine.
RCL_START.ind	RCLC	RCL_Indtype, RCL_IndDA, RCL_IndPri, RCL_IndPort	Indicates a start of the RCL frame to DLM based on the ring control state machine.
Node_ST.ind	RCLC	Node_ST, PortA_ST, PortB_ST	Indicates a change of the node or port status to DLM based on the ring control state machine.

The parameters used with the primitives exchange between the RCLC and the DLM are described in Table 21.

Table 21 – Parameters used with primitives exchanged between RCLC and DLM

Parameter name	Description
RCL_Indtype	This parameter specifies the RCL type of the requested RCL frames for the DLM due to the change of the node status.
RCL_IndDA	This parameter specifies the DL-address of the requested RCL frames for the DLM due to the change of the node status.
RCL_IndPri	This parameter specifies the priority with VLAN of the requested RCL frames for the DLM due to the change of the node status.
RCL_IndPort	This parameter specifies the transmission port of the requested RCL frames for the DLM due to the change of the node status.
Node_ST	This parameter contains the node status (ISL/EGA/EGB/ITM) for the DLM due to the change of the node status.
PortA_ST	This parameter contains the status of port A on own node for the DLM due to the change of the node status.
PortB_ST	This parameter contains the status of port B on own node for the DLM due to the change of the node status.

7.2.3 RCLC state machine

7.2.3.1 RHE state machine of port A and B (RHE_SM-A/RHE_SM-B)

The RHE state machine is used to confirm the link status of communication with the neighboring node. There are two state machines on a node, one for port A (RHE_SM-A) and one for port B (RHE_SM-B). The state is updated when RHE is received and the link state between the node and the neighboring node is confirmed. These state machines have the following states.

- No_Neighborhood: The node does not connect to the neighboring node nor does it receive the RHE frame from the neighboring node.
- Wait_Linkup: The node waits to link up with the neighboring node. Although this state is “link up” status in ISO/IEC/IEEE 8802-3, the node should not communicate by any frames except the RHE frame to the neighboring node.
- Port_Linkup: The node can communicate using any ISO/IEC/IEEE 8802-3 frame to the neighboring node.

7.2.3.1.1 State machine RHE_SM-A

Figure 10 shows the state diagram of RHE_SM-A, and Table 22 is the state table of port A.

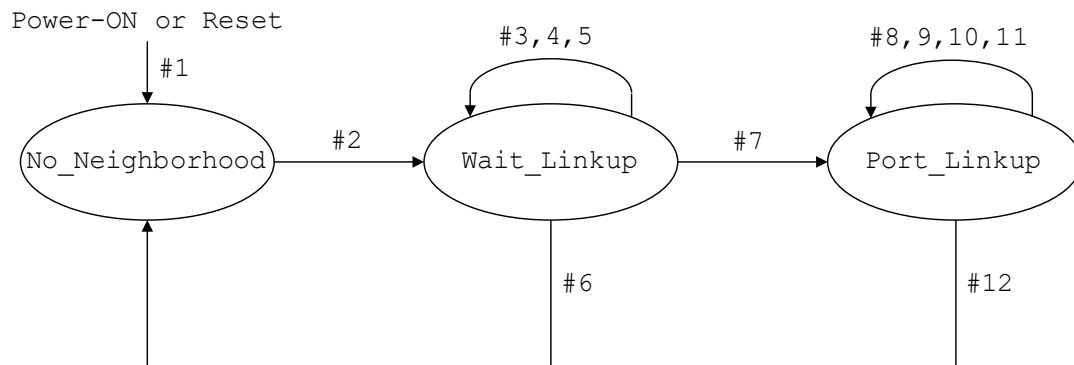


Figure 10 – State transition diagram of RHE_SM-A

Table 22 – Transitions of RHE_SM-A at RCL communication

#	Current state	Event /condition => actions	Next state
1	Any states	Power-ON or Reset => V(PA_STATUS) = NNB V(PA_NBST_LKST) = NNB V(PA_NBST_NDST) = ISL V(PA_NBST_RCLADD) = 0 C(PA_RHE_LKUP) = 0 V(PA_RHE_RxSeq) = 0 C(PA_RHE_RxCK) = 0 START_TIMER(T(PA_RHE_TIME), V(PA_RHE_CYCLE))	No_Neighborhood
2	No_Neighborhood	RCLC-Rx.ind{D_add,S_add,Rx_port, Frame_pri,RCL_type,DLSDU} /RCL_type == RHE && Rx_port == A => V(PA_STATUS) = WLU C(PA_RHE_LKUP) = 1 C(PA_RHE_RxCK) = P(RHE_RxCK_NUM) V(PA_NBST_RCLADD) = S_add V(PA_RHE_RxSeq) = UPDATE_RHESeq(DLSDU)	Wait_Linkup

#	Current state	Event /condition => actions	Next state
3	Wait_Linkup	RCLC-Rx.ind{D_add,S_add,Rx_port, Frame_pri,RCL_type,DLSDU} /RCL_type == RHE && Rx_port == A && (V(PA_NBST_RCLADD) != S_add (V(PA_RHE_RxSeq)+1) != RHE_Seq) => C(PA_RHE_LKUP) = 1 C(PA_RHE_RxCK) = P(RHE_RxCK_NUM) V(PA_NBST_RCLADD) = S_add V(PA_RHE_RxSeq) = UPDATE_RHESeq(DLSDU)	Wait_Linkup
4	Wait_Linkup	RCLC-Rx.ind{D_add,S_add,Rx_port, Frame_pri,RCL_type,DLSDU} /RCL_type == RHE && Rx_port == A && V(PA_NBST_RCLADD) == S_add && V(PA_RHE_RxSeq)+1 == RHE_Seq => C(PA_RHE_LKUP)++ C(PA_RHE_RxCK) = P(RHE_RxCK_NUM) V(PA_RHE_RxSeq) = UPDATE_RHESeq(DLSDU)	Wait_Linkup
5	Wait_Linkup	EXPIRED_TIMER(T(PA_RHE_TIME)) == "True" => C(PA_RHE_RxCK)--	Wait_Linkup
6	Wait_Linkup	/C(PA_RHE_RxCK) == 0 => V(PA_STATUS) = NNB C(PA_RHE_LKUP) = 0 V(PA_NBST_RCLADD) = 0 V(PA_RHE_RxSeq) = 0 V(PA_NBST_LKST) = NNB V(PA_NBST_NDST) = ISL	No_Neighborhood
7	Wait_Linkup	/C(PA_RHE_LKUP) == P(RHE_LKUP_NUM) => V(PA_STATUS) = PLU C(PA_Rx-RHE_NotMatch) = 0 V(PA_NBST_LKST) = UPDATE_LKST(DLSDU) V(PA_NBST_NDST) = UPDATE_NDST(DLSDU)	Port_Linkup
8	Port_Linkup	RCLC-Rx.ind{D_add,S_add,Rx_port, Frame_pri,RCL_type,DLSDU} /RCL_type == RHE && Rx_port == A && V(PA_NBST_RCLADD) != S_add => C(PA_Rx-RHE_NotMatch)++	Port_Linkup

#	Current state	Event /condition => actions	Next state
9	Port_Linkup	RCLC-Rx.ind{D_add,S_add,Rx_port, Frame_pri,RCL_type,DLSDU} /RCL_type == RHE && Rx_port == A && V(PA_NBST_RCLADD) != S_add && C(PA_Rx- RHE_NotMatch) >= 1 => C(PA_Rx-RHE_NotMatch)++ C(PA_RHE_RxCK) = P(RHE_RxCK_NUM) V(PA_NBST_RCLADD) = S_add V(PA_NBST_LKST) = UPDATE_LKST(DLSDU) V(PA_NBST_NDST) = UPDATE_NDST(DLSDU) V(PA_RHE_RxSeq) = UPDATE_RHESeq(DLSDU)	Port_Linkup
10	Port_Linkup	RCLC-Rx.ind{D_add,S_add,Rx_port, Frame_pri,RCL_type,DLSDU} /RCL_type == RHE && Rx_port == A && V(PA_NBST_RCLADD) == S_add => C(PA_Rx-RHE_NotMatch) = 0 C(PA_RHE_RxCK) = P(RHE_RxCK_NUM) V(PA_NBST_LKST) = UPDATE_LKST(DLSDU) V(PA_NBST_NDST) = UPDATE_NDST(DLSDU) V(PA_RHE_RxSeq) = UPDATE_RHESeq(DLSDU)	Port_Linkup
11	Port_Linkup	EXPIRED_TIMER(T(PA_RHEcycle)) == "True" => C(PA_RHE_RxCK)--	Port_Linkup
12	Port_Linkup	/C(PA_RHE_RxCK) == 0 => V(PA_STATUS) = NNB C(PA_RHE_LKUP) = 0 V(PA_NBST_RCLADD) = 0 V(PA_RHE_RxSeq) = 0 V(PA_NBST_LKST) = NNB V(PA_NBST_NDST) = ISL	No_Neighborhood

7.2.3.1.2 State machine RHE_SM-B

Figure 11 shows the state diagram of RHE_SM-B, and Table 23 is the state table of port B.

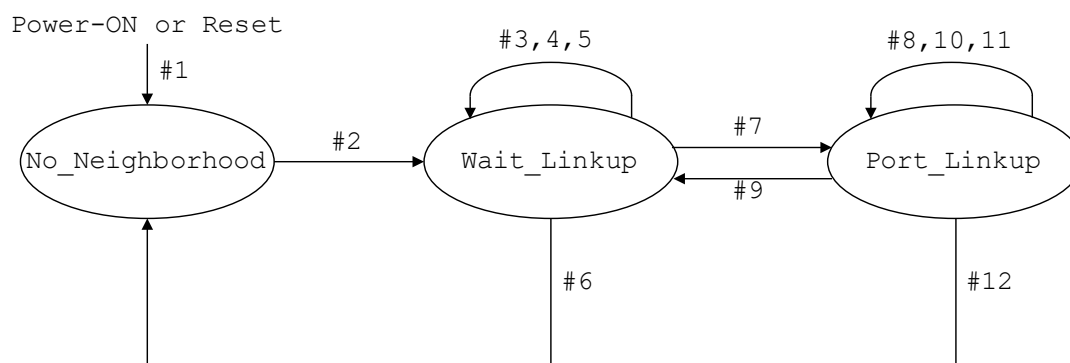


Figure 11 – State transition diagram of RHE_SM-B

Table 23 – Transitions of RHE_SM-B at RCL communication

#	Current state	Event /condition => actions	Next state
1	Any states	Power-ON or Reset => V(PB_STATUS) = NNB V(PB_NBST_LKST) = NNB V(PB_NBST_NDST) = ISL V(PB_NBST_RCLADD) = 0 C(PB_RHE_LKUP) = 0 V(PB_RHE_RxSeq) = 0 C(PB_RHE_RxCK) = 0 START_TIMER(T(PB_RHE_TIME), V(PB_RHE_CYCLE))	No_Neighborhood
2	No_Neighborhood	RCLC-Rx.ind{D_add,S_add,Rx_port, Frame_pri,RCL_type,DLSDU} /RCL_type == RHE && Rx_port == B => V(PB_STATUS) = WLU C(PB_RHE_LKUP) = 1 C(PB_RHE_RxCK) = P(RHE_RxCK_NUM) V(PB_NBST_RCLADD) = S_add V(PB_RHE_RxSeq) = UPDATE_RHESeq(DLSDU)	Wait_Linkup
3	Wait_Linkup	RCLC-Rx.ind{D_add,S_add,Rx_port, Frame_pri,RCL_type,DLSDU} /RCL_type == RHE && Rx_port == B && (V(PB_NBST_RCLADD) != S_add V(PB_RHE_RxSeq)+1 != RHE_Seq) => C(PB_RHE_LKUP) = 1 C(PB_RHE_RxCK) = P(RHE_RxCK_NUM) V(PB_NBST_RCLADD) = S_add V(PB_RHE_RxSeq) = UPDATE_RHESeq(DLSDU)	Wait_Linkup

#	Current state	Event /condition => actions	Next state
4	Wait_Linkup	RCLC-Rx.ind{D_add,S_add,Rx_port, Frame_pri,RCL_type,DLSDU} /RCL_type == RHE && Rx_port == B && V(PB_NBST_RCLADD) == S_add && V(PB_RHE_RxSeq)+1 == RHE_Seq => C(PB_RHE_LKUP)++ C(PB_RHE_RxCK) = P(RHE_RxCK_NUM) V(PB_RHE_RxSeq) = UPDATE_RHESeq(DLSDU)	Wait_Linkup
5	Wait_Linkup	EXPIRED_TIMER(T(PB_RHE_TIME)) == "True" => C(PB_RHE_RxCK)--	Wait_Linkup
6	Wait_Linkup	/C(PB_RHE_RxCK) == 0 => V(PB_STATUS) = NNB C(PB_RHE_LKUP) = 0 V(PB_NBST_RCLADD) = 0 V(PB_RHE_RxSeq) = 0 V(PA_NBST_LKST) = NNB V(PA_NBST_NDST) = ISL	No_Neighborhood
7	Wait_Linkup	/C(PB_RHE_LKUP) == P(RHE_LKUP_NUM) => V(PB_STATUS) = PLU C(PB_Rx-RHE_NotMatch) = 0 V(PB_NBST_LKST) = UPDATE_LKST(DLSDU) V(PB_NBST_NDST) = UPDATE_NDST(DLSDU)	Port_Linkup
8	Port_Linkup	RCLC-Rx.ind{D_add,S_add,Rx_port, Frame_pri,RCL_type,DLSDU} /RCL_type == RHE && Rx_port == B && V(PB_NBST_RCLADD) != S_add => C(PB_Rx-RHE_NotMatch)++	Port_Linkup

#	Current state	Event /condition => actions	Next state
9	Port_Linkup	RCLC-Rx.ind{D_add,S_add,Rx_port, Frame_pri,RCL_type,DLSDU} /RCL_type == RHE && Rx_port == B && V(PA_NBST_RCLADD) != S_add && C(PA_Rx- RHE_NotMatch) >= 1 => C(PB_Rx-RHE_NotMatch)++ C(PB_RHE_LKUP) = 1 C(PB_RHE_RxCK) = P(RHE_RxCK_NUM) V(PB_NBST_RCLADD) = S_add V(PB_NBST_LKST) = UPDATE_LKST(DLSDU) V(PB_NBST_NDST) = UPDATE_NDST(DLSDU) V(PB_RHE_RxSeq) = UPDATE_RHESeq(DLSDU)	Wait_Linkup
10	Port_Linkup	RCLC-Rx.ind{D_add,S_add,Rx_port, Frame_pri,RCL_type,DLSDU} /RCL_type == RHE && Rx_port == B && V(NBST_RCLADD) == S_add => C(PB_Rx-RHE_NotMatch) = 0 C(PB_RHE_RxCK) = P(RHE_RxCK_NUM) V(PB_NBST_LKST) = UPDATE_LKST(DLSDU) V(PB_NBST_NDST) = UPDATE_NDST(DLSDU) V(PB_RHE_RxSeq) = UPDATE_RHESeq(DLSDU)	Port_Linkup
11	Port_Linkup	EXPIRED_TIMER(T(PB_RHEcycle)) == "True" => C(PB_RHE_RxCK)--	Port_Linkup
12	Port_Linkup	/C(PB_RHE_RxCK) == 0 => V(PB_STATUS) = NNB C(PB_RHE_LKUP) = 0 V(PB_NBST_RCLADD) = 0 V(PB_RHE_RxSeq) = 0 V(PA_NBST_LKST) = NNB V(PA_NBST_NDST) = ISL	No_Neighborhood

7.2.3.2 RCL node status state machine (RCLNode_SM)

The RCLNode_SM selects an Edge-A node and an Edge-B node in the network. All of the nodes in Type 25 network use this state machine to decide the status of their own node.

The node controls the link status of ports by RCL_SM-A and RCL_SM-B. The RCLNode_SM uses these link status and informs other nodes in the network by RCL frames. All nodes in the network select an Edge-A node and an Edge-B node using this state machine. This state machine has the following states.

- Node_ISL: Isolated node state, port A and B are blocked.

- Edge-A_PLD: Edge-A physical link down state. At the state, the node is the Edge-A node, port A is link up, and port B is blocked due to physical factor for example not connected to the cable.
- Edge-A_LLD: Edge-B logical link down state. At the state, the node is the Edge-A node, port A is link up, port B is blocked, and the ring network is normal.
- Edge-B_PLD: Edge-B physical link down state.
- Edge-B_LLD: Edge-B logical link down state.
- Node_ITM: Intermediate node state. Ports A and B are link up.

Figure 12 and Table 24 show the state diagram and the state table of RCLNode_SM.

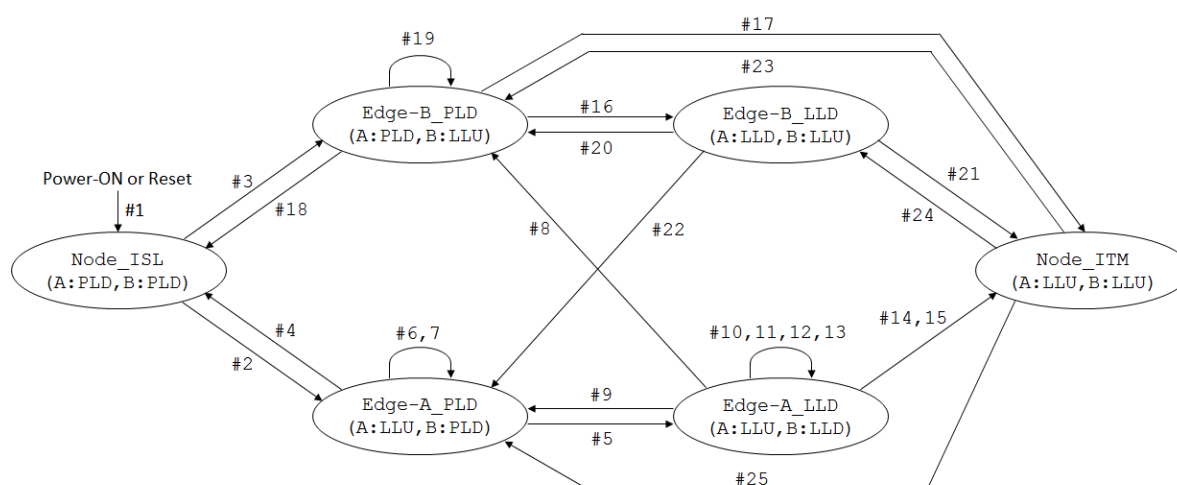


Figure 12 – The state diagram of RCLNode_SM

Table 24 – Transitions of RCLNode_SM at RCL communication

#	Current state	Event /condition => actions	Next state
1	Any states	Power-ON or Reset => Node_ST = ISL PortA_ST = PLD PortB_ST = PLD RCL_Indtype = LCN RCL_STOP.ind{RCL_Indtype} BLKport = A Blocking = True RCLC-SetPT.req{BLKport,Blocking} BLKport = B RCLC-SetPT.req{BLKport,Blocking} Node_ST.ind{Node_ST,PortA_ST,PortB_ST}	Node_ISL