

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Industrial communication networks – Fieldbus specifications –
Part 4-11: Data-link layer protocol specification – Type 11 elements**

**Réseaux de communication industriels – Spécifications des bus de terrain –
Partie 4-11: Spécification du protocole de la couche liaison de données –
Éléments de type 11**



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**Industrial communication networks – Fieldbus specifications –
Part 4-11: Data-link layer protocol specification – Type 11 elements**

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**INDUSTRIAL COMMUNICATION NETWORKS –
FIELDBUS SPECIFICATIONS –****Part 4-11: Data-link layer protocol specification –
Type 11 elements**

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

International Standard IEC 61158-4-11 has been prepared by subcommittee 65C: Industrial networks, of IEC technical committee 65: Industrial-process measurement, control and automation.

This third edition cancels and replaces the second edition published in 2010. This edition constitutes a technical revision.

The main changes with respect to the previous edition are addition in the loop (ring)-architecture. More details:

- Subclauses 4.6.1, 4.6.4 and 5.4.6, Clause 6 and 7.2 for the loop-architecture are modified to cover the additional specifications for the higher data rate in the loop-architecture;
- specifications for existing star-architecture are maintained as they are.

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

FDIS	Report on voting
65C/762/FDIS	65C/772/RVD

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

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

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

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

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- withdrawn;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

INTRODUCTION

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

The data-link protocol provides the data-link service by making use of the services available from the physical layer. The primary aim of this standard is to provide a set of rules for communication expressed in terms of the procedures to be carried out by peer 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 implementors 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 standard is concerned, in particular, with the communication and interworking of sensors, effectors and other automation devices. By using this standard together with other standards positioned within the OSI or fieldbus reference models, otherwise incompatible systems may work together in any combination.

Attention is drawn to the fact that 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 patents concerning Type 11 elements and possibly other types given in 4.2, 4.4, 4.5, 5.4, 6.2 to 6.10, 7.1 and 7.2 as follows:

AU 2007320662(B2) [TO] Double ring network system, communication control method thereof, transmission station, and communication control program of double ring network system

ZL 200780042584.7 [TO] Double ring network system, communication control method thereof, transmission station, and communication control program of double ring network system

JP 4991254(B2) [TO] Control method for double-ring network, initializing method for double-ring network, transmission station of double-ring network, restructuring method for abnormality occurrence of double-ring network, network system, control method for network system, transmission station, and program of transmission station

KR 101149837(B1) [TO] Double ring network system, communication control method thereof, transmission station, and communication control program of double ring network system

RU 2420899(C2) [TO] Double-ring network system and method of controlling communication in said network, transmission station and programme for transmission stations

US 8411559(B2) [TO] Double ring network system and communication control method thereof, and transmission station, and program for transmission stations

EP 2093942(A1) [TO] Double ring network system, communication control method thereof, transmission station, and communication control program of double ring network system

US 6711131(B1) [TO] Data transmitting apparatus, network interface apparatus, and data transmitting system

JP 3461954(B2) [TO] Data transmitter

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INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 4-11: Data-link layer protocol specification – Type 11 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 standard 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 data-link 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 standard ISO/IEC 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 standard, 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 capabilities, and thus its applicability to various time-critical communications needs.

1.5 Conformance

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

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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.

IEC 61158-3-11:2007, *Industrial communication networks – Fieldbus specifications – Part 3-11: Data-link layer service definition – Type 11 elements*

IEC 61158-5-11:2007, *Industrial communication networks – Fieldbus specifications – Part 5-11: Application layer service definition – Type 11 elements*

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

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

ISO/IEC 8802-3:2000, *Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications*

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

3 Terms, definitions, symbols and abbreviations

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

3.1 Reference model terms and definitions

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

3.1.1	called-DL-address	[ISO/IEC 7498-3]
3.1.2	calling-DL-address	[ISO/IEC 7498-3]
3.1.3	centralized multi-end-point-connection	[ISO/IEC 7498-1]
3.1.4	correspondent (N)-entities correspondent DL-entities (N=2) correspondent Ph-entities (N=1)	[ISO/IEC 7498-1]
3.1.5	demultiplexing	[ISO/IEC 7498-1]
3.1.6	DL-address	[ISO/IEC 7498-3]
3.1.7	DL-address-mapping	[ISO/IEC 7498-1]
3.1.8	DL-connection	[ISO/IEC 7498-1]
3.1.9	DL-connection-end-point	[ISO/IEC 7498-1]
3.1.10	DL-connection-end-point-identifier	[ISO/IEC 7498-1]
3.1.11	DL-connection-mode transmission	[ISO/IEC 7498-1]
3.1.12	DL-connectionless-mode transmission	[ISO/IEC 7498-1]
3.1.13	DL-data-sink	[ISO/IEC 7498-1]
3.1.14	DL-data-source	[ISO/IEC 7498-1]
3.1.15	DL-duplex-transmission	[ISO/IEC 7498-1]
3.1.16	DL-facility	[ISO/IEC 7498-1]
3.1.17	DL-local-view	[ISO/IEC 7498-3]
3.1.18	DL-name	[ISO/IEC 7498-3]
3.1.19	DL-protocol	[ISO/IEC 7498-1]
3.1.20	DL-protocol-connection-identifier	[ISO/IEC 7498-1]
3.1.21	DL-protocol-control-information	[ISO/IEC 7498-1]
3.1.22	DL-protocol-data-unit	[ISO/IEC 7498-1]
3.1.23	DL-protocol-version-identifier	[ISO/IEC 7498-1]
3.1.24	DL-relay	[ISO/IEC 7498-1]
3.1.25	DL-service-connection-identifier	[ISO/IEC 7498-1]
3.1.26	DL-service-data-unit	[ISO/IEC 7498-1]
3.1.27	DL-simplex-transmission	[ISO/IEC 7498-1]
3.1.28	DL-subsystem	[ISO/IEC 7498-1]
3.1.29	DL-user-data	[ISO/IEC 7498-1]
3.1.30	flow control	[ISO/IEC 7498-1]
3.1.31	layer-management	[ISO/IEC 7498-1]
3.1.32	multiplexing	[ISO/IEC 7498-1]

3.1.33	naming-(addressing)-authority	[ISO/IEC 7498-3]
3.1.34	naming-(addressing)-domain	[ISO/IEC 7498-3]
3.1.35	naming-(addressing)-subdomain	[ISO/IEC 7498-3]
3.1.36	(N)-entity DL-entity Ph-entity	[ISO/IEC 7498-1]
3.1.37	(N)-interface-data-unit DL-service-data-unit (N=2) Ph-interface-data-unit (N=1)	[ISO/IEC 7498-1]
3.1.38	(N)-layer DL-layer (N=2) Ph-layer (N=1)	[ISO/IEC 7498-1]
3.1.39	(N)-service DL-service (N=2) Ph-service (N=1)	[ISO/IEC 7498-1]
3.1.40	(N)-service-access-point DL-service-access-point (N=2) Ph-service-access-point (N=1)	[ISO/IEC 7498-1]
3.1.41	(N)-service-access-point-address DL-service-access-point-address (N=2) Ph-service-access-point-address (N=1)	[ISO/IEC 7498-1]
3.1.42	peer-entities	[ISO/IEC 7498-1]
3.1.43	Ph-interface-control-information	[ISO/IEC 7498-1]
3.1.44	Ph-interface-data	[ISO/IEC 7498-1]
3.1.45	primitive name	[ISO/IEC 7498-3]
3.1.46	reassembling	[ISO/IEC 7498-1]
3.1.47	recombining	[ISO/IEC 7498-1]
3.1.48	reset	[ISO/IEC 7498-1]
3.1.49	responding-DL-address	[ISO/IEC 7498-3]
3.1.50	routing	[ISO/IEC 7498-1]
3.1.51	segmenting	[ISO/IEC 7498-1]
3.1.52	sequencing	[ISO/IEC 7498-1]
3.1.53	splitting	[ISO/IEC 7498-1]
3.1.54	synonymous name	[ISO/IEC 7498-3]
3.1.55	systems-management	[ISO/IEC 7498-1]

3.2 Service convention terms and definitions

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

- 3.2.1 **acceptor**
- 3.2.2 **asymmetrical service**
- 3.2.3 **confirm (primitive);
requestor.deliver (primitive)**
- 3.2.4 **deliver (primitive)**
- 3.2.5 **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 **DL-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**

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

3.3.1 **common memory**

virtual common memory over Type 11 fieldbus, which is shared by participating Type 11 fieldbus nodes and is primarily used for real-time communications by the time-critical cyclic data service

3.3.2 **data DLPDU**

DLPDU that carries a DLSDU from a local DLS-user to a remote DLS-user

3.3.3

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

3.3.4

DL-segment, link, local link

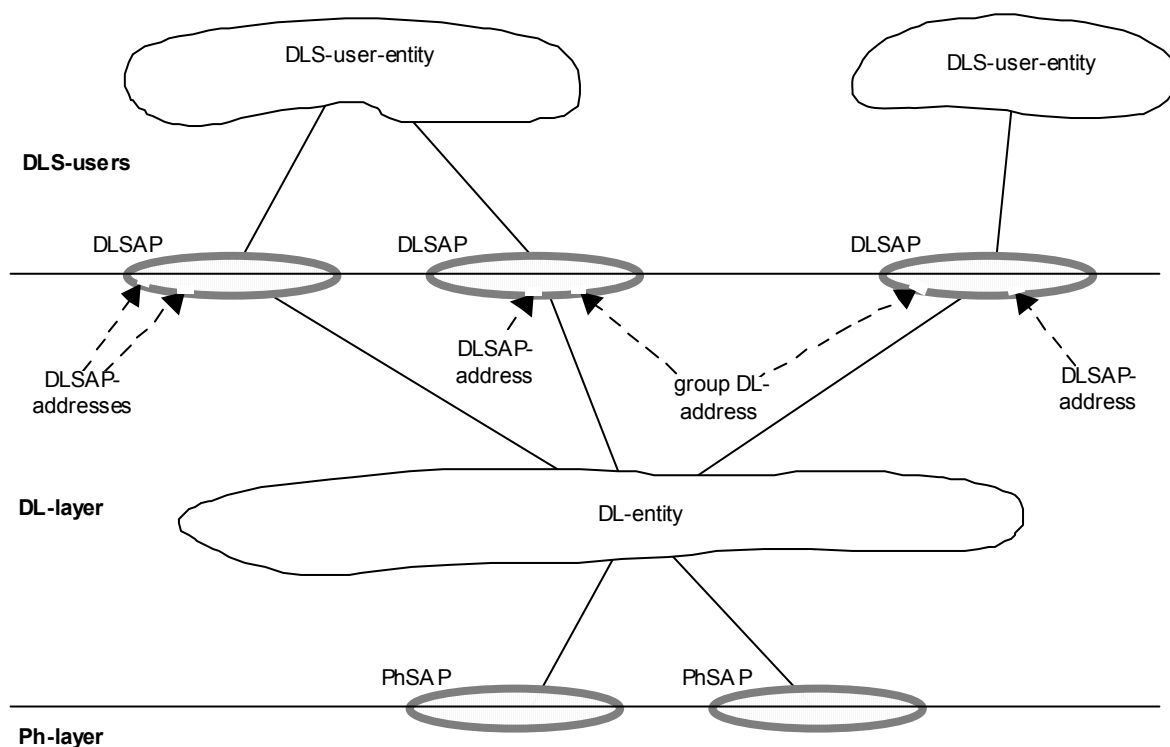
single DL-subnetwork in which any of the connected DLEs may communicate directly, without any intervening DL-relaying, whenever all of those DLEs that are participating in an instance of communication are simultaneously attentive to the DL-subnetwork during the period(s) of attempted communication

3.3.5

DLSAP

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

Note 1 to entry: This definition, derived from ISO/IEC 7498-1, is repeated here to facilitate understanding of the critical distinction between DLSAPs and their DL-addresses. (See Figure 1).



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

3.3.6**DLSAP**

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

Note 1 to entry: This definition, derived from ISO/IEC 7498-1, is repeated here to facilitate understanding of the critical distinction between DLSAPs and their DL-addresses. (See Figure 1).

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 can 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

Note 1 to entry: An extended link can be composed of just a single link.

3.3.10**FCS error**

error that occurs when the computed frame check sequence value after reception of all the octets in a DLPDU does not match the expected residual

3.3.11**frame**

denigrated synonym for DLPDU

3.3.12**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.

Note 2 to entry: A single DL-entity also may have a single group DL-address associated with more than one DLSAP.

3.3.13**high-speed cyclic data**

data conveyed by means of high-speed cyclic data transmission

3.3.14**high-speed cyclic data transmission**

highest priority of time-critical cyclic data service

3.3.15

implicit token

mechanism that governs the right to transmit

Note 1 to entry: No actual token message is transmitted on the medium. Each node keeps track of the node that it believes currently holds the right to transmit. The right to transmit is passed from node to node by keeping the node that last transmitted. A slot time is used to allow a missing node to be skipped in the rotation.

3.3.16

low-speed cyclic data

data conveyed by means of low-speed cyclic data transmission

3.3.17

low-speed cyclic data transmission

lowest priority of time-critical cyclic data service

3.3.18

medium-speed cyclic data

data conveyed by means of medium-speed cyclic data transmission

3.3.19

medium-speed cyclic data transmission

second-highest priority of time-critical cyclic data service

3.3.20

multi-peer DLC

centralized multi-end-point DL-connection offering DL-duplex-transmission between a single distinguished DLS-user known as the publisher or publishing DLS-user, and a set of peer but undistinguished DLS-users known collectively as the subscribers or subscribing DLS-users

Note 1 to entry: The publishing DLS-user can send to the subscribing DLS-users as a group (but not individually), and the subscribing DLS-users can send to the publishing DLS-user (but not to each other).

3.3.21

multipoint connection

connection from one node to many nodes

Note 1 to entry: Multipoint connections allows data transfer from a single publisher to be received by many subscriber nodes.

3.3.22

node

single DL-entity as it appears on one local link

3.3.23

node DL-address

DL-address which designates the (single) DL-entity associated with a single node on a specific local link

3.3.24

node-id

two-octet primary identifier for the DLE on the local link, whose values are constrained

Note 1 to entry: A permissible value is from 1 to 255. A value 0 is specifically used for SYN node, which emits SYN frame.

3.3.25

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

3.3.26**sending DLS-user**

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

3.3.27**slot-time**

512-bit time and 4 096-bit time of the physical signaling symbol for the data rate of 100 Mbps and 1 000 Mbps respectively specified in the ISO/IEC 8802-3:2000, Clause 29

3.3.28**sporadic message data service**

aperiodic message transfer which sporadically occurs upon DLS-user requesting one or more message to transfer, and regular ISO/IEC 8802-3 Ethernet message frame is transferred by means of this message transfer

3.3.29**SYN node**

node transmitting SYN frame

3.3.30**time-critical cyclic data service**

cyclic data transfer with three levels of data transmission at the same time, of which each data transmission level is according to the data priority and the data transmission period for real-time delivery, and of which data transmission period and total data volume for each level can be specified in designing phase and on application needs

3.3.31**token**

right to transmit on the local link

3.4 Symbols and abbreviations

ACM	Access control machine
CLM	Claim frame
CMP	Transmission complete frame
CTRC	Cyclic-transmission TX/RX control
COM	Command frame
DT	Cyclic data frame
CW	Control word (as parameter of SYN DLPDU)
DT-CMP	DT with transmission complete frame
FC	Frame control field
LL	Live list (as parameter of SYN DLPDU)
Mbps	Million bits per second
PhIDU	Ph-interface-data-unit

PM	Periodic mode (as parameter of SYN DLPDU)
PN	Transmission permits node number (as parameter of SYN DLPDU)
Pri	Priority field
RAS	RAS frame
REC	In-ring request frame
RMC	Redundancy medium control
RMSEL	Redundant medium selection
RN	Recipient node number
SN	Source node number field
ST	Slot time (as parameter of SYN DLPDU)
SYN	Synchronization frame
Th	High-speed transmission period (as transmission period)
Tm	Medium-speed transmission period (as transmission period)
Ts	Sporadic-speed transmission period (as transmission period)
Tl	Low-speed transmission period (as transmission period)

4 Overview of the DL-protocol

4.1 General

This standard meets the industrial automation market objective of providing predictable time deterministic and reliable time-critical data transfer and means, which allow co-existence with non-time-critical data transfer over the ISO/IEC 8802-3 series communications media, for support of cooperation and synchronization between automation processes on field devices in a real-time application system. 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.

4.1.1 Field of applications

In industrial control systems, several kinds of field devices such as Drives, Sensors and Actuators, Programmable controllers, Distributed Control Systems and Human Machine Interface devices are required to be connected with control networks. The process control data and the state data is transferred among these field devices in the system and the communications between these field devices requires simplicity in application programming and to be executed with adequate response time. In most industrial automation systems such as food, water, sewage, paper and steel, including a rolling mill, the control network is required to provide time-critical response capability for their application, as required in ISO/TR 13283 for time-critical communications architectures.

Plant production may be compromised due to errors, which could be introduced to the control system if the network does not provide a time-critical response. Therefore, the following characteristics are required for a time-critical control network:

- deterministic response time between the control device nodes;
- ability to share process data seamlessly across the control system.

This protocol is applicable to such an industrial automation environment, in which time-critical communications is primarily required. 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.

4.2 Overview of the medium access control

The Type 11 fieldbus has a deterministic medium access control in order to avoid collisions that occur when a number of the nodes send data frames simultaneously, and to provide the opportunity of sending data to each node in a sequential order and within a predetermined time period. Figure 2 shows the basic principle of medium access control of the Type 11 fieldbus.

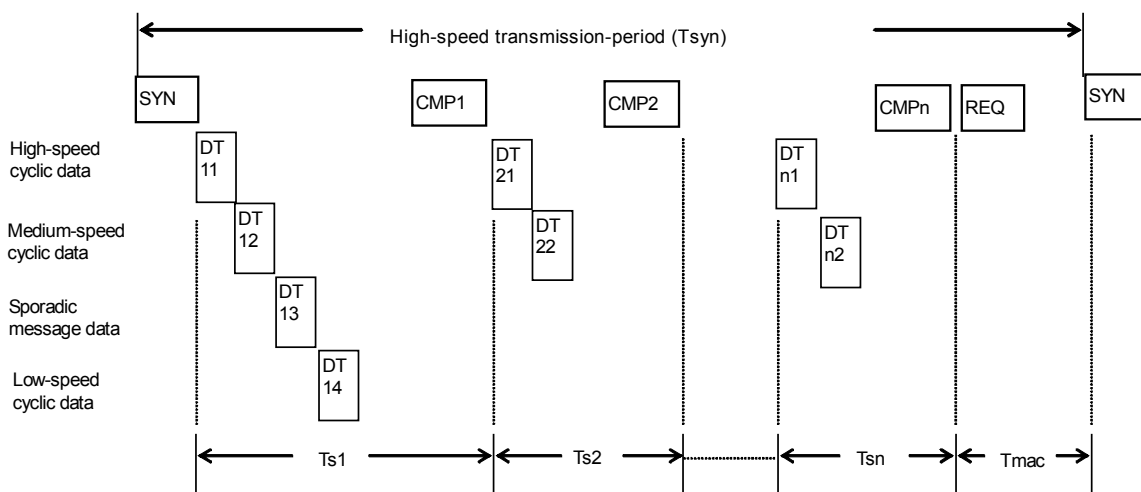


Figure 2 – Basic principle of medium access control

At the start time of every high-speed-transmission-period (T_{syn}), the SYN frame is broadcasted to all nodes. Receiving the SYN frame, the node with sequential number 1 starts sending its data frames, and after that broadcasts its CMP frame in order to indicate the completion of its data frames transmission. The Nth node can send out its data frames after receiving the CMP frame from the (N-1) node. After all the nodes send their data frames, the time period to solicit new nodes begins. The REQ frame is used for a new node requesting inclusion to the Type 11 fieldbus network. The sequential number is assigned to a new node at the time approval to join is granted.

Each node can hold the transmission right for a preset time and shall send its CMP frame to transfer the transmission right to the next node within the preset time. The data to be sent and the data to be held over are determined by priority.

Transmission includes Time-critical cyclic data and sporadic Ethernet message transmission. Cyclic data transmission is divided into High-, Medium- and Low-speed data transmission. Each node sends the High-speed cyclic data frames on each occasion when it obtains the transmission right. The data of lower priorities, that is the Medium-speed cyclic data, the sporadic Ethernet message data and the Low-speed cyclic data respectively, is sent only when the High-speed cyclic data transmission is completed.

sent depending on the circumstances. The holding time of the transmission right of each node is determined by the settings of the High-speed cyclic, the Medium-speed cyclic, the sporadic Ethernet message and the Low-speed cyclic data transmission periods and by the volume of transmission data for each node. After sending all the High-speed cyclic data, the node sends the Medium-speed cyclic data. If the holding time of the transmission right ends during sending the Medium-speed cyclic data, the transmission of the Medium-speed cyclic data is interrupted, and the CMP frame is sent. The n^{th} node obtains the transmission right again during the next High-speed data transmission period, during which time all the High-speed cyclic data and the remainder of the previous Medium-speed cyclic data is sent. Tmac is the period for a new node sending out REQ frame to enter the network.

Two kinds of the architecture, that are the star- and the loop-architecture, are specified in 4.4. Particularly in the loop-architecture the order of priority for the sporadic Ethernet message data and the Low-speed cyclic data changes with the capability for sending out the Low-speed cyclic data in the 100 Mbps and the 1 000 Mbps operation. The order of priority for the sporadic Ethernet message data is of the lowest, and the Low-speed cyclic data is not capable in the 100 Mbps operation.

4.3 Service assumed from the PhL

4.3.1 General

Subclause 4.3 describes the assumed Physical Service (PhS) and the constraints on use by the Type 11 DLE. The Physical Service is assumed to provide the following service primitives specified by ISO/IEC 8802-3:2000, Clause 6.

4.3.2 Assumed primitives of PhS

The PhS is assumed to provide the following two categories of primitives to the Type 11 DL-protocol.

- service primitives for transmitting and receiving frames to / from other peer DLEs;
- service primitives that provide information needed by the local DLE to perform the media access functions.

The assumed primitives of PhS are grouped into these two categories:

- a) Transfer of Data to all other peer DLE:
 - PLS_DATA request;
 - PLS_DATA indication;
- b) Media access management by local DLE:
 - PLS_CARRIER indication;
 - PLS_SIGNAL indication;
 - PLS_DATA_VALID indication.

The interaction of the PhS primitives to the DLE is shown in Figure 3.

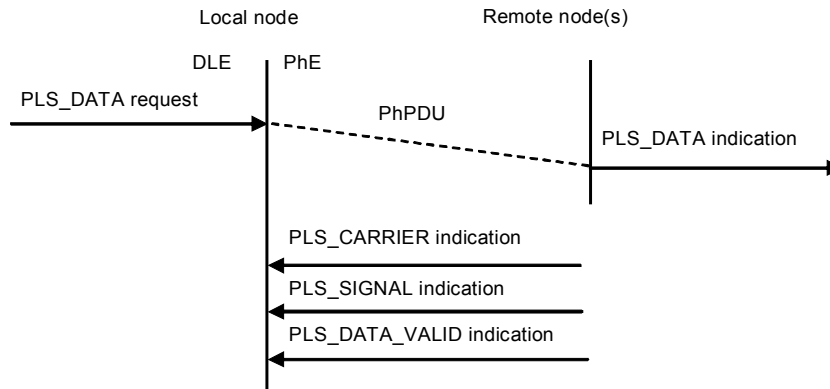


Figure 3 – Interaction of PhS primitives to DLE

4.4 DLL architecture

4.4.1 Overview

The Type 11 fieldbus DLL is modeled as a combination of control components of Access Control Machine (ACM), Cyclic transmission TX/RX Control (CTRC), Sporadic TX/RX Control (STRC), Redundancy Medium Control (RMC), Serializer, Deserializer and DLL management interface.

The Access Control Machine as the primary control component provides the function for deterministic medium access control cooperating with the Cyclic-transmission TX/RX Control, the Sporadic TX/RX Control and the Redundancy Medium Control for reliable and efficient support of higher-level connection-mode and connectionless data transfer services. Specifically the Access Control Machine has the primary responsibility for

- assuring that the local node detects and fully utilizes its assigned access time period;
- assuring that the local node does not interfere with the transmissions of other nodes, especially of the node transmitting the SYN frame;
- detecting network disruption, and initiating the SYN frame transmission for restoration of the network disruption from after prescribed time duration in which the SYN frame is not heard;
- assuring a new node adding to and removing from the network.

The DLL management interface provides DLL management functions. PhL framing and delimiters are managed by DLL functions for serializing and deserializing M_symbol requests and indications.

4.4.2 Star-architecture

The Data-link layer is comprised of the components listed in Table 1. The internal arrangement of these components, and their interfaces, are shown in Figure 4. The arrowheads illustrate the primary direction of flow of data and control.

Table 1 – Data-link layer components of star-architecture

Components	Description
Access control machine (ACM)	Deterministic medium access control and scheduling the opportunities to sending out the DLPDUs, control for adding and removing nodes, restoration from disruption. Assembles and transmits the DLPDUs to the TX framer through the RMC, receives and disassembles the DLPDUs with the control information from the RMC, and determines the timing and duration of the transmissions. Signals the RMC to sending out the DLPDUs for control and diagnosis of the Type 11 fieldbus. Buffers and dispatches in time the DLPDUs received between the DLS-user and the RMC
Cyclic transmission TX/RX control (CTRC)	Buffers and dispatches in time DLSDU received for the time-critical cyclic data transfer between the DLS-user and the ACM
Sporadic TX/RX control (STRC)	Buffers and dispatches in time DLSDU received for the Sporadic message data between DLS-user and the ACM
Redundancy medium control (RMC)	Receives the DLPDUs from the ACM and breaks them down into octet symbol requests to the Octet serializer, assembles received octets from the Octet deserializer into DLPDUs and submits them to the ACM. Selects one of two outputs of the Octet deserializers through the RX framers for medium redundancy
TX/RX framer	Receives the octet symbols from the RMC, detects and indicates the start timing of a DLPDU to the Octet serializer, passes received octets from the Octet deserializer and indicates the start timing of a DLPDU to the RMC
Octet serializer	Receives octet symbols, encodes and serializes them, and sends them as M_symbols to the PhL. It is also responsible for generating the FCS
Octet deserializer	Receives M_symbols from the PhL, converts M_symbols into octets and sends them to the RX framer. It is also responsible for checking the FCS
DLL management interface	Holds the station management variables that belong to the DLL, and manages synchronized changes of the link parameters

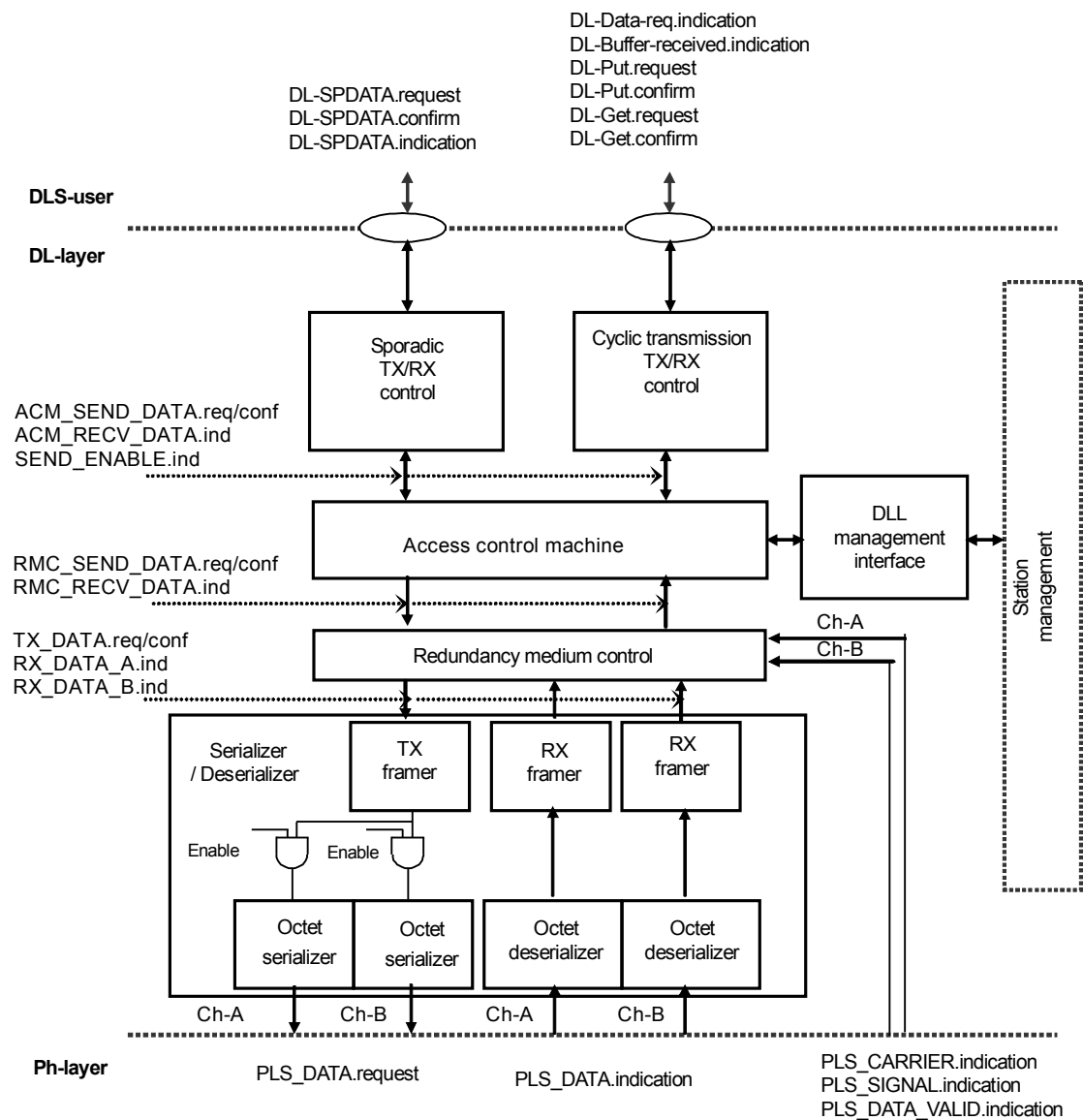


Figure 4 – Data-link layer internal architecture of star-architecture

4.4.3 Loop-architecture

The Data-link layer is comprised of the components listed in Table 2. The internal arrangement of these components, and their interfaces, are shown in Figure 5. The arrowheads illustrate the primary direction of flow of data and control.

Table 2 – Data-link layer components of loop-architecture

Components	Description
Access control machine (ACM)	Deterministic medium access control and scheduling the opportunities to sending out the DLPDUs, control for adding and removing nodes, restoration from disruption. Assembles and transmits the DLPDUs to the TX framer through the RMC, receives and disassembles the DLPDUs with the control information from the RMC, and determines the timing and duration of the transmissions. Signals the RMC to sending out the DLPDUs for control and diagnosis of the Type 11 fieldbus. Buffers and dispatches in time the DLPDUs received between the DLS-user and the RMC
Cyclic transmission TX/RX control (CTRC)	Buffers and dispatches in time DLSDU received for the time-critical cyclic data transfer between the DLS-user and the ACM
Sporadic TX/RX control (STRC)	Buffers and dispatches in time DLSDU received for the Sporadic message data between DLS-user and the ACM
Redundancy medium control (RMC)	Receives the DLPDUs from the ACM and breaks them down into the octet-symbol requests to the TX-framer, assembles received-octets from the RX-framers into the DLPDUs, selects one of two outputs from the RX-framers and submits them to the ACM. Receives the signal from the ACM and activates the transmission of the DLPDU frames for control and diagnosis of the Type 11 fieldbus
TX/RX framer	TX framer receives the octet-symbols from the RMC, detects and indicates the start timing of a DLPDU to the Octet-serializer, forwards received-octets from the Octet-deserializer connected to a Ring-port to other Octet-serializer connected to other Ring-port. RX framer passes received-octets from the Octet-deserializer and indicates the start-delimiter of a DLPDU to the RMC
Octet serializer	Receives octet symbols, encodes and serializes them, and sends them as M_symbols to the PhL. It is also responsible for generating the FCS
Octet deserializer	Receives M_symbols from the PhL, converts M_symbols into octets and sends them to the RX framer and the TX framer. It is also responsible for checking the FCS
DLL management interface	Holds the station management variables that belong to the DLL, and manages synchronized changes of the link parameters



The ACM functions schedule all communications between the DLEs participating in the Type 11 fieldbus, and the timing of this communications is controlled as to

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- c) provide sporadic message data transfer opportunities of sending out to node that the request to transfer is happened sporadically by the DLS-user, and the data transfer is performed in pre-specified time period of the corresponding level of priority and is based on regular ISO/IEC 8802-3 applications.

Accurate scheduling timing is very important to support many control and data collection tasks in the applications domain of this protocol.

4.6 Local parameters, variables, counters, timers and queues

4.6.1 Overview

4.6.1.1 General

This standard uses DLS-user request parameters P(...) and local variables V(...) as a means of clarifying the effect of certain actions and the conditions under which those actions are valid, local timers T(...) 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(...) for performing rate measurement functions. It also uses local queues Q(...) as a means of ordering certain activities, of clarifying the effects of certain actions, and of clarifying the conditions under which those activities are valid.

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;
- d) all queues shall be initialized to empty.

DL-management may change the values of configuration variables.

4.6.1.2 Summary of variables, parameters, counters, timers for star-architecture

Table 3 and Table 4 summarize the variables and their usage.

The data types used in the data link variables, parameters, state machines are specified in IEC 61158-5-11, Clause 5. The most significant bit of the most significant octet is always used as the most significant bit of the binary number. The bits of each octet are numbered 0 to 7, where bit 0 is the least significant bit of the octet. Each octet is transferred to the Ph layer low-bit first and multiple octets is transferred low-order octet first (little endian format).

Table 3 – DLE-variables and permissible values of star-architecture

Variable -name	Description	Permissible values	Data type
BW	Length of TCC data word in a DLPDU	The default value is 128 (octets). See 4.6.2.7	UINT
DR	Data-rate	The default value is 100 (Mbps). See 4.6.2.11	UINT
HTh	Maximum observational time period for detecting the continuous high-speed transmission cycle disrupted	2 to $2^{16}-1$ (in units of 1 ms). The default value is $3 \times V(Th)$. See 4.6.2.12	UDINT
HTI	Maximum observational time period for detecting the continuous low-speed transmission cycle disrupted	2 to $2^{16}-1$ (in units of 1 ms). The default value is $3 \times V(Th)$. See 4.6.3.5	UDINT
HTm	Maximum observational time period for detecting the continuous medium-speed transmission cycle disrupted	2 to $2^{16}-1$ (in units of 1 ms). The default value is $3 \times V(Th)$. See 4.6.2.14	UDINT
IA	Individual address of this node	Individual 48-bit address identical to ISO/IEC 8802-3. See 4.6.2.16	USINT[6]
IGP	Time interval from the end of a previous frame to the start of the consecutive frame sent by a node	The default value is 24 (0,96 μ s in units of 0,04 μ s). See 4.6.2.17	UDINT
IP	IP address of this node	32-bit address identical to IPv4. See 4.6.2.18	USINT[4]
MD	Maximum distance on the connection path between any 2 nodes	1 to 100 (km). The default value is 8. See 4.6.2.21	UINT
MDD	Maximum difference of the distance of two redundant physical mediums on the connection path between any 2 nodes	0 to 2 000 (in m). The default value is 500. See 4.6.3.7	UINT
MGA	Multicast group address	Multicast 48-bit address identical to ISO/IEC 8802-3, for logically associated Type 11 fieldbus nodes. The default value is 0x01-0x00-0x5e-0x50-0x00-0x01. See 4.6.2.22	USINT[6]
MN	Maximum node number	254 (default value). See 4.6.2.23	USINT
MPD	Maximum difference of the signal delay time propagating over two redundant physical mediums on the connection path between any 2 nodes	1 to 0x7c (in units of 0,04 μ s). The default value is 0x7c ($\approx 5 \mu$ s). See 4.6.3.8	UDINT
MRT	Maximum number of the repeater units on the connection path between any 2 nodes	0 to 7. The default value is 3. See 4.6.2.24	UINT
MTHT	Maximum-token-hold-time for high-speed cyclic data transmission	1 to $2^{16}-1$ (octet times). The default value is 0x30B4 (= 900 μ s). See 4.6.2.25	UDINT
PBh	List of up to 2 048 data buffers using for sending out high-speed TCC data	1 to 2 048. See 4.6.2.28	UINT
PBI	List of up to 2 048 data buffers using for sending out low-speed TCC data	1 to 2 048. See 4.6.3.10	UINT
PBm	List of up to 2 048 data buffers using for sending out medium-speed time-critical cycle data	1 to 2 048. See 4.6.2.29	UINT
RCS	Receive-channel switching control for receiving frames. Designates the switching control for receiving frames out of one of two receive-channel A and B corresponding to each of the redundant media A and B	“Automatic”, “Force A”, “Force B” “Automatic”: Automatically switch to the proper receive-channel. “Force A”, “Force B”: Force to switch Receive-channel A or B respectively. The default is “Automatic”. See Table 10, Table 12, 4.6.3.12	BOOL
RMGP	Maximum time-interval for one receive-channel, which has already completed one frame received and has waited for IGP time, to wait for the completion of a frame to be received on the other receive-channel in order to detect the other receive-channel disrupted	250 (in units of 0,04 μ s). The value 250 represents 10 μ s. See 4.6.3.14	UDINT

Variable -name	Description	Permissible values	Data type
ST	The slot-time is the fundamentally observational time unit, used in the DLME for observing to initiate action such as re-initialization in sending out the CLM frame, and also used in the DLME for observing the CMP frame sent by the corresponding node, and in case that the node failed to send out, used in the DLME for initiating action just as the CMP frame is received	1 to 255 (in units of physical symbol times for 512 bits, identical to ISO/IEC 8802-3). The default value is 20 (= 100 µs). See Table 14, 4.6.2.38	USINT
SCMP	Medium-access-control-time for substitute CMP	1 to 255 (in units of physical symbol times for 512 bits, identical to ISO/IEC 8802-3). The default value is 20 (= 100 µs). See 4.6.2.31	USINT
SCMPL	Permissible repetitive count within which the node can behave like that the node received the CMP frame even though the corresponding node had failed to send out the CMP frame. The node determines the corresponding node is out of service if the count is over	1 to 16. The default value is 3. See 4.6.2.33	USINT
SEN _A SEN _B	Send enable control for sending frames out of the transmitter-A or –B	"True" / "Enable" or "False" / "Disable" The default value is "True" / "Enable". See 4.6.3.16	BOOL
Th	High-speed transmission period	1 to 160 (in units of 0,1 ms). See Table 15, 4.6.2.39	USINT[3]
Tl	Low-speed transmission period	1 to 10 000 (in units of 1 ms). See Table 18, 4.6.3.17	UINT
TISPD	Time-interval cyclically processed for Sporadic message data service	1 to 1 000 (in units of 1 ms). The default value is 100. See Table 17, 4.6.2.40, 4.6.2.41	UINT
Tm	Medium-speed transmission period	1 to 1 000 (in units of 1 ms). The default value is 100. See Table 16, 4.6.2.42	UINT
TMAC	Maximum observation time period for the SYN node to solicit new nodes into the Type 11 fieldbus	1 to 100 (in units of 0.1 ms). The default value is 100. See 4.6.2.43, 4.6.2.44	USINT
Tsl	DLE number able to send out next slot	1 to 255. See 4.6.2.46	USINT
TSYN	Target-periodic-time from SYN frame arrival to SYN frame arrival	1 to 160 (in units of 0,1 ms). See 4.6.2.47	UDINT
TTRT0	Target-token-rotation-time for access class 0	1 to 2 ¹⁶ -1 (octet time). The default value is P(TSYN). See 4.6.3.18	UDINT
TTRT1	Target-token-rotation-time for access class 1	1 to 2 ¹⁶ -1 (octet time). The default value is P(TSYN). See 4.6.2.48	UDINT
TTRT2	Target-token-rotation-time for access class 2	1 to 2 ¹⁶ -1 (octet time). The default value is P(TSYN). See 4.6.2.49	UDINT
TN	Node identifier number of the node. The initial value is 0 on power-up or reset	1 to 255. See 4.6.2.45	USINT

Table 4 – Observable variables and their value ranges of star-architecture

Variable -name	Description	Range of value	Data type
AIGP _A AIGP _B	IGP monitor over the receive-channel A and B	0 to 24, continuously decrementing. The value 24 represents 0,96 µs. See 4.6.3.1	UDINT
ARMGP	The observed time period for one receive-channel, which has already completed one frame received and has waited for IGP time (0,96 µs), to wait the completion of a frame received on the other receive-channel in order to detect the other receive-channel disrupted	0 to 250, continuously decrementing. The value 250 represents 10 µs. See 4.6.3.2	UDINT
ASCMP	Collection of counters of total number of nodes. Each counter corresponding to a node indicates observed repetitive count that the corresponding node failed to send out the CMP frame and the other node can behave like that the CMP frame received without error. The node determines the corresponding node is out of service when the count reaches the pre-specified number. The number counted is indicated and is incremented coincidentally at each DLME	1 to 16. The default value is equal to the value of SCMPL, which is 3. See 4.6.2.1	USINT
ATHT	The observed time period of the MTHT	0 to MTHT, continuously decrementing. See 4.6.2.2	UDINT
ATSYN	The observed time period from SYN frame arrival to SYN frame arrival	1 to 2 ¹⁶ (octet times). See 4.6.2.3	UDINT
ATTRT0	The observed time period of the TTRT0	1 to 2 ¹⁶ -1, continuously decrementing. See 4.6.3.3	UDINT
ATTRT1	The observed time period of the TTRT1	1 to 2 ¹⁶ -1, continuously decrementing. See 4.6.2.4	UDINT
ATTRT2	The observed time period of the TTRT2	1 to 2 ¹⁶ -1, continuously decrementing. See 4.6.2.5	UDINT
CDh	Cumulative count of transmitted high-speed-cyclic data frames	0 to 2 ³² -1. See 4.6.2.8	UDINT
CDH _{blk}	Information data status of the data buffer with the identifier number "blk", indicating the corresponding TCC data being active (healthy) or inactive (unhealthy)	True: active. False: inactive. See 4.6.2.9	BOOL
CDI	Cumulative count of transmitted low-speed-cyclic data frames	0 to 2 ³² -1. See 4.6.3.4	UDINT
CDm	Cumulative count of transmitted medium-speed-cyclic data frames	0 to 2 ³² -1. See 4.6.2.10	UDINT
LL	Live list indicating whether the corresponding node, at this moment, is connected to and running in the Type 11 fieldbus domain in the received SYN frame. The Live list is a set of 256 Booleans, represented in 32 octets, in which each bit corresponds to a node in the Type 11 fieldbus domain and indicates the current status of that node	256-bit set of Booleans True: node is connected and working. False: node is not connected or not working. See 4.6.2.19	USINT[16]
LN	Extracted number from LL at each node and used by each node to decide whether the node is able to send the data frame out over the medium	1 to 255. See 4.6.2.20	USINT
NCD _A , NCD _B	Cumulative count of No-Carrier detected on the receive-channel A or B	0 to 2 ³² -1. See 4.6.3.9	UDINT
NONC	Permissible repetitive count of no CMP frame received by the SYN node within the corresponding consecutive Tsyn cycles, that is 256 times by SCMPL, in order to detect no other node except the SYN node in the Type 11 fieldbus domain	1 to 16. The default value is 3. See 4.6.2.26, 4.6.2.27	USINT

Variable -name	Description	Range of value	Data type
RE _A , RE _B	Cumulative count of DLPDUs received in error on the receive-channel A or B. RE _A is incremented when an error is detected on receive-channel A while receive-channel B is error-free. RE _B corresponds, but with interchanged channel roles.	0 to 2 ³² -1. See 4.6.3.13	UDINT
ROK _A , ROK _B	Cumulative count of DLPDU-received without error on the receive-channel A or B	0 to 2 ³² -1. See 4.6.3.15	UDINT
SL	The observed time period of the SL	0 to V(SL). See 4.6.2.35, 4.6.2.36	USINT
SD	Cumulative count of transmitted sporadic data frames	0 to 2 ³² -1. See 4.6.2.34	UDINT

4.6.1.3 Summary of variables, parameters, counters, timers for loop-architecture

Table 5 and Table 6 summarise the variables and their usage. The data types used in the data link variables, parameters, state machines are specified in IEC 61158-5-11, Clause 5.

The data types used in the data link variables, parameters, state machines are specified in IEC 61158-5-11, Clause 5. The most significant bit of the most significant octet is always used as the most significant bit of the binary number. The bits of each octet are numbered 0 to 7, where bit 0 is the least significant bit of the octet. Each octet is transferred to the Ph layer low-bit first and multiple octets is transferred low-order octet first (little endian format).

Table 5 – DLE variables and permissible values of loop-architecture

Variable -name	Description	Permissible values	Data type
BW	Length of TCC data word in a DLPDU	16 to 128. The default value is 64. See 4.6.2.7	UINT
DR	Data-rate	The value is 100 or 1 000 (Mbps). See 4.6.2.11	UINT
ESYN	Enable SYN	“Enable” or “Disable”. “Enable” is capable of SYN node. “Disable” is not capable of SYN node. The default value is “Enable”. See 6.4.3, 4.6.4.5	
FWE _{AB} , FWE _{BA}	Forwarding control for receiving frame enable to each direction to/from Ring-port-A and -B. FWE _{AB} controls forwarding frames receiving from Ring-port-A to Ring-port-B. On the other hand, FWE _{BA} controls forwarding frames receiving from Ring-port-B to Ring-port-A	“Enable” or “Disable”. “Enable”: permit forwarding frames receiving from one Ring-port to other Ring-port. “Disable”: prohibit forwarding frames between Ring-ports. The default value is “Disable”. See 6.9.3, 4.6.4.6	BOOL
HTh	Maximum observational time period for detecting the continuous high-speed transmission cycle disrupted	2 to 2 ¹⁶ -1 (in units of: – 1 ms for 100 Mbps operation; – 0,1 ms for 1 000 Mbps operation). The default value is 3 x V(Th). See 4.6.2.12	UDINT
HTI	Maximum observational time period for detecting the continuous low-speed transmission cycle disrupted	2 to 2 ¹⁶ -1 (in units of 1 ms). The default value is 3 x V(Th). See 4.6.4.7	UDINT
HTm	Maximum observational time period for detecting the continuous medium-speed transmission cycle disrupted	2 to 2 ¹⁶ -1 (in units of 1 ms). The default value is 3 x V(Th). See 4.6.2.14	UDINT
IA	Individual address of this node	Individual 48-bit address identical to ISO/IEC 8802-3. See 4.6.2.16	SWORD[6]

Variable -name	Description	Permissible values	Data type
IGP	Time interval from the end of a previous frame to the start of the consecutive frame sent by a node	The default value is: – 24 for 100 Mbps operation; – 12 for 1 000 Mbps operation. See 4.6.2.17	UDINT
IP	IP address of this node	32-bit address identical to IPv4. See 4.6.2.18	USINT[4]
MD	Maximum distance on the connection path between any 2 nodes	1 to 20 (km). The default value is 4. See 4.6.2.21	UINT
MDAD	Maximum distance between adjacent node	The value is: – 1 to 2 (km) for 100 Mbps operation; – 1 to 5 (km) for 1 000 Mbps operation. The default value is 1. See 4.6.4.11	UINT
MGA	Multicast group address	Multicast 48-bit address identical to ISO/IEC 8802-3, for logically associated Type 11 fieldbus nodes. The default value is 0x01-0x00-0x5e-0x50-0x00-0x01. See 4.6.2.22	USINT[6]
MN	Maximum node number	254 (default value). See 4.6.2.23	USINT
MRT	Maximum number of the repeater units on the connection path between any 2 nodes	0 to 252. The default value is 30. See 4.6.2.24	USINT
MHTT	Maximum-token-hold-time for high-speed cyclic data transmission	1 to $2^{16}-1$ (octet time). The default value is 0x30B4 (= 900 µs for 100 Mbps and 90 µs for 1 000 Mbps operation). See 4.6.2.25	UDINT
PBh	List of data buffers using for sending out high-speed TCC data	The value is: – 1 to 2 048 for 100 Mbps operation; – 1 to 4 096 for 1 000 Mbps operation. See 4.6.2.28	UINT
PBl	List of data buffers using for sending out low-speed TCC data	The value is: – 1 to 2 048 for 100 Mbps operation; – 1 to 4 096 for 1 000 Mbps operation. See 4.6.4.16	UINT
PBm	List of data buffers using for sending out medium-speed TCC data	The value is: – 1 to 2 048 for 100 Mbps operation; – 1 to 4 096 for 1 000 Mbps operation. See 4.6.2.29	UINT
PS _A PS _B	Port state control for blocking or non-blocking frame receiving from the Ring-port-A or –B	“Blocked” or “Non-blocked”. The default value is “Blocked”. See Table 27, 4.6.4.18	BOOL
REN _A REN _B	Receive enable control for receiving frames from the Ring-port-A or –B.	“Enable” or “Disable”. The default value is “Enable”. See Table 28, 4.6.4.20	BOOL
ST	The slot-time is the fundamentally observational time unit, used in the DLME for observing to initiate action such as re-initialization in sending out the CLM frame, and also used in the DLME for observing the CMP frame sent by the corresponding node, and in case that the node failed to send out, used in the DLME for initiating action just as the CMP frame is received	1 to 255 (in units of physical symbol times for 512 bits in 100 Mbps operation and for 4 096 bits in 1 000 Mbps operation, identical to ISO/IEC 8802-3). The default value is 20 (= 100 µs for 100 Mbps, and 8 µs for 1 000 Mbps operation). See Table 14, 4.6.2.38	USINT
SCMP	Medium-access-control-time for substitute CMP	1 to 255 (in units of physical symbol times for 512 bits in 100 Mbps operation and for 4 096 bits in 1 000 Mbps operation, identical to ISO/IEC 8802-3). The default value is 20 (=100 µs for 100 Mbps, and 8 µs for 1 000 Mbps operation). See 4.6.2.31	USINT

Variable -name	Description	Permissible values	Data type
SCMPL	Permissible repetitive count within which the node can behave like that the node received the CMP frame even though the corresponding node had failed to send out the CMP frame. The node determines the corresponding node is out of service if the count is over	1 to 16. The default value is 3. See 4.6.2.33	USINT
SEN _A SEN _B	Send enable control for sending frames out of the Ring-port-A or –B	“True” / “Enable” or “False” / “Disable”. The default value is “True” / “Enable”. See Table 25, 4.6.4.22	BOOL
Th	High-speed transmission period	1 to 160 (in units of 0,1 ms). See Table 15, 4.6.2.39	USINT[3]
Tl	Low-speed transmission period	1 to 10 000 (in units of 1 ms). The default value is 100. See Table 18, 4.6.4.23	UINT
TISPD	Time-interval cyclically processed for Sporadic message data service	1 to 1 000 (in units of 1 ms). The default value is 100. See Table 17, 4.6.2.40, 4.6.2.41	UINT
Tm	Medium-speed transmission period	10 to 1 000 (in units of 1 ms). The default value is 100. See Table 16, 4.6.2.42	UINT
TMAC	Maximum observation time period for the SYN node to solicit new nodes into the Type 11 fieldbus	1 to 100 (in units of 0.1 ms for 100 Mbps and of 0,01 ms for 1 000 Mbps operation). The default value is 100. See 4.6.2.43, 4.6.2.44	USINT
Tsl	DLE number able to send out next slot	1 to 255. See 4.6.2.46	USINT
TSYN	Target-periodic-time from SYN frame arrival to SYN frame arrival	1 to 160 (in units of 0,1 ms). See 4.6.2.47	UDINT
TTRT0	Target-token-rotation-time for access class 0	1 to 2 ¹⁶ -1 (octet time). The default value is P(TSYN). See 4.6.4.24	UDINT
TTRT1	Target-token-rotation-time for access class 1	1 to 2 ¹⁶ -1 (octet time). The default value is P(TSYN). See 4.6.2.48	UDINT
TTRT2	Target-token-rotation-time for access class 2	1 to 2 ¹⁶ -1 (octet time). The default value is P(TSYN). See 4.6.2.49	UDINT
TN	Node identifier number of the node. The initial value is 0 on power-up or reset	1 to 255. See 4.6.2.45	USINT

Table 6 – Observable variables and their value ranges of loop-architecture

Variable -name	Description	Range of value	Data type
AN _A AN _B	Node number of adjacent node neighboring Ring-port-A or -B	1 to 254. See 4.6.4.1	USINT
ASCMP	Collection of counters of total number of nodes. Each counter corresponding to a node indicates observed repetitive count that the corresponding node failed to send out the CMP frame and the other node can behave like that the CMP frame received without error. The node determines the corresponding node is out of service when the count reaches the pre-specified number. The number counted is indicated and is incremented coincidentally at each DLME	1 to 16. The default value is equal to the value of SCMPL, which is 3. See 4.6.2.1	USINT
ATHT	The observed time period of the MHTT	0 to MHTT, continuously decrementing. See 4.6.2.2	UDINT
ATSYN	The observed time period from SYN frame arrival to SYN frame arrival	1 to 2 ¹⁶ (octet times). See 4.6.2.3	UDINT
ATTRT0	The observed time period of the TTRT0	1 to 2 ¹⁶ -1, continuously decrementing. See 4.6.4.2	UDINT
ATTRT1	The observed time period of the TTRT1	1 to 2 ¹⁶ -1, continuously decrementing. See 4.6.2.4	UDINT
ATTRT2	The observed time period of the TTRT2	1 to 2 ¹⁶ -1, continuously decrementing. See 4.6.2.5	UDINT
CDh	Cumulative count of transmitted high-speed-cyclic data frames	0 to 2 ³² -1. See 4.6.2.8	UDINT
CDH _{blk}	Information data status of the data buffer with the identifier number “blk”, indicating the corresponding TCC data being active (healthy) or inactive (unhealthy)	True: active. False: inactive. See 4.6.2.9	BOOL
CDm	Cumulative count of transmitted medium-speed-cyclic data frames	0 to 2 ³² -1. See 4.6.2.10	UDINT
CRE _A CRE _B	Observed repetitive count for the abnormal reception error detected during receiving incoming frame from the Ring-port-A or -B respectively. The count is decreased by each abnormal reception detection repetitively but reset to the initial value when the abnormal reception is cleared. When reached to 0, abnormal reception error is detected	0 to 15. The default value is 2. See 4.6.4.4	USINT
LINK _A LINK _B	Link state indicating the condition of physical link connection at Ring-port-A or -B	“Abnormal” or “Normal”. See 4.6.4.9	BOOL
LSYN	Node number of the node in current master state	1 to 254. See 4.6.4.10	USINT
LL	Live list indicating whether the corresponding node, at this moment, is connected to and running in the Type 11 fieldbus domain in the received SYN frame. The Live list is a set of 256 Booleans, represented in 32 octets, in which each bit corresponds to a node in the Type 11 fieldbus domain and indicates the current status of that node	256-bit set of Booleans. True: node is connected and working. False: node is not connected or not working. See 4.6.2.19	USINT[16]
LN	Extracted number from LL at each node and used by each node to decide whether the node is able to send the data frame out over the medium	1 to 255. See 4.6.2.20	USINT
NCD _A , NCD _B	Cumulative count of No-Carrier detected on the Ring-port-A or B	0 to 2 ³² -1. See 4.6.4.12	UDINT

Variable -name	Description	Range of value	Data type
NONC	Permissible repetitive count of no CMP frame received by the SYN node within the corresponding consecutive Tsyn cycles, that is 256 times by SCMP, in order to detect no other node except the SYN node in the Type 11 fieldbus domain	1 to 16. The default value is 3. See 4.6.2.26, 4.6.2.27	USINT
NOS	Node operation state indicating the operation condition of a node in normal or open state	“Normal” or “Open”. The default value is “Open”. See 4.6.4.13	BOOL
NRF _A NRF _B	Observed time period in which no frame received from Ring-port-A or –B after from other Ring-port-B or –A respectively, a frame has been received	0 to 15 (in units of Th time). The default value is 2. See 4.6.4.14	USINT
NS	Node state indicating the node condition operating as master or slave	“Master” or “Slave”. The default value is “Slave”. See 4.6.4.15	BOOL
PP	Primary port indicating the Ring-port-A or –B through which SYN or CLM received first since this node is power-up, or in the system start-up, or in the system initialization	“Ring-port-A” or “Ring-port-B”. The default value is “Ring-port-A”. See Table 26, 4.6.4.17	BOOL
RE _A , RE _B	Cumulative count of DLPDUs received in error on the Ring-port-A or –B. RE _A is incremented when an error is detected on the Ring-port-A while the Ring-port-B respectively is error-free. RE _B corresponds, but with interchanged channel roles	0 to 2 ³² -1. See 4.6.4.20	UDINT
ROK _A , ROK _B	Cumulative count of DLPDU-received without error on the Ring-port-A or –B	0 to 2 ³² -1. See 4.6.4.21	UDINT
SL	The observed time period of the SL	0 to V(SL). See 4.6.2.35, 4.6.2.36	USINT
SD	Cumulative count of transmitted sporadic data frames	0 to 2 ³² -1. See 4.6.2.34	UDINT

4.6.2 Type 11 common variables, parameters, counters, timers and queues

4.6.2.1 C(ASCMP) : ASCMP count

A collection of counters, each of which indicates the number of observed repetitive count that the corresponding node failed to send out the CMP frame and the other node can behave like that the CMP frame received without error. The number of C(ASCMP) is incremented coincidentally at each node in Type 11 fieldbus. The value is in the range of 1 to V(SCMPL) and the default value is 3.

4.6.2.2 T(ATHT) : MTHT monitor

T(ATHT) is used by the DLE to measure the time elapsed of MTHT. The value is decremented in the range of P(MTHT) to 0.

4.6.2.3 T(ATSYN) : TSYN monitor

T(ATSYN) is used by the DLE to monitor the time period from SYN frame arrival to SYN frame arrival. The value is indicated in octet time by the data signaling rate.

4.6.2.4 T(ATTRT1) : TTRT1 monitor

T(ATTRT1) is used by the DLE to monitor the time period of TTRT1. The value is decremented in the range of 2¹⁶-1 to 1, of which unit is in octet time by the data-signaling rate.

4.6.2.5 T(ATTRT2) : TTRT2 monitor

T(ATTRT2) is used by the DLE to monitor the time period of TTRT2. The value is decremented in the range of $2^{16}-1$ to 1, of which unit is in octet time by the data-signaling rate.

4.6.2.6 Q(BF_{blk}) : Data buffer used for sending and receiving a DLPDU for time-critical cyclic data DLPDU

The total number of buffers is equivalent of the total number of DLCEP. Each buffer with the identifier “blk” number corresponds to a DLCEP with the identifier number “identifier”.

4.6.2.7 V(BW), P(BW) : Length of time-critical cyclic data word in a DLPDU

This variable holds and designates the length of the Time-critical cyclic data word in a DLPDU.

The possible value of the length in octet is as follows:

- a) star-architecture: The default value is 128;
- b) loop-architecture: 16 to 128. The default value is 64.

4.6.2.8 C(CDh) : Cumulative count of high-speed-cyclic data frame sent

C(CDh) indicates the number of cumulative count of high-speed-cyclic data frame sent on the medium. C(CDh) is a roll-over binary counter of 32-bit length.

4.6.2.9 V(CDH_{blk}) Information data status of the data buffer with identifier number “blk”

This variable indicates the status of the corresponding time-critical cyclic data being active (healthy) or inactive (unhealthy). The value “True” indicates active, and the value “False” indicates inactive.

4.6.2.10 C(CDm) : Cumulative count of medium-speed-cyclic data frame sent

C(CDm) indicates the number of cumulative count of medium-speed-cyclic data frame sent on the medium. C(CDm) is a roll-over binary counter of 32 bits length.

4.6.2.11 V(DR) : Data-rate

The value of this variable indicates the data signaling rate in Mbps. The value is 100 for the star-architecture and is either 100 or 1 000 for the loop-architecture.

4.6.2.12 V(HTh), P(HTh) : Maximum observational time period for detecting the continuous high-speed transmission cycle disrupted

This variable holds and designates the value of maximum observational time period for detecting the continuous High-speed transmission cycle disrupted. The value of this variable is in the range of 2 to $2^{16}-1$, of which the unit is 1 ms in 100 Mbps and 0,1 ms in 1 000 Mbps operation. The default value is $3 \times V(Th)$.

4.6.2.13 T(HTh) : HTh monitor

T(HTh) is used by the DLE to measure the HTh time elapsed to detect the continuous High-speed transmission cycle failed. The value is decremented in the range of V(HTh) to 1.

4.6.2.14 V(HTm), P(HTm) : Maximum observational time period for detecting the continuous medium-speed transmission cycle disrupted

This variable holds and designates the value of maximum observational time period for detecting the continuous Medium-speed transmission cycle disrupted. The value of this variable is in the range of 2 to $2^{16}-1$, of which the unit is 1ms. The default value is $3 \times V(Th)$.

4.6.2.15 T(HTm) : HTm monitor

T(HTm) is used by the DLE to measure the HTm time elapsed to detect the continuous Medium-speed transmission cycle disrupted. The value is decremented in the range of V(HTm) to 1.

4.6.2.16 V(IA) : Individual-address-of-this-node

This variable holds the individual address of this node in the 48-bit length specified by ISO/IEC 8802-3. The value is set by DLMS.

4.6.2.17 V(IGP) : Inter-frame-time-gap

This variable indicates the value of the time interval from the end of a previous frame to the start of the consecutive frame sent by a node. The value is equivalent to 0,96 μ s for 100 Mbps and 0,096 μ s for 1 000 Mbps operation and is identical to that specified by ISO/IEC 8802-3.

4.6.2.18 V(IP), P(IP) : IP address of this node

This variable holds and designates DLSAP value assigned for Type 11 fieldbus Sporadic message data service.

4.6.2.19 V(LL) : Live-list

This variable indicates the current operational status, whether a corresponding node is connecting to and is running normally in the Type 11 fieldbus. The possible value is "True" or "False", "True" means the node is connecting to and working normally and "False" is not. V(LL) is used by the DLE and is generated from the information conveyed by SYN frame. Live-list is a collection of 8 words of 32-bit length, each bit of which corresponds to the node in the Type 11 fieldbus and indicates the current operational status. Each bit corresponds to the node number V(TN) in a sequential order from 0 to 255 in little endian format.

4.6.2.20 V(LN) : Live-node-number

This variable indicates the TN number of node, extracted from V(LL), which connects to and is running normally in the Type 11 fieldbus at this point. V(LN) is used by the DLE to decide whether the node is able to send the data frame out over the medium. The range of this value is 1 to 255.

4.6.2.21 V(MD), P(MD) : Maximum-distance

The value of this variable holds, and is set by DLMS, the maximum distance in kilometer on the connection path between any 2 nodes.

The range of this value is as follows:

- a) star-architecture: 1 to 100, and the default value is 8;
- b) loop-architecture: 1 to 20, and the default value is 4.

4.6.2.22 V(MGA), P(MGA) : Multicast group address

This variable holds and designates the multicast group address, used by the DLE to build logically associated group of the Type 11 fieldbus nodes, in 48-bit length specified by and identical to ISO/IEC 8802-3. The default value is 0x01-0x00-0x5e-0x50-0x00-0x01.

4.6.2.23 V(MN), P(MN) : Maximum-node-number

This variable holds the maximum node number, and is set by DLMS. The default value of this variable is 254.

4.6.2.24 V(MRT), P(MRT) : Maximum-number-of-the-repeater-unit

This variable holds, and is set by the DLMS, maximum number of the repeater units on the connection path between any 2 nodes.

The possible value is as follows:

- a) star-architecture: 0 to 7, and the default value is 3;
- b) loop-architecture: 0 to 252, and the default value is 30.

4.6.2.25 V(MTHT), P(MTHT) : Maximum-token-hold-time

This variable holds and designates the value of maximum-token-hold-time for high-speed cyclic data transmission. The range of this value is 1 to $2^{16}-1$ of which unit is in octet time by the data signaling rate. The default value is 0x30B4, that is approx. 900 μ s for 100 Mbps and 90 μ s for 1 000 Mbps operation.

4.6.2.26 V(NONC), P(NONC) : Permissible repetitive count of no CMP

This variable holds and designates the value of permissible repetitive count of no CMP frame received by the SYN node within the corresponding consecutive T_{syn} cycles, that is 256 times by V(SCMPL), in order to detect no other node except the SYN node in the Type 11 fieldbus. The range of this value is 1 to 16, and the default value is 3.

4.6.2.27 C(NONC) : NONC count

C(NONC) indicates the number of repetitive count of no CMP frame received by the SYN node within $V(MN) \times V(SCMPL)$ of the consecutive T_{syn} cycles. C(NONC) reached to the number of V(NONC), the SYN node detects and recognizes no other node hooking up to the Type 11 fieldbus.

4.6.2.28 V(PBh), P(PBh) Maximum number of the data buffers used for sending high-speed time-critical cyclic data

This variable holds and designates the maximum number of the data buffers used for sending high-speed time-critical cyclic data.

4.6.2.29 V(PBm), P(PBm) Maximum number of the data buffers used for sending medium-speed time-critical cyclic data

This variable holds and designates the maximum number of the data buffers used for sending medium-speed time-critical cyclic data.

4.6.2.30 Q(QBF_{SPD}) : Queue buffer for sporadic data

The queue buffer for the Sporadic message data service holds the DLPDU by DL-user to be sent. The queue buffer size to transfer as well as to receive the Sporadic message data is implementation matter.

4.6.2.31 V(SCMP), P(SCMP) : Medium-access-control-time for substitute CMP

This variable holds and designates the value of maximum observational time period for the node to initiate the action like that the node received the CPM frame even though the corresponding node failed to send out the CMP frame.

4.6.2.32 T(SCMP) : SCMP monitor

T(SCMP) is used by the DLE of the node to measure the SCMP time elapsed to initiate the action like that the node received the CMP frame even though the corresponding node failed to send out the CMP frame. The value is decremented in the range of V(SCMP) to 0.

4.6.2.33 V(SCMPL), P(SCMPL) : Permissible repetitive count of substitute CMP

This variable holds and designates the value of permissible repetitive count within which the node can behave like that the node received the CMP frame without error even though the corresponding node failed to send out the CMP frame. The range of this value is 1 to 16 and the default value is 3.

4.6.2.34 C(SD) : Cumulative count of sporadic data frame sent

C(SD) indicates the number of cumulative count of sporadic data frames sent on the medium. C(SD) is a roll-over binary counter of 32-bit length.

4.6.2.35 V(SL), P(SL) : Silence time

This variable holds and designates the value of the silence time or inactivity time period for detecting the current SYN node out of order, following to initiate sending the CLM frame out from this node in order to claim new SYN node if this node is designated and permitted to be a SYN node. The value is set by the DLE to the T(SL) timer as follows:

$$T(SL) = V(TSYN) + V(ST) \times V(TN) \times 2$$

4.6.2.36 T(SL) : SL monitor

T(SL) is used by the DLE to measure the time elapsed of SL. The value is decremented in the range of V(SL) to 0.

4.6.2.37 V(SM), P(SM) : Subnet address mask

This variable holds and designates the value of subnet address mask for V(IP) for Type 11 fieldbus Sporadic message data service.

4.6.2.38 V(ST), P(ST), T(ST) : Type 11 fieldbus slot-time

Slot-time is the fundamentally observational time unit, used in the DLME for observation of initiation of the action such as re-initialization in sending out the CLM frame, for observation of initiation of the action that the node behaves like the CMP frame received even though the corresponding node failed to send out the CMP frame.

This variable holds and designates the fundamentally observational time value of slot time. The range of the value is 1 to 255, of which time is in 512-bit physical symbol time for 100 Mbps operation and in 4 096 bit physical symbol time for 1 000 Mbps operation specified by and identical to ISO/IEC 8802-3. The default value is 20, which is equivalent to Approx.100 μs for 100 Mbps operation and 8 μs for 1 000 Mbps operation, i.e. 20 x 512 x 1/100 μs in case of 100 Mbps operation.

The slot time value is calculated from the following formula:

$$V(ST) = \text{round up } [2 \times V(MD) + V(MRT)/2 + 2]$$

4.6.2.39 V(Th), P(Th) : High-speed transmission period

This variable holds and designates the cyclic time period of High-speed time-critical data transmission. P(Th) is used by the DLE and the value is set to V(SYN). The range of this value is 1 to 160, of which the unit is 0,1ms. The default value is 100.

4.6.2.40 V(TISPD), P(TISPD) : Time-interval for sporadic-message-data-service

This variable holds and designates the value of time interval cyclically processed for Sporadic-message-data service. The range of this value is 1 to 1 000, of which unit is in 1 ms. The default value is 100.

4.6.2.41 T(TISPD) : TISPD monitor

T(TISPD) is used by the DLE to measure the time interval of TISPD.

4.6.2.42 V(Tm), P(Tm) : Medium-speed transmission period

This variable holds and designates the cyclic time period of Medium-speed time-critical data transmission. P(Tm) is used by the DLE. The range of this value is 1 to 1 000, of which the unit is 1ms. The default value is 100.

4.6.2.43 V(TMAC), P(TMAC) : Medium-access-control-time to solicit new nodes

This variable holds and designates the value of maximum observational time period for the SYN node to solicit new nodes into the Type 11 fieldbus. During the time period new nodes attempt to send out the REQ frame to the SYN node. The default value is 100, the unit of which is in 0,1 ms for 100 Mbps operation and in 0,01 ms for 1 000 Mbps operation.

4.6.2.44 T(TMAC) : TMAC monitor

T(TMAC) is used by the DLE of the SYN node to measure the time elapsed of TMAC in order to wait for REQ frames sent from node which attempts to enter the Type 11 fieldbus. The value is decremented in the range of V(TMAC) to 0.

4.6.2.45 V(TN), P(TN) : This-node

This variable holds and designates the node identifier number of this node. The initial value is 0 on power-up or reset of this node. The range of this value is 1 to 255.

4.6.2.46 V(Tsl) : DLE number able to send out next slot

This variable is used by the DLE to hold and indicate the node identifier number of V(TN) of which the node can send out its data next in the sequential order in succession to a node currently having completed sending out all its data and CMP or DT-CMP DLPDU. The value of this variable is updated and set to the value of V(TN) of the node next to send out, every time on the reception of CMP or DT-CMP DLPDU. The range of this variable is 1 to 255.

4.6.2.47 V(TSYN) : Target-periodic-time of synchronization

This variable indicates the target time period from SYN frame arrival to SYN frame arrival. The value is equal to V(Th), and the value of P(Th) is used by the DLMS and is set to V(Th). The possible range of this time period is 0,1 ms to 160 ms. V(SYN) and V(Th) indicate the cyclic time period in which all the node with high-speed cyclic data can obtain the transmission right to send out all of the high-speed cyclic data.

4.6.2.48 V(TTRT1), P(TTRT1) : Target-token-rotation-time for access class 1

This variable holds and designates the value of target-token-rotation-time for access class 1, especially for sporadic message data transmission. The range of this value is 1 to $2^{16}-1$ of which unit is in octet time by the data signaling rate. The default value is equal to P(TSYN). This value is used by the DLE and should be equal and common to all DLEs of the Type 11 fieldbus.

P(TTRT1) is used by the DLME and the value is the time period in which a node with sporadic message data can expect to obtain the transmission right to send out.

4.6.2.49 V(TTRT2), P(TTRT2) : Target-token-rotation-time for access class 2

This variable holds and designates the value of target-token-rotation-time for access class 2, especially for medium-speed cyclic data transmission. The range of this value is 1 to $2^{16}-1$ of which unit is in octet time by the data signaling rate. The default value is equal to P(TSYN). This value is used by the DLE and should be equal and common to all DLEs of the Type 11 fieldbus.

P(TTRT2) is used by the DLME, and the value is the expected time period in which all nodes with medium-speed cyclic data can obtain the transmission right and send out all of the medium-speed cyclic data.

4.6.3 Star-architecture specific variables, parameters, counters, timers and queues

4.6.3.1 T(AIGP_A), T(AIGP_B) : IGP monitor over the receive-channel A and B

T(AIGP_A) and T(AIGP_B) are used by the DLE to measure the time elapsed of IGP over the receive-channel A and B respectively. The value is decremented in the range of 24 to 0, and value 24 is equivalent to 0,96 μ s.

4.6.3.2 T(ARMGP) : RMGP monitor

T(ARMGP) is used by the DLE to monitor the time elapsed of RMGP. The value is decremented in the range of 250 to 0, and value 250 is equivalent to 10 μ s.

4.6.3.3 T(ATTRT0) : TTRT0 monitor

T(ATTRT0) is used by the DLE to monitor the time period of TTRT0. The value is decremented in the range of $2^{16}-1$ to 1, of which unit is in octet time by the data-signaling rate.

4.6.3.4 C(CDI) : Cumulative count of low-speed-cyclic data frame sent

C(CDI) indicates the number of cumulative count of low-speed-cyclic data frames sent on the medium. C(CDI) is a roll-over binary counter of 32-bit length.

4.6.3.5 V(HTI), P(HTI) : Maximum observational time period for detecting the continuous low-speed transmission cycle

This variable holds and designates the value of maximum observational time period for detecting the continuous Low-speed transmission cycle disrupted. The value is in the range of 2 to $2^{16}-1$, of which the unit is 1ms. The default value is 3 x V(Th).

4.6.3.6 T(HTI) : HTI monitor

T(HTI) is used by the DLE to measure the HTI time elapsed to detect the continuous Low-speed transmission cycle disrupted. The value is decremented in the range of V(HTI) to 1.

4.6.3.7 V(MDD), P(MDD) : Maximum-difference-of-the-distance

This variable holds, and is set by DLMS, the maximum difference in meter of the distance of two redundant physical mediums on the connection path between any 2 nodes. The range of this value is 0 to 2 000, and the default value is 500.

4.6.3.8 V(MPD), P(MPD) : Maximum-distance-of-the-signal-propagate-delay

This variable holds, and is set by DLMS, the maximum difference in microsecond of the signal delay time propagating over two redundant physical mediums on the connection path between any 2 nodes. The range of this value is 1 to 0x7c, and the default value is 0x7c which is equivalent to approx. 5 μ s, i.e. 0x7c (=124) x 0,04 μ s.

4.6.3.9 C(NCD_A), C(NCD_B) : Cumulative count of non-carrier detected on the receive-channel A or B

C(NCD_A) or C(NCD_B) indicates the number of cumulative count of non-carrier detected on one receive-channel while the carrier occurs on the other side of receive-channel. C(NCD_A) and C(NCD_B) are roll-over binary counters of 32-bit length.

4.6.3.10 V(PBI), P(PBI) : Maximum number of the data buffers used for sending low-speed time-critical cyclic data

This variable holds and designates the maximum number of the data buffers used for sending low-speed time-critical cyclic data. The value is 0 to 2 048.

4.6.3.11 V(RCS), P(RCS) : Receive-channel switching control for receiving frames

This variable holds and designates the switching control for receiving frames out of one of two receive-channel A and B corresponding to each of the redundant medium A and B.

The possible value is "Automatic", "Force A" or "Force B". "Automatic" indicates that the switching control for receiving frames is automatically to switch to the proper receive-channel. "Force A" or "Force B" indicates that the switching control is forced to switch to Receive-channel A or B respectively. The default value is "Automatic".

4.6.3.12 V(RCS_A), V(RCS_B) : Receive-channel A or B selected for receiving frames

This variable indicates the corresponding receive-channel is selected for receiving frames from the other node. The value "True" indicates that the corresponding receive-channel is selected, and "False" is not.

4.6.3.13 C(RE_A), C(RE_B) : Cumulative count of DLPDU received with error on the receive-channel A or B

C(RE_A) or C(RE_B) indicates the number of cumulative count of DLPDU received with error while on the other side of the receive-channel no error occurs. C(RE_A) and C(RE_B) are roll-over binary counters of 32-bit length.

4.6.3.14 V(RMGP), P(RMGP) : IGP over other redundant media

This variable holds and designates the value of maximum time-interval for one receive-channel, which has already completed one frame received and has waited for IGP time, to wait the completion of a frame to be received on the other receive-channel in order to detect the other receive-channel disrupted. The default value is 250, of which unit is in 0,04 μ s, and is equivalent to 10 μ s.

4.6.3.15 C(ROK_A), C(ROK_B) : Cumulative count of DLPDU received without error on the receive-channel A or B

C(ROK_A) or C(ROK_B) indicates the number of the cumulative count of DLPDU received without error on the receive-channel A or B respectively. C(ROK_A) and C(ROK_B) are roll-over binary counters of 32-bit length.

4.6.3.16 V(SEN_A), P(SEN_A); V(SEN_B), P(SEN_B) : Transmitter A or B enabled to send out frames

This variable designates the transmitter A or B enable to send out frames from, and indicates the state of the transmitter A or B being enabled or disabled. The value “True” is to be enabled and “False” is not for the corresponding Transmitter A or B. The default value is “True”.

4.6.3.17 V(TI), P(TI) : Low-speed transmission period

This variable holds and designates the cyclic time period of Low-speed time-critical data transmission. P(TI) is used by the DLE. The range of this value is 100 to 1 000, of which the unit is 1 ms, and the default value is 100.

4.6.3.18 V(TTRT0), P(TTRT0) : Target-token-rotation-time for access class 0

This variable holds and designates the value of target-token-rotation-time for access class 0, especially for low-speed cyclic data transmission. The range of this value is 1 to $2^{16}-1$ of which unit is in octet time by the data signaling rate. The default value is equal to P(TSYN). This value is used by the DLE and should be equal and common to all DLEs of the Type 11 fieldbus.

P(TTR0) is used by the DLME, and the value is the expected time period in which all nodes with low-speed cyclic data can obtain the transmission right and send out all of the low-speed cyclic data.

4.6.4 Loop-architecture specific variables, parameters, counters, timers and queues

4.6.4.1 V(AN_A), V(AN_B) : Node-number of adjacent node-A, -B

This variable holds the node-number of adjacent node. The V(AN_A) and V(AN_B) indicate the node-number of the adjacent node in the neighborhood of the Ring-port-A and -B of this node respectively. The initial value on power-up or reset of this node is 0.

4.6.4.2 T(ATTRT0) : TTRT0 monitor

T(ATTRT0) is used by the DLE to monitor the time period of TTRT0 in 1 000 Mbps operation. The value is decremented in the range of $2^{16}-1$ to 1, of which unit is in octet time by the data-signaling rate.

4.6.4.3 C(CDI) : Cumulative count of low-speed-cyclic data frame sent

C(CDI) indicates the number of cumulative count of low-speed-cyclic data frames sent on the medium. C(CDI) is a roll-over binary counter of 32-bit length.

4.6.4.4 V(CRE_A), P(CRE_A), C(CRE_A); V(CRE_B), P(CRE_B), C(CRE_B) : Maximum permissible repetitive count for abnormal-reception error-A, -B

This variable holds, is set by the DLE and indicates the number of observed repetitive count of the abnormal-reception error detected during receiving the incoming frames from the Ring-port-A and -B respectively. The abnormal-reception is happened under the condition of the reception-abnormal and the long-silence of reception. The range of this variable is 15 to 0. The default value is 2. The count is decremented by each abnormal-reception detected.

repetitively, and is set to the default value when the abnormal-reception is cleared. When reached to 0, the RMC recognizes the failure happened.

4.6.4.5 V(ESYN), P(ESYN): Enable SYN node

This variable holds, is set by the DLE and indicates that the DLE is capable of SYN node. The value “Enable” is to be enabled and “Disable” is not. The default value is “Enable”.

4.6.4.6 V(FWE_{AB}), P(FWE_{AB}), V(FWE_{BA}), P(FWE_{BA}) : Forwarding state-AB, -BA

This variable holds and designates the Ring-port-A or –B enable to forward frames received from the Ring-port-A to –B or from the Ring-port-B to –A respectively.

The value “Enable” is to be enabled and “Disable” is not for corresponding Ring-port-A or –B. the default value is “Disable”.

4.6.4.7 V(HTI), P(HTI) : Maximum observational time period for detecting the continuous low-speed transmission cycle

This variable holds and designates the value of maximum observational time period for detecting the continuous Low-speed transmission cycle disrupted in 1 000 Mbps operation. The value is in the range of 2 to $2^{16}-1$, of which the unit is 1ms. The default value is $3 \times V(Th)$.

4.6.4.8 T(HTI) : HTI monitor

T(HTI) is used by the DLE to measure the HTI time elapsed to detect the continuous Low-speed transmission cycle disrupted in 1 000 Mbps operation. The value is decremented in the range of V(HTI) to 1.

4.6.4.9 V(LINK_A), V(LINK_B) : Link state-A, -B

This variable indicates the link state of the Ring-port-A and -B of this node. The value of this variable is “normal” or “abnormal” according to the physical link connection to the trunk specified by ISO/IEC 8802-3.

4.6.4.10 V(LSYN) : Node number in the master-state

This variable indicates the node number of the node in the current master-state.

4.6.4.11 V(MDAD), P(MDAD) : Maximum-distance between adjacent node

The value of this variable holds, and is set by DLE, the maximum-distance in kilometer between the adjacent nodes. The range of this value is 1 to 2 for 100 Mbps operation and 1 to 5 for 1 000 Mbps operation. The default value is 1.

4.6.4.12 C(NCD_A), C(NCD_B) : Cumulative count of no-carrier detected -A, -B

C(NCD_A) or C(NCD_B) indicates the number of cumulative count of no-carrier detected on the Ring-port-A or –B respectively while the carrier occurs on the other port. The C(NCD_A) and the C(NCD_B) are roll-over binary counters of 32-bit length.

4.6.4.13 V(NOS) : Node-operation state

This variable holds and indicates the operation state of the node which is in the normal- or the open-state. The value of this variable is either “Normal” or “Open” according the normal-state or the open-state respectively. The initial value on power-up or reset of this node is “Open”.

4.6.4.14 $V(NRF_A)$, $P(NRF_A)$, $T(NRF_A)$; $V(NRF_B)$, $P(NRF_B)$, $T(NRF_B)$: Maximum observational time period for no frame received -A, -B

This variable holds, is set, and is used by the DLE to monitor the time period in which no frame received from the Ring-port -A or -B after from the other port, that is the Ring-port-B or -A respectively, a frame has been received. The range of this value is 15 to 0. The default value is 2, of which the unit is equal to $V(TSYN)$. The timer is set to 2 and starts to clock every time when any frame has been received from the other port, and is decremented during no frame received from the port.

4.6.4.15 $V(NS)$: Node state

This variable holds and indicates the node state which is the master- or slave-state. The value of this variable is “Master” if in the master-state, or “Slave” in the slave-state. The initial value on power-up or reset of this node is “Slave”.

4.6.4.16 $V(PBI)$, $P(PBI)$: Maximum number of the data buffers used for sending low-speed time-critical cyclic data

This variable holds and designates the maximum number of the data buffers used for sending low-speed time-critical cyclic data in 1 000 Mbps operation. The range of this value is 1 to 4 096.

4.6.4.17 $V(PP)$: Primary-port

This variable holds and indicates the port through which the SYN-frame first received since this node is power-up, or in the system start-up, or in the system initialization. The value of this variable is “Ring-port-A” or “Ring-port-B”.

4.6.4.18 $V(PS_A)$, $P(PS_A)$; $V(PS_B)$, $P(PS_B)$: Ring-port state-A, -B

These variables hold and designate the port state of this node. The $V(PS_A)$, $P(PS_A)$ and the $V(PS_B)$, $P(PS_B)$ holds, and is set by the DLE, the port state of the Ring-port-A and -B respectively. The value is either “Blocked” or “Non-blocked”. Each initial value on power-up or reset of this node is “Blocked”.

4.6.4.19 $C(RE_A)$, $C(RE_B)$: Cumulative count of frame received with error -A, -B

$C(RE_A)$ or $C(RE_B)$ indicates the number of cumulative count of the frame received with error from the Ring-port-A or -B respectively while no error occurs on the other port. The $C(RE_A)$ and the $C(RE_B)$ are roll-over binary counters of 32-bit length.

4.6.4.20 $V(REN_A)$, $P(REN_A)$; $V(REN_B)$, $P(REN_B)$: Receive enable -A, -B

These variables hold and designate the receive enable from the Ring-port-A or -B of this node. The $V(REN_A)$, $P(REN_A)$ and the $V(REN_B)$, $P(REN_B)$ holds, and is set by the DLME, the state of receive frame enable from the Ring-port-A and -B respectively.

The value of this variable is “Enable” or “Disable”. The default value is “Enable”.

4.6.4.21 $C(ROK_A)$, $C(ROK_B)$: Cumulative count of frame received without error-A, -B

$C(ROK_A)$ or $C(ROK_B)$ indicates the number of the cumulative count of the frame received without error from the Ring-port-A or -B respectively. The $C(ROK_A)$ and the $C(ROK_B)$ are roll-over binary counters of 32-bit length.

4.6.4.22 V(SEN_A) , P(SEN_A); V(SEN_B), P(SEN_B) : Send enable -A, -B

These variables hold and designate the send enable out of the Ring-port-A or -B of this node. The V(SEN_A), P(SEN_A) and the V(SEN_B), P(SEN_B) holds, and is set by the DLME, the state of send-frame-enable out of the Ring-port-A and -B respectively.

The value of this variable is "Enable" or "Disable". The default value is "Enable".

4.6.4.23 V(TI), P(TI) : Low-speed transmission period

This variable holds and designates the cyclic time period of Low-speed time-critical data transmission in 1 000 Mbps operation. P(TI) is used by the DLE. The range of this value is 1 to 10 000, of which the unit is 1 ms, and the default value is 100.

4.6.4.24 V(TTRT0), P(TTRT0) : Target-token-rotation-time for access class 0

This variable holds and designates the value of target-token-rotation-time for access class 0, especially for low-speed cyclic data transmission. The range of this value is 1 to $2^{16}-1$ of which unit is in octet time by the data signaling rate. The default value is equal to P(TSYN). This value is used by the DLE and should be equal and common to all DLEs of the Type 11 fieldbus.

P(TTR0) is used by the DLME, and the value is the expected time period in which all nodes with low-speed cyclic data can obtain the transmission right and send out all of the low-speed cyclic data.

5 General structure and encoding of PhIDU and DLPDU and related elements of procedure**5.1 Overview**

The DLL and its procedures are those 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 PhIDU, MA_PDU, DLPDU and the procedure, commonly used in this standard nevertheless this portion is identical to and fully compliant with ISO/IEC 8802-3.

Within Clause 5, any reference to bit k of an octet is a reference to the bit whose weight in a one-octet unsigned is 2^k , and this is sometimes referred to as "little endian" bit numbering.

5.2 PhIDU structure and encoding

The local MAC sublayer uses the service primitives provided by the PLS sublayer specified by ISO/IEC 8802-3:2000, Clause 6. All of the service primitives provided by the PLS sublayer are as follows and are considered mandatory:

- a) PLS_DATA request;
- b) PLS_DATA indication;
- c) PLS_CARRIER indication;
- d) PLS_SIGNAL indication;
- e) PLS_DATA_VALID indication.

In the case where specifications of 100 Mbps and above are applied, the reconciliation sublayer maps the signals provided at the MII for 100 Mbps and at the GMII for 1 000 Mbps to the PLS service primitives as specified by ISO/IEC 8802-3:2000, Clause 22 and Clause 35 respectively. The PLS service primitives provided by the reconciliation sublayer behave in exactly same manner as defined in Clause 6 of ISO/IEC 8802-3:2000.

5.3 Common MAC frame structure, encoding and elements of procedure

5.3.1 MAC frame structure

5.3.1.1 Common MAC frame format for the Type 11 fieldbus DLPDU

The structure of the MAC frame for the Type 11 fieldbus DLPDU is encapsulated in the frame format of Ethernet V2.0 specified by ISO/IEC 8802-3:2000, Clause 3. The value of the Length/Type field is designated to 0x888B, which is authorized and registered as the protocol identification number by the IEEE Registration Authority, to be identified as the Type 11 fieldbus frame. Figure 6 shows the MAC frame format used common to the Type 11 fieldbus DLPDU except for sporadic data transmission of the Type 11 fieldbus.

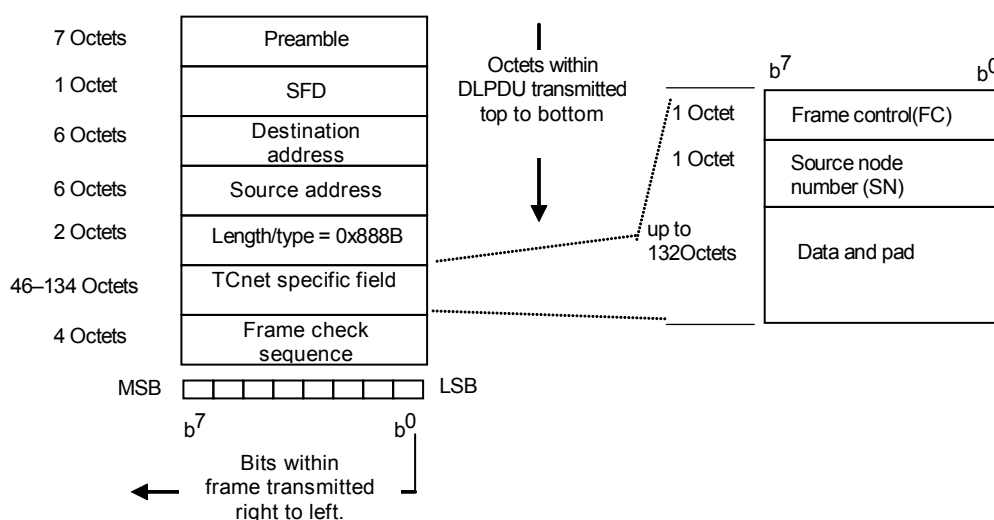


Figure 6 – Common MAC frame format for DLPDUs

5.3.1.2 MAC frame format for Type 11 fieldbus sporadic DLPDU

The MAC frame format used for sporadic data transmission of the Type 11 fieldbus shall be according to ISO/IEC 8802-3:2000, Figure 3-1.

5.4 Elements of the MAC frame

5.4.1 General

The elements of the MAC frame are the preamble, the start frame delimiter, the destination address, the source address, the length/type code, and the frame check sequence, all as specified by ISO/IEC 8802-3:2000, Clause 3.

5.4.2 Preamble field

The preamble of the MAC frame is identical to ISO/IEC 8802-3:2000, Clause 3. The preamble field is a 7-octet 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”