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**Industrielle Kommunikationsnetze –
Feldbusse –
Teil 4-24: Protokollspezifikation des Data Link Layer
(Sicherheitsschicht) – Typ 24-Elemente
(IEC 61158-4-24:2014);
Englische Fassung EN 61158-4-24:2014, nur auf CD-ROM**

Industrial communication networks –
Fieldbus specifications –
Part 4-24: Data-link layer protocol specification – Type 24 elements
(IEC 61158-4-24:2014);
English version EN 61158-4-24:2014, only on CD-ROM

Réseaux de communication industriels –
Spécifications des bus de terrain –
Partie 4-24: Spécification du protocole de la couche liaison de données –
Éléments de type 24
(CEI 61158-4-24:2014);
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Anwendungsbeginn

Anwendungsbeginn für die von CENELEC am 2014-09-19 angenommene Europäische Norm als DIN-Norm ist 2015-08-01.

Nationales Vorwort

Vorausgegangener Norm-Entwurf: E DIN EN 61158-400:2013-08.

Für dieses Dokument ist das nationale Arbeitsgremium K 956 „Feldbus“ der DKE Deutsche Kommission Elektrotechnik Elektronik Informationstechnik in DIN und VDE (www.dke.de) zuständig.

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Der Zusammenhang der zitierten Normen mit den entsprechenden Deutschen Normen ergibt sich, soweit ein Zusammenhang besteht, grundsätzlich über die Nummer der entsprechenden IEC-Publikation. Beispiel: IEC 60068 ist als EN 60068 als Europäische Norm durch CENELEC übernommen und als DIN EN 60068 ins Deutsche Normenwerk aufgenommen.

Das Präsidium des DIN hat mit Präsidialbeschluss 1/2004 festgelegt, dass DIN-Normen, deren Inhalt sich auf internationale Arbeitsergebnisse der Informationsverarbeitung gründet, unter bestimmten Bedingungen allein in englischer Sprache veröffentlicht werden dürfen. Diese Bedingungen sind für die vorliegende Norm erfüllt.

Da sich die Benutzer der vorliegenden Norm der englischen Sprache als Fachsprache bedienen, wird die Englische Fassung der EN 61158-4-24 veröffentlicht. Zu deren Abschnitt 1, der den Anwendungsbereich festlegt, und Abschnitt 3, der die Begriffe festlegt, wurde eine Übersetzung angefertigt und als Nationaler Anhang NA der vorliegenden Norm hinzugefügt. Für viele der verwendeten Begriffe existieren keine gebräuchlichen deutschen Benennungen, da sich die deutschen Anwender in der Regel ebenfalls der englischen Benennungen bedienen. Diese Norm steht nicht in unmittelbarem Zusammenhang mit Rechtsvorschriften und ist nicht als Sicherheitsnorm anzusehen.

Einführung

Ein Feldbus ist ein digitaler serieller Datenbus für die Kommunikation zwischen Geräten der industriellen Automatisierungstechnik wie beispielsweise Messeinrichtungen, Stellgliedern, Reglern und speicherprogrammierbaren Steuerungen. Die Normen der Reihe DIN EN 61158 legen eine Anzahl von Feldbus-Protokolltypen fest. Die Reihe DIN EN 61158-4 legt das Protokoll des Data Link Layer für die einzelnen Typen fest.

Nationaler Anhang NA (informativ)

1 Anwendungsbereich^{N1)}

1.1 Allgemeines

Der Data Link Layer stellt grundlegende zeitkritische Kommunikation für den Datentransfer zwischen Geräten in einer Automatisierungsumgebung bereit.

Dieses Protokoll stellt Kommunikationsmöglichkeiten für alle teilnehmenden Data Link-Einheiten bereit

- a) in einem synchron gestarteten, zyklischen Ablauf, gemäß eines vordefinierten Ablaufplans, und
- b) in einer zyklischen oder azyklischen asynchronen Weise, wie für jede derartige Data Link-Einheit im jeweiligen Zyklus gefordert.

Demnach kann dieses Protokoll als eines charakterisiert werden, welches zyklischen und azyklischen asynchronen Zugriff bereitstellt, aber mit einem synchronen Neustart jedes Zyklus.

1.2 Spezifikationen

Diese Norm legt Folgendes fest:

- a) Prozeduren für zeitgerechten Datentransfer und Informationssteuerung von einer Data Link-Benutzereinheit zu einer gleichartigen Benutzereinheit sowie zwischen der Data Link-Einheit, welche den verteilten Data Link-Dienst-Anbieter bildet;
- b) Prozeduren zur Vergabe von Kommunikationsmöglichkeiten an alle teilnehmenden DL-Einheiten, sequenziell und in einer zyklischen Weise für deterministischen und synchronisierte Transfer bei zyklischen Intervallen bis zu einer Millisekunde;
- c) Prozeduren zur Vergabe von Kommunikationsmöglichkeiten, welche für zeitkritische Datentransfers zusammen mit nicht zeitkritischen Datentransfers ohne Beeinträchtigung des zeitkritischen Datentransfers erhältlich sind;
- d) Prozeduren zur Vergabe von zyklischen und azyklischen Kommunikationsmöglichkeiten für zeitkritischen Datentransfer mit priorisiertem Zugriff;
- e) Prozeduren zur Vergabe von Kommunikationsmöglichkeiten basierend auf ISO/IEC 8802-3, Medium Zugriffsteuerung, mit Maßnahmen zur Hinzufügung und Entfernung von Knoten während des normalen Betriebs;
- f) die Struktur der Feldbus-DLPDUs, welche verwendet werden für den Transfer von Daten und Informationssteuerung durch das Protokoll dieser Norm und ihre Darstellung als Physical Layer.

1.3 Prozeduren

Die Prozeduren sind definiert in Form von

- a) den Interaktionen zwischen gleichartigen DL-Einheiten (DLEs) durch den Austausch der Feldbus-DLPDUs,
- b) den Interaktionen zwischen einem DL-Dienst-(DLS-)Anbieter und einem DLS-Benutzer im selben System durch den Austausch von DLS-Primitiven,
- c) den Interaktionen zwischen einem DLS-Anbieter und einem Ph-Dienst-Anbieter im selben System durch den Austausch von Ph-Dienstprimitiven.

^{N1)} Die Nummerierung aus IEC 61158-4-24 wurde beibehalten.

1.4 Anwendbarkeit

Diese Prozeduren sind auf Instanzen der Kommunikation zwischen Systemen anwendbar, welche die zeitkritischen Kommunikationsdienste innerhalb des Data Link Layer des OSI oder des Feldbusreferenzmodells unterstützen und die Fähigkeit erfordern, in einer offenen Systemverbundumgebung zu verbinden.

Profile stellen ein einfaches Multiattribut Hilfsmittel zur Zusammenfassung der Implementierungsfähigkeiten bereit und unterstützen dadurch die Anwendbarkeit für unterschiedliche zeitkritische Kommunikationsanforderungen.

1.5 Konformität

Diese Norm legt auch Konformitätsanforderungen für Systeme fest, die diese Prozeduren implementieren. Sie enthält jedoch keine Prüfungen, um die Konformität mit diesen Anforderungen nachzuweisen.

3.3 Allgemeine Begriffe

Für die Anwendung dieses Dokuments gelten die folgenden Begriffe.

3.3.1

azyklische Übertragung

(en: acyclic transmission)

nicht periodischer Austausch von Telegrammen

3.3.2

C1-Master

(en: C1 master)

einer der Stationstypen, der die zyklische Übertragung initiiert und steuert

3.3.3

C1-Nachricht

(en: C1 message)

Nachrichtenkommunikation, bei der der C1-Master als Initiator zum Austausch von Nachrichten mit dem Slave oder C2-Master, dient

3.3.4

C2-Master

(en: C2 master)

einer der Stationstypen, der die Funktion hat, alle Prozessdaten, die über das Netzwerk übertragen worden sind und die die Nachrichtenkommunikation initiieren können, zu überwachen

3.3.5

C2-Nachricht

(en: C2 message)

Nachrichtenkommunikation, bei der der C2-Master als Initiator zum Austausch von Nachrichten mit dem Slave oder C1-Master, dient

3.3.6

zyklische Übertragung

(en: cyclic transmission)

periodischer Austausch von Telegrammen

3.3.7

Daten

(en: data)

allgemeine Bezeichnung für jegliche über einen Feldbus übertragene Informationen

3.3.8**Gerät**

(en: device)

an den Feldbus angeschlossene physische Entität, die aus mindestens einem Datenübermittlungselement (dem Netzelement) besteht und die ein Steuerungselement und/oder ein Abschlusselement (Wandler, Stellgerät usw.) enthalten darf

3.3.9**ereignisgesteuerter Modus**

(en: event driven mode)

Übertragungsmodus für das Application Layer-Protokoll des Kommunikationstyps 24, in welchem ein Vorgang von Befehl-Antwort-Austausch als Benutzeranforderung auftritt

3.3.10**Rahmen**

(en: frame)

umgangssprachliches Synonym für DLPDU

3.3.11**Initiator**

(en: initiator)

Station, die den Austausch von Prozessdaten oder Nachrichten initiiert

3.3.12**Schnittstelle**

(en: interface)

gemeinsam genutzte Grenze zwischen zwei funktionalen Einheiten, die durch funktionale Merkmale, Signalmerkmale oder andere dementsprechende Merkmale festgelegt ist

3.3.13**Eingangsdaten**

(en: input data)

Prozessdaten, welche vom Slave gesendet und vom C1-Master empfangen werden

3.3.14**Nachricht**

(en: message)

geordnete Folge von Oktetten für die Übermittlung von Informationen

Anmerkung 1 zum Begriff: Nachrichten werden normalerweise für die Übermittlung von Informationen zwischen Peers auf der Anwendungsschicht verwendet.

3.3.15**Monitor-Slave**

(en: monitor slave)

Slave, welcher die Funktion hat, alle Prozessdaten zu überwachen, die über das Netzwerk übertragen werden

3.3.16**Netzwerk**

(en: network)

Menge von Knoten, die über ein bestimmtes Kommunikationsmedium miteinander verbunden sind, einschließlich zwischengeschalteter Repeater, Bridges, Router und Gateways unterer Schichten

3.3.17

Knoten

(en: node)

- a) einzelne DL-Entität, wie sie auf einem lokalen Verbindungszweig existiert;
- b) Endpunkt einer Verbindung in einem Netzwerk oder Punkt, an welchem zwei oder mehr Verbindungen aufeinandertreffen

3.3.18

Ausgangsdaten

(en: output data)

Prozessdaten, welche vom C1-Master gesendet und vom Slave empfangen werden

3.3.19

Protokoll

(en: protocol)

Vereinbarung über die Datenformate, Zeitabfolgen und Fehlerkorrektur für den Datenaustausch von Kommunikationssystemen

3.3.20

Echtzeit-Kommunikation

(en: real-time communication)

Transfer von Daten in Echtzeit

3.3.21

empfangender DLS-Benutzer

(en: receiving DLS-user)

Benutzer der DL-Dienste, der als Empfänger von DL-Benutzerdaten agiert

Anmerkung 1 zum Begriff: Ein Benutzer der DL-Dienste kann gleichzeitig sender und empfangender DLS-Benutzer sein.

3.3.22

Antwortender

(en: responder)

Station, welche mit Prozessdaten und Nachrichten reagiert, nachdem sie vom Initiator initiiert wurde

3.3.23

Daten senden mit Quittierung

(en: send data with acknowledge)

Datentransferdienst mit Quittierung des Empfangs vom entsprechenden DLE

3.3.24

Daten senden ohne Quittierung

(en: send data without acknowledge)

Datentransferdienst ohne Quittierung des Empfangs vom entsprechenden DLE

3.3.25

Slave

(en: slave)

einer der Stationstypen, der nur auf das Medium zugreift, nachdem er vom C1-Master oder C2-Master initiiert wurde

3.3.26

sendender DLS-Benutzer

(en: sending DLS-user)

Benutzer der DL-Dienste, der als Quelle von DL-Benutzerdaten agiert

3.3.27

Station

(en: station)

Knoten

3.3.28

Topologie

(en: topology)

physische Netzwerkarchitektur in Bezug auf die Verbindung zwischen den Stationen des Kommunikationssystems

3.3.29

Übertragungszyklus

(en: transmission cycle)

festgelegter Zeitraum der zyklischen Übertragung

3.3.30

Zeitfenster

(en: time slot)

Zeitraum, in welchem jeweils der Initiator und der Antwortende ein Rahmen austauschen können

– Leerseite –

ICS 35.100.20; 25.040.40; 35.110

English Version

**Industrial communication networks - Fieldbus specifications -
Part 4-24: Data-link layer protocol specification - Type 24
elements
(IEC 61158-4-24:2014)**

Réseaux de communication industriels - Spécifications des
bus de terrain - Partie 4-24: Spécification du protocole de la
couche liaison de données - Éléments de type 24
(CEI 61158-4-24:2014)

Industrielle Kommunikationsnetze - Feldbusse - Teil 4-24:
Protokollspezifikation des Data Link Layer
(Sicherheitsschicht) - Typ 24-Elemente
(IEC 61158-4-24:2014)

This European Standard was approved by CENELEC on 2014-09-19. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

Foreword

The text of document 65C/762/FDIS, future edition 1 of IEC 61158-4-24, prepared by SC 65C "Industrial networks" of IEC/TC 65 "Industrial-process measurement, control and automation" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 61158-4-24:2014.

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- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2015-06-19
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2017-09-19

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This document has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association.

Endorsement notice

The text of the International Standard IEC 61158-4-24:2014 was approved by CENELEC as a European Standard without any modification.

In the official version, for bibliography, the following notes have to be added for the standards indicated:

IEC 61158-1	NOTE	Harmonised as EN 61158-1
IEC 61784-1	NOTE	Harmonised as EN 61784-1
IEC 61784-2	NOTE	Harmonised as EN 61784-2

CONTENTS

INTRODUCTION.....	7
1 Scope	9
1.1 General.....	9
1.2 Specifications	9
1.3 Procedures.....	9
1.4 Applicability	10
1.5 Conformance.....	10
2 Normative references	10
3 Terms, definitions, symbols, abbreviations and conventions	11
3.1 Reference model terms and definitions.....	11
3.2 Service convention terms and definitions.....	12
3.3 Common terms and definitions	12
3.4 Symbols and abbreviations	15
3.5 Additional type 24 symbols and abbreviations	16
3.6 Common Conventions.....	16
3.7 Additional Type 24 conventions.....	17
4 Overview of DL-protocol	18
4.1 Characteristic feature of DL-protocol.....	18
4.2 DL layer component.....	19
4.3 Timing sequence	20
4.4 Service assumed from PhL	28
4.5 Local parameters, variable, counters, timers	29
5 DLPDU structure	34
5.1 Overview.....	34
5.2 Basic format DLPDU structure	35
5.3 Short format DLPDU structure.....	44
6 DLE element procedure	47
6.1 Overview.....	47
6.2 Cyclic transmission control sublayer.....	47
6.3 Send Receive Control	100
7 DL-management layer (DLM)	107
7.1 Overview.....	107
7.2 Primitive definitions	107
7.3 DLM protocol machine	108
7.4 Functions	117
Bibliography	119
Annex ZA (normative) Normative references to international publications with their corresponding European publications.....	120
Figure 1 – Data-link layer component.....	20
Figure 2 – Timing chart of fixed-width time slot type cyclic communication	21
Figure 3 – Timing chart of configurable time slot type cyclic communication	23
Figure 4 – Schematic Diagram of Communication Interrupt Occurrence.....	25
Figure 5 – Timing relationship between cyclic transmission and data processing	27

Figure 6 – Timing chart example of acyclic communication	28
Figure 7 – Basic format DLPDU structure	35
Figure 8 – Short format DLPDU structure	44
Figure 9 – The state diagram of C1 master for fixed-width time slot	49
Figure 10 – The state diagram of C2 master for fixed-width time slot	56
Figure 11 – The state diagram of slave for fixed-width time slot	60
Figure 12 – The state diagram of C1 master for configurable time slot	63
Figure 13 – The state diagram of C2 master for configurable time slot	72
Figure 14 – The state diagram of slave for configurable time slot	75
Figure 15 – The state diagram of message initiator for basic format	79
Figure 16 – The state diagram of message responder for basic format	83
Figure 17 – The state diagram of message initiator for short format	87
Figure 18 – The state diagram of message responder for short format	92
Figure 19 – The state diagram of acyclic transmission protocol machine	98
Figure 20 – Internal architecture of one-port SRC	101
Figure 21 – Internal architecture of multi-port SRC	102
Figure 22 – Internal architecture of serializer	102
Figure 23 – Internal architecture of deserializer	104
Figure 24 – State diagram of C1 master DLM	109
Figure 25 – State diagram of Slave and C2 master DLM	114
Table 1 – State transition descriptions	17
Table 2 – Description of state machine elements	18
Table 3 – Conventions used in state machines	18
Table 4 – Characteristic features of the fieldbus data-link protocol	18
Table 5 – List of the values of variable Cyc_sel	30
Table 6 – List of the values of variable Tunit	30
Table 7 – List of the values of variable PDUType	32
Table 8 – List of the values of variable SlotType	32
Table 9 – Transfer syntax for bit sequences	34
Table 10 – Bit order	35
Table 11 – Destination and Source address format	36
Table 12 – Station address	36
Table 13 – Extended address	36
Table 14 – Message control field format (Information transfer format)	37
Table 15 – Message control field format (Supervisory format)	37
Table 16 – The list of Supervisory function bits	37
Table 17 – Frame type and Data length format	38
Table 18 – The list of Frame type	38
Table 19 – Data format of Synchronous frame	39
Table 20 – The field list of Synchronous frame	39
Table 21 – Data format of Output data or Input data frame	39

Table 22 – The field list of Output data or Input data frame	39
Table 23 – Data format of Delay measurement start frame	40
Table 24 – The field list of Delay measurement start frame	40
Table 25 – Data format of Delay measurement frame	40
Table 26 – The field list of Delay measurement frame	40
Table 27 – Data format of Status frame	41
Table 28 – The field list of Status frame	41
Table 29 – The list of the DLE status	42
Table 30 – The list of Repeater status	42
Table 31 – Data format of Delay measurement frame	42
Table 32 – The field list of Cycle Information frame	43
Table 33 – Data format of Message frae	43
Table 34 – The field list of Message frame	43
Table 35 – Range of Station address field	44
Table 36 – Control field format (I/O data exchange format)	45
Table 37 – Control field format (Message format)	45
Table 38 – The field list of Message format	45
Table 39 – Data format of Synchronous frame	46
Table 40 – The field list of Sync frame	46
Table 41 – Data format of Output data frame	46
Table 42 – The field list of Output data frame	46
Table 43 – Data format of Input data frame	47
Table 44 – The field list of Input data frame	47
Table 45 – The primitives and parameters for DLS-user interface issued by DLS-user	48
Table 46 – The primitives and parameters for DLS-user interface issued by CTC	48
Table 47 – The state table of C1 master for fixed-width time slot	50
Table 48 – The state table of C2 master for fixed-width time slot	56
Table 49 – The state table of slave for fixed-width time slot	60
Table 50 – The state table of C1 master for configurable time slot	63
Table 51 – The state table of C2 master for configurable time slot	72
Table 52 – The state table of slave for configurable time slot	75
Table 53 – The list of functions used by cyclic transmission machine	77
Table 54 – The state table of message initiator for basic format	80
Table 55 – The state table of message responder for basic format	84
Table 56 – The state table of message initiator for short format	88
Table 57 – The state table of message responder for short format	92
Table 58 – List of functions used by the message segmentation machine	96
Table 59 – The state table of acyclic transmission protocol machine	98
Table 60 – The list of functions used acyclic transmission protocol machine	99
Table 61 – Primitives and parameters exchanged between CTC and DLM	99
Table 62 – Error event primitive and parameters	100
Table 63 – primitives and parameters for SRC-CTC interface	101

Table 64 – Send frame primitive and parameters 101

Table 65 – Receive frame primitives and parameters..... 101

Table 66 – Primitives and parameters exchanged between SRC and DLM 106

Table 67 – Get value primitive and parameters..... 107

Table 68 – Error event primitive and parameters 107

Table 69 – The list of primitives and parameters (DLMS-user source) 107

Table 70 – The list of primitives and parameters (DLM source) 108

Table 71 – State table of C1-Master DLM 109

Table 72 – State table of Slave and C2 master DLM..... 114

Table 73 – The list of the functions used by DLM protocol machine..... 117

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.

NOTE Use of some of the associated protocol types is restricted by their intellectual-property-right holders. In all cases, the commitment to limited release of intellectual-property-rights made by the holders of those rights permits a particular data-link layer protocol type to be used with physical layer and application layer protocols in Type combinations as specified explicitly in the profile series. 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 as follows, where the [xx] notation indicates the holder of the patent right:

US 8223804	[YE]	COMMUNICATION DEVICE, SYNCHRONIZED
JP 4760978		SYSTEM, AND SYNCHRONIZED COMMUNICATION METHOD
CN 200880002225.3		
EPC 08738862.5		
KR 10-2009-7011514		
TW 97111183		

US 7769935	[YE]	MASTER SLAVE COMMUNICATION SYSTEM AND MASTER
JP 4683346		SLAVE COMMUNICATION METHOD
US 8046512		
EPC 07850686.2		
TW 96150287		

JP 4356698	[YE]	COMMUNICATION DEVICE, SYNCHRONIZED COMMUNICATION
		SYSTEM, AND SYNCHRONIZED COMMUNICATION METHOD

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INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 4-24: Data-link layer protocol specification – Type 24 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, or
- b) in an acyclic manner, as requested 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 datalink service provider;
- b) procedures for giving communications opportunities to all participating DL-entities, sequentially and in a cyclic manner for deterministic and synchronized transfer at cyclic intervals up to 64 ms;
- 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 61158-2, *Industrial communication networks – Fieldbus specifications – Part 2: Physical layer specification and service definition*

IEC 61158-3-24:2014, *Industrial communication networks – Fieldbus specifications – Part 3-24: Data-link layer service definition – Type 24 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 9899, *Information technology – Programming languages – C*

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

ISO/IEC 13239:2002, *Information technology – Telecommunications and information exchange between systems – High-level data link control (HDLC) procedures*

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

3 Terms, definitions, symbols, abbreviations and conventions

For the purposes of this document, the following terms, definitions, symbols, abbreviations and conventions 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	acknowledgement	[ISO/IEC 7498-1]
3.1.2	correspondent (N)-entities	[ISO/IEC 7498-1]
	correspondent DL-entities (N=2)	
	correspondent Ph-entities (N=1)	
3.1.3	DL-address	[ISO/IEC 7498-3]
3.1.4	DL-protocol	[ISO/IEC 7498-1]
3.1.5	DL-protocol-data-unit	[ISO/IEC 7498-1]
3.1.6	DL-service-data-unit	[ISO/IEC 7498-1]
3.1.7	DLS-user	[ISO/IEC 7498-1]
3.1.8	DLS-user-data	[ISO/IEC 7498-1]
3.1.9	event	[ISO/IEC 19501]
3.1.10	layer-management	[ISO/IEC 7498-1]
3.1.11	primitive name	[ISO/IEC 7498-1]
3.1.12	reset	[ISO/IEC 7498-1]
3.1.13	segmenting	[ISO/IEC 7498-1]
3.1.14	state	[ISO/IEC 19501]
3.1.15	state machine	[ISO/IEC 19501]
3.1.16	systems-management	[ISO/IEC 7498-1]
3.1.17	transition	[ISO/IEC 19501]
3.1.18	(N)-entity	[ISO/IEC 7498-1]
	DL-entity (N=2)	
	Ph-entity (N=1)	
3.1.19	(N)-layer	[ISO/IEC 7498-1]
	DL-layer (N=2)	
	Ph-layer (N=1)	
	(N)-service	[ISO/IEC 7498-1]

DL-service (N=2)

Ph-service (N=1)

(N)-service-access-point

[ISO/IEC 7498-1]

DL-service-access-point (N=2)

Ph-service-access-point (N=1)

3.2 Service convention terms and definitions

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

- | | |
|-------|-------------------------------|
| 3.2.1 | confirm (primitive) |
| 3.2.2 | DL-service-primitive; |
| 3.2.3 | DL-service-provider |
| 3.2.4 | DL-service-user |
| 3.2.5 | indication (primitive) |
| 3.2.6 | request (primitive) |
| 3.2.7 | requestor |
| 3.2.8 | response (primitive) |

3.3 Common terms and definitions

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

3.3.1

acyclic transmission

non-periodic exchange of telegrams

3.3.2

C1 master

one of the station type that initiates and control cyclic transmission

3.3.3

C1 message

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

3.3.4

C2 master

one of the station type that has the function of monitoring all process data transmitted through the network and may initiates message communication

3.3.5

C2 message

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

3.3.6

cyclic transmission

periodic exchange of telegrams

3.3.7

data

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

3.3.8

device

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

3.3.9

event driven mode

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

3.3.10

frame

synonym for DLPDU

3.3.11

initiator

station that initiates the exchange of process data or message

3.3.12

interface

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

3.3.13

input data

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

3.3.14

message

ordered series of octets intended to convey information

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

3.3.15

monitor slave

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

3.3.16

network

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

3.3.17

node

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

3.3.18

output data

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

3.3.19

protocol

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

3.3.20

real-time communication

transfer of data in real-time

3.3.21

receiving DLS-user

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

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

3.3.22

responder

station that responds process data or message after it has been initiated by initiator

3.3.23

send data with acknowledge

data transfer service with acknowledge of reception from corresponding DLE

3.3.24

send data without acknowledge

data transfer service without acknowledge of reception from corresponding DLE

3.3.25

slave

one of the station type that accesses the medium only after it has been initiated by C1-master or C2 master

3.3.26

sending DLS-user

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

3.3.27

station

node

3.3.28

topology

physical network architecture with respect to the connection between the stations of the communication system"

3.3.29

transmission cycle

fixed time period of cyclic transmission

3.3.30

time slot

Time period reserved so that initiator and responder may exchange one frame respectively

3.4 Symbols and abbreviations

3.4.1	DA	Destination address
3.4.2	DL-	Data-link layer (as a prefix)
3.4.3	DLE	DL-entity (the local active instance of the data-link layer)
3.4.4	DLL	DL-layer
3.4.5	DLM	DL-management
3.4.6	DLME	DL-management entity (the local active instance of DL-management)
3.4.7	DLMS	DL-management service
3.4.8	DLPDU	DL-protocol-data-unit
3.4.9	DLS	DL-service
3.4.10	DLSAP	DL-service-access-point
3.4.11	DLSDU	DL-service-data-unit
3.4.12	FIFO	First-in first-out (queuing method)
3.4.13	ID	Identifier
3.4.14	OSI	Open systems interconnection
3.4.15	PDU	Protocol data unit
3.4.16	Ph-	Physical layer (as a prefix)
3.4.17	PhE	Ph-entity (the local active instance of the physical layer)
3.4.18	PhL	Ph-layer
3.4.19	PHY	Physical layer device (specified in ISO/IEC 8802-3)
3.4.20	QoS	Quality of service
3.4.21	RT	Real-time
3.4.22	SAP	Service access point
3.4.23	SDU	Service data unit

3.5 Additional type 24 symbols and abbreviations

3.5.1	ACK	Acknowledge
3.5.2	C1MSG	C1 message
3.5.3	C2MSG	C2 message
3.5.4	I/O	Input and/or output
3.5.5	MSG	Message
3.5.6	Rx	Receive
3.5.7	SDA	Send data with acknowledge
3.5.8	SDN	Send data without acknowledge
3.5.9	SM	State machine
3.5.10	Tcycle	Transmission cycle
3.5.11	Tslot	Time slot
3.5.12	Tx	Transmit

3.6 Common Conventions

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

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

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

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

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

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

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

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

Some entries are further qualified by items in brackets. These may be a parameter-specific constraint:

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

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

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

3.7 Additional Type 24 conventions

3.7.1 Primitive conventions

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

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

3.7.2 State machine conventions

The protocol sequences are described by means of state machines.

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

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

Table 1 – State transition descriptions

No.	Current state	Event /condition =>action	Next state

The description of state machine elements are shown in Table 2.

Table 2 – Description of state machine elements

Description element	Meaning
No	Number of the transition.
Current state, Next state	Names of the originating state and the target state of transition.
Event	Name or description of the trigger event that fire the transition.
/ conditions	Boolean expression, which must be true for the transition to be fired.
=>action	List of assignments and service or function invocations. The action should be atomic. The preceding "=>" is not part of the action.
NOTE "/ conditions" can be omitted.	

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

Table 3 – Conventions used in state machines

Convention	Meaning
+ - * /	Arithmetic operators
:=	Value of an item on the left is replaced by value of an item on the right. If an item on the right is a parameter, it comes from the primitive shown as an input event.
=	A logical condition to indicate an item on the left is equal to an item on the right.
<	A logical condition to indicate an item on the left is less than the item on the right.
>	A logical condition to indicate an item on the left is greater than the item on the right.
<=	A logical condition to indicate an item on the left is less than or equal to the item on the right.
>=	A logical condition to indicate an item on the left is greater than or equal to the item on the right.
<>	A logical condition to indicate an item on the left is not equal to an item on the right.
&&	Logical "AND"
	Logical "OR"

4 Overview of DL-protocol

4.1 Characteristic feature of DL-protocol

Table 4 shows the characteristic features of DL protocol of Type 24.

Table 4 – Characteristic features of the fieldbus data-link protocol

Profiles	Description
Station type and max. stations	-C1 master (active station with bus access control, 1 station (mandatory)) -C2 master (active station with restricted bus access control, max.1 (optional)) -Slave (passive stations without bus access control, max.62)
Station addressing	1 to 255 (255 = global addresses for broad-cast messages), 8 bit-width address extension for integrated device

Profiles	Description
Transmission cycle	31,25 us to 64 ms
DLSDU size	8 to 64 octets
Transmission characteristic	-Cyclic data exchange and cyclic event, synchronized with accurate cycle time (jitter below 1 us) -Max 62 times (n times/1 station) retry within cycle time -Acyclic message transmission

There are three types of stations, C1 master, C2 master and slave. Data exchange is executed between one master station (C1 master or C2 master) and N slave stations. This protocol supports 2 communication modes, cyclic transmission and acyclic transmission.

In cyclic transmission mode, transmission is executed cyclically with an accurate period. The transmission cycle is set by the C1 master to a value within a range of 31,25 [µs] to 64 [ms]. Since the set value of transmission cycle is specific to the transmission line, all of the connected slaves shall support that value. It is not permitted to set different transmission cycle values for slaves connected in the same network.

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

Acyclic transmission mode is used by DLS-user that operates in event driven mode. In acyclic transmission mode, transmissions are executed sporadically. The same transmission sequence and message communication may be executed in acyclic transmission, as in cyclic transmission mode without fixing the transmission cycle.

4.2 DL layer component

DL layer is composed of three sublayers, CTC (Cyclic transmission control), SRC (Send Receive Control) and DLM (Data-link management). SRC is positioned at lower layer of CTC and DLM covers both CTC sublayer and SRC sublayer. The data-link layer component is show in Figure 1.

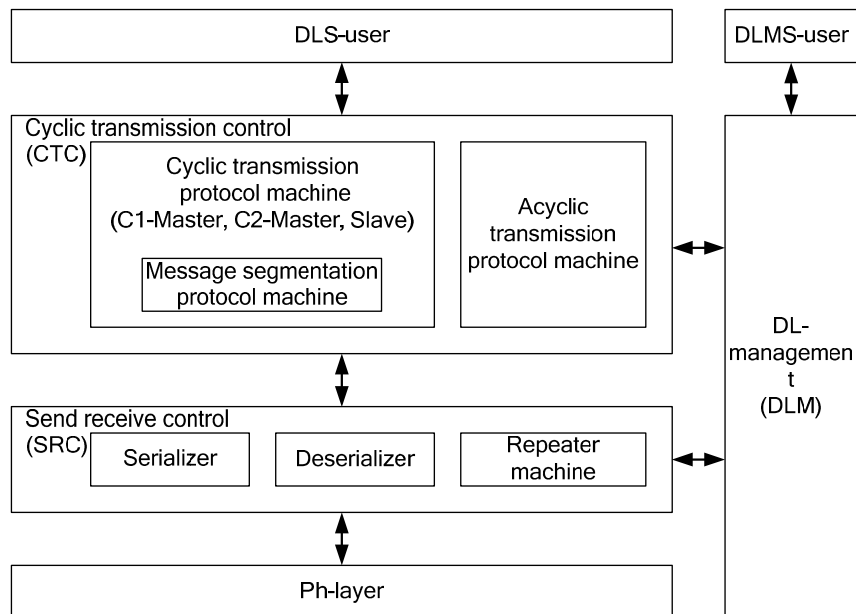


Figure 1 – Data-link layer component

4.2.1 Cyclic transmission control (CTC)

This is a sublayer that builds DLPDU and executes a protocol machine. It has 2 communication modes, i.e. cyclic transmission mode and acyclic transmission mode. CTC executes either of them according to a request from DLMS user.

4.2.2 Send Receive Control (SRC)

SRC sends or receives frames by request of CTC sublayer. It is serialized or de-serialized according to corresponding PHY. When the SRC implements two or more PHY port, the SRC provides frame repeat function between the implemented PHY ports.

4.2.3 DL-management

This is a sublayer that configures DLE operation by setting the internal variables and manages errors detected by each sublayer.

4.3 Timing sequence

4.3.1 Overview

There are two types of transmission mode, cyclic transmission mode and acyclic transmission mode. Cyclic transmission has two types, one is “fixed-width time slot type” whose time slot is same width for all stations and the other is “configurable time slot type” whose time slot can be defined for each station.

The width of the time slot is static in both type, and the value is set by DL-management during initialization. Once cyclic communication starts, it shall not be changed.

4.3.2 Cyclic transmission mode

4.3.2.1 Fixed-width time slot type

4.3.2.1.1 Overview

Figure 2 shows transmission sequence of fixed-width time slot type. In this type, the width of time slots that are allocated to execute exchange of process data one by one between the master and the slave is identical for all slaves. One or more time slots are allocated to each bandwidth shown in the timing chart.

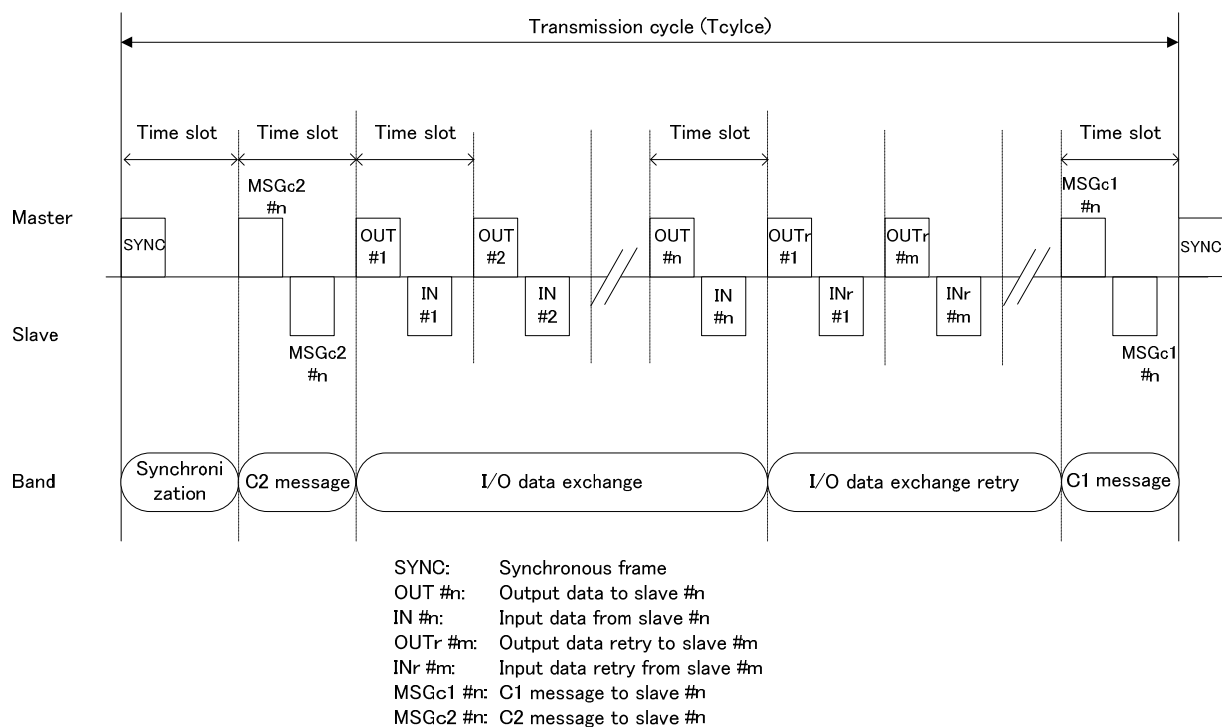


Figure 2 – Timing chart of fixed-width time slot type cyclic communication

4.3.2.1.2 Detailed description of communication band

4.3.2.1.2.1 Synchronization

This is a bandwidth through which C1 master broadcasts a synchronous frame to slave and C2 master. One time slot is allocated to this bandwidth. Within this bandwidth, only the transition of synchronizing frame from C1 master is allowed; slave and C2 master are prohibited transmitting any frame.

4.3.2.1.2.2 C2 message

This is a bandwidth for a message transmission (C2 message transmission) where C2 master is the client (primary station) and C1 master or slave is the server (secondary station). One time slot is allocated to this bandwidth, and request and response are transmitted once, respectively.

4.3.2.1.2.3 I/O data exchange

This is a bandwidth through which C1 master exchanges I/O data with all slaves that are connected to the network. The time slots of the number of slaves are assigned to this bandwidth. C1 master and one slave station execute I/O data exchange once within one time slot.

C1 master registers the slave with which it has failed to exchange I/O data through this bandwidth into the retry list as a retry target for re-transmission through a following I/O data exchange retry bandwidth.

4.3.2.1.2.4 I/O data exchange retry

This is a bandwidth through which C1 master retries the I/O data exchange that has not been completed successfully through the I/O data exchange bandwidth. C1 master re-executes the I/O exchange with the retry target slave that has been registered in the I/O data exchange bandwidth. Time slots of the number that is set in C1 master before starting cyclic transmission are allocated to this bandwidth. C1 master retries according to the registered order of the retry list for up to the number of the allocated time slots. DLE quits retry when it uses all allocated time slots even if a slave that is waiting for retry is registered in the retry list.

C1 master retries the I/O data exchange once for each of the registered slave. If the retry is not completed successfully, C1 master will not repeat the retry for the same slave.

4.3.2.1.2.5 C1 message

This is a bandwidth for a message transmission (C1 message transmission) where C1 master is the client (initiator) and C2 master or slave is the server (responder). One time slot is allocated at the maximum within the bandwidth that is allocated to the retry of the I/O data exchange mentioned above, and request and response are transmitted once, respectively. Because one of the bandwidths for retry of I/O data exchange is allocated as this bandwidth, when all of the time slots allocated for retry are used, C1 message can not be executed within the transmission cycle.

4.3.2.1.3 Estimation of cycle time

The transmission cycle of the fixed-width slot type T_{cycle} is calculated as the sum of the bandwidths described in 4.3.2.2, i.e.:

$$T_{cycle} = T_{sync} + T_{C2msg} + T_{io} + T_{retry} + T_{C1msg}$$

where

T_{sync}	is the Sync band;
T_{C2msg}	is the C2 message band;
T_{io}	is the I/O data exchange band;
T_{retry}	is the I/O data exchange retry band;
T_{C1msg}	is the C1 message band.

An integral multiple of the number of time slots is allocated to the bandwidths. The formula shown above can be transformed by indicating the time slot with T_{slot} , the number of slave stations connected to the network with n , and the number of retry with n_r .

$$\begin{aligned} T_{cycle} &= T_{slot} + T_{slot} + n \times T_{slot} + n_r \times T_{slot} + T_{slot} \\ &= (n + n_r + 3) \times T_{slot} \end{aligned}$$

Time slot T_{slot} can be calculated as shown in the following formula by indicating the frame transmission time (identical to the instruction frame, answer frame, request frame, and response frame) with T_{tr} and the gap between frames with T_{gap} :

$$T_{slot} = \max(T_{tr_c}(n) + T_{dly}(n) + T_{gap} + T_{tr_r}(n) + T_{dly}(n) + T_{gap})$$

$$\diamond = 2 \times \max(T_{tr_c}(n) + T_{dly}(n) + T_{gap})$$

T_{tr_c} is the instruction transmission time from C1 master to the slave n;

T_{tr_r} is the response transmission time from slave n to C1 master;

T_{gap} is the gap between the frames;

T_{dly} is the frame transmission delay time between C1 master and slave n.

4.3.2.2 Configurable time slot type

4.3.2.2.1 Overview

Figure 3 shows transmission sequence of configurable time slot type. In this type, the length of time slots that are allocated to execute exchange of command and response one by one between the master and the slave is differ for each slave. DLE manages the residual time of the transmission cycle by using the time slots configured for each slave by the DLMS user. Details of each transmission bandwidth are described in the following subclauses.

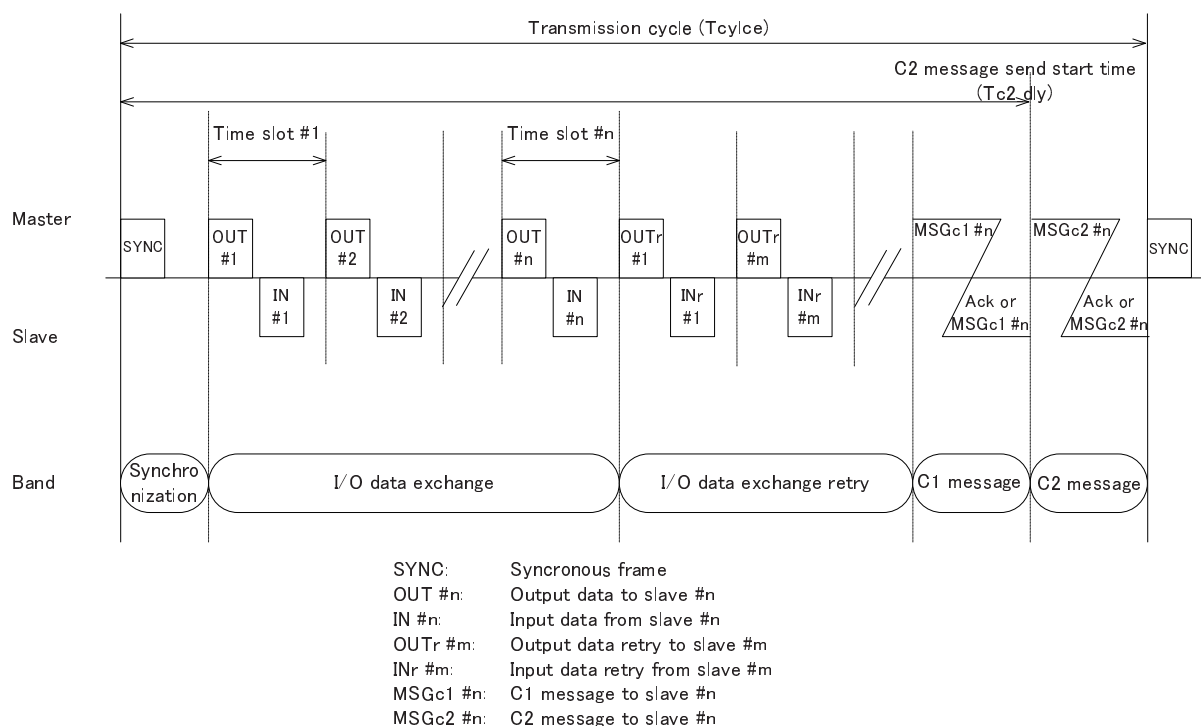


Figure 3 – Timing chart of configurable time slot type cyclic communication

4.3.2.2.2 Detailed description of communication phase

4.3.2.2.2.1 Synchronization

See 4.3.2.1.2.1.

4.3.2.2.2 IO data exchange

This is a bandwidth where C1 master executes I/O data exchange with all slaves connected to the network. The time from the end of Synchronization bandwidth in the head of the transmission cycle to the start of the C2 message is allocated for the bandwidth that aggregates this bandwidth, the succeeding I/O data exchange retry bandwidth, and C1 message bandwidth. C1 master and one slave station execute I/O data exchange once within one time slot.

C1 master registers the slave that fails I/O data exchange within this bandwidth into the retry list as a re-transmission target within the succeeding I/O data exchange retry bandwidth.

4.3.2.2.3 IO data exchange retry

This band is basically same as the case of fixed-width time slot (see 4.3.2.1.2.4). Subclause 4.3.2.2.2.3 describes the differences.

The time from the end of Synchronization bandwidth in the head of the transmission cycle to the start of the C2 message is allocated for the bandwidth that aggregates the I/O data exchange bandwidth, this bandwidth, and C1 message bandwidth. C1 master executes the retry for the slave registered in the retry list in the order of registration, and when the retry succeed, clears the registration. At the same time, C1 master compares the time required to complete the I/O data exchange with the slave and the residual time until the bandwidth ends (until C2 message starts), then executes the retry if the residual time is longer. If the residual time is shorter than the required time, C1 master ends this bandwidth.

C1 master executes the retry for the slave registered in the retry list in the order of registration, and when the retry succeed, clears the registration. When the bandwidth ends before executing the retries for all of the retry targets, C1 master quits retry.

In the case when the retry executed for a registered slave does not completed successfully, C1 master registers the slave again at the end of the retry list. C1 master repeats retry for the identical slave within the residual time of the bandwidth. When the retries for all of the retry targets within the retry list is executed, C1 master retrieves the slave from the retry list and then execute the retry again. C1 master ends the bandwidth when all of the slaves are cleared from the retry list.

4.3.2.2.4 C1 message

This is a bandwidth for a message transmission (C1 message transmission) where C1 master is the client (primary station) and C2 master or slave is the server (secondary station). Residual time from the end of the I/O data exchange retry bandwidth to the start of C2 message transmission is allocated to this bandwidth. C1 master executes the C1 message transmission within the allocated bandwidth. C1 master can repeat the transmission that consists of one request and one response as a pair within this bandwidth. However, C1 master can not execute C1 message transmission if there is no residual time enough for one transmission when the I/O data exchange retry bandwidth ends.

4.3.2.2.5 C2 message

This is a bandwidth for a message transmission (C2 message transmission) where C2 master is the client (primary station) and C1 master or slave is the server (secondary station). Time from the start of C2 message to the end of the transmission cycle is allocated to this bandwidth. C2 master executes the C2 message transmission within the allocated bandwidth. C2 master can repeat the transmission that consists of one request and one response as a pair within the bandwidth.

4.3.2.2.3 Estimation of cycle time

The operation of multiple slaves is synchronized with the command sent by the C1 master. To enable this, the transmission delay time of each slave is measured during initialization. The measured delay time is retained by the C1 master and each slave.

Based on the measured transmission delay time, the C1 master calculates the response monitoring time and the interrupt delay time for each slave to match the communication interrupt timing in the system.

The interrupt delay time is delivered with the synchronous frame (SYN frame in the figure). C1 master and each slave generates communication interrupt timing according to the interrupt delay time and the transmission delay time retained in the local station. As the result, communication interrupt occurs at the same time throughout the system.

By executing data reception processing simultaneously at all slaves at the cyclic event timing, the system can operate synchronously.

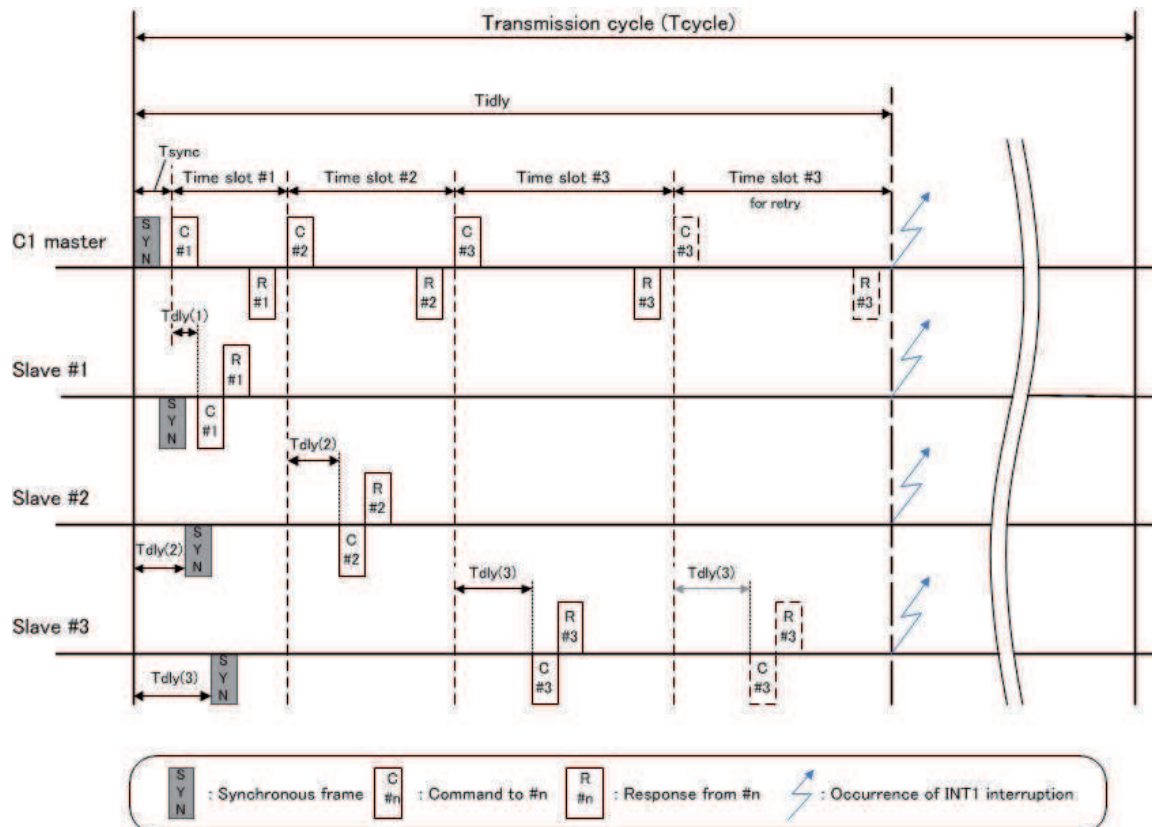


Figure 4 – Schematic Diagram of Communication Interrupt Occurrence

The transmission cycle of variable time slot type T_{cycle} is calculated as an aggregation of the bandwidth described in 4.3.2.3.2, as shown in the following formula:

$$T_{cycle} = T_{sync} + T_{io} + T_{retry} + T_{C1msg} + T_{C2msg}$$

where

- T_{sync} is the Sync band;
- T_{io} is the I/O data exchange band;
- T_{retry} is the I/O data exchange retry band;
- T_{C1msg} is the C1 message band;
- T_{C2msg} is the C2 message band.

The calculation method for the bandwidths mentioned above is shown in the followings.

a) Sync band

Sync bandwidth T_{sync} is calculated as follows: where T_{tr_s} is the transmission time of synchronous frame, and T_{gap} is the gap between the frames:

$$T_{sync} = T_{tr_s} + T_{gap}$$

b) I/O data exchange band

I/O data exchange bandwidth T_{io} is calculated as follows: where N is the number of slave connections, $T_{tr_c}(n)$ is the instruction transmission time from C1 master to the slave of the number n , $T_{dly}(n)$ is the frame transmission delay time between C1 master and the slave of the number n , and T_{gap} is the gap between the frames:

$$\begin{aligned} T_{io} &= \sum_n \{ T_{tr_c}(n) + T_{dly}(n) + T_{gap} + T_{tr_r}(n) + T_{dly}(n) + T_{gap} \} \\ &= \sum_n \{ T_{tr_c}(n) + T_{tr_r}(n) + 2 \times T_{dly}(n) \} + 2 \times N \times T_{gap} \end{aligned}$$

c) I/O data exchange retry band

I/O data exchange bandwidth T_{retry} is calculated as follows: where N_r is the number of retry, $T_{tr_c}(r)$ instruction transmission time from C1 master to the slave of the number r , $T_{dly}(r)$ is the frame transmission delay time between C1 master and the slave of the number r , and T_{gap} is the gap between the frames:

$$\begin{aligned} T_{retry} &= \sum_{ir} \{ T_{tr_c}(r) + T_{dly}(r) + T_{gap} + T_{tr_r}(r) + T_{dly}(r) + T_{gap} \} \\ &= \sum_r \{ T_{tr_c}(r) + T_{tr_r}(r) + 2 \times T_{dly}(r) \} + 2 \times N_r \times T_{gap} \end{aligned}$$

d) C1 message band

C1 message bandwidth T_{c1msg} is calculated as follows: $T_{tr_c1c}(m_1)$ is the request transmission time from the primary station (C1 master) to the secondary station m_1 (m_1 is the station number of slave or C2 master that becomes the secondary station), $T_{tr_c1r}(m_1)$ is the response transmission time from the secondary station to the primary station, $T_{dly}(m_1)$ is the transmission delay between the primary station and the secondary station, N_{c1msg} is the number of the C1 messages, and T_{gap} is the gap between the frames:

$$\begin{aligned} T_{C1msg} &= N_{c1msg} \times \{ T_{tr_c1c}(m_1) + T_{dly}(m_1) + T_{gap} + T_{tr_c1r}(m_1) + T_{dly}(m_1) + T_{gap} \} \\ &= N_{c1msg} \times \{ T_{tr_c1c}(m_1) + T_{tr_c1r}(m_1) + 2 \times T_{dly}(m_1) + 2 \times T_{gap} \} \end{aligned}$$

e) C2 message band

C2 message bandwidth T_{c2msg} is calculated as follows: $T_{tr_c2c}(m_2)$ is the request transmission time from the primary station (C2 master) to the secondary station m_2 (m_2 is the station number of slave or C1 master that becomes the secondary station), $T_{tr_c2r}(m_2)$ is the response transmission time

from the secondary station to the primary station, $T_{dly}(m_2)$ is the transmission delay between the primary station and the secondary station, N_{c2msg} is the number of the C2 messages, and T_{gap} is the gap between the frames:

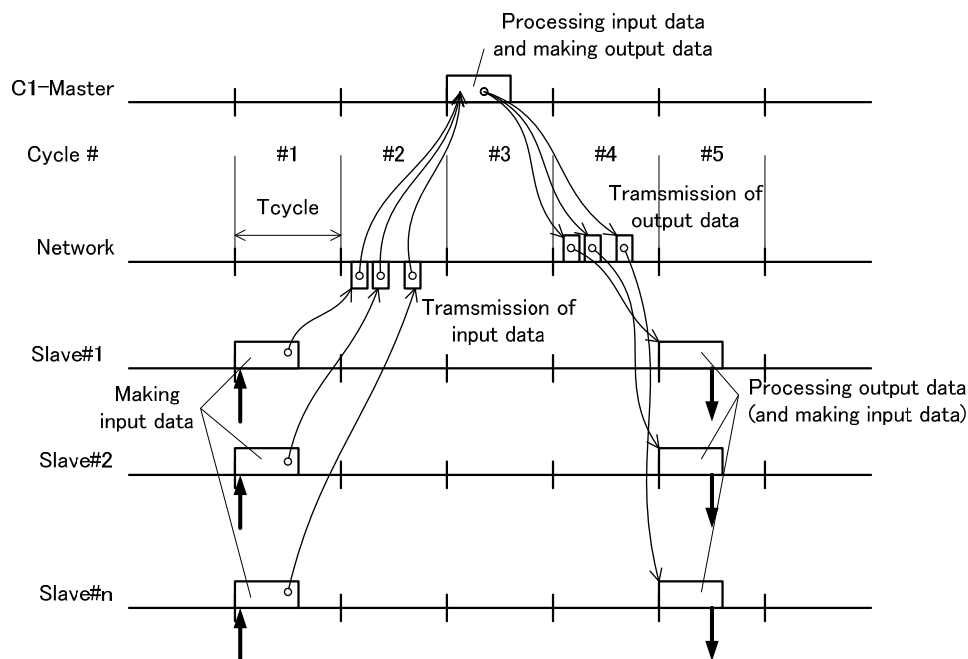
$$T_{c2msg} = N_{c2msg} \times \{T_{tr_c2c}(m_2) + T_{dly}(m_2) + T_{gap} + T_{tr_c2r}(m_2) + T_{dly}(m_2) + T_{gap}\}$$

$$= N_{c2msg} \times \{T_{tr_c2c}(m_2) + T_{tr_c2r}(m_2) + 2 \times T_{dly}(m_2) + 2 \times T_{gap}\}$$

4.3.2.3 Timing relationship between cyclic transmission and data processing

This subclause explains timing relationship between cyclic transmission and data processing by using Figure 5. In cycle #1, the slaves latch input and make the input data to be sent. The input data that the each slave made is transmitted to C1 master in cycle #2. Though it is received by C1 master, it is not processed by C1 master at this time. C1 master starts to process it at the top of the cycle #3. Therefore, the delay from the timing of slave's latched input to the timing of the master processing it is two transmission cycle.

Similarly, the output data that the C1 master made at cycle #3 is transmitted to all slaves, slave by slave, in cycle #4. Though it is received by each slave in cycle #4, it is not processed by the slave at this time. All slaves start to process it all together at the top of cycle #5. Therefore, the delay from the timing of master's making output data to the timing of the slave processing it is two transmission cycles, that is same as input data.



NOTE Output data and input data are transmitted in every cycle, but these drawings are omitted in this figure to explain easily. Data processing by C1 master and slaves in every cycle are also omitted.

Figure 5 – Timing relationship between cyclic transmission and data processing

4.3.3 Acyclic transmission mode

Acyclic transmission may be used in a system that does not require real-time communication or cyclical data exchange. In acyclic transmission mode, it is possible to execute the same transmission sequence as cyclic transmission mode without fixing the transmission cycle. Although

C2 message communication is also possible, the DLS-user shall execute the arbitration of the transmission timing. In acyclic transmission mode, the data length is fixed at 64 octets.

Since acyclic transmission may not use the synchronous frame, slaves execute processing of the output data sent by the master and processing of the data to send the input data at its own timing. (Slaves do not operate simultaneously.)

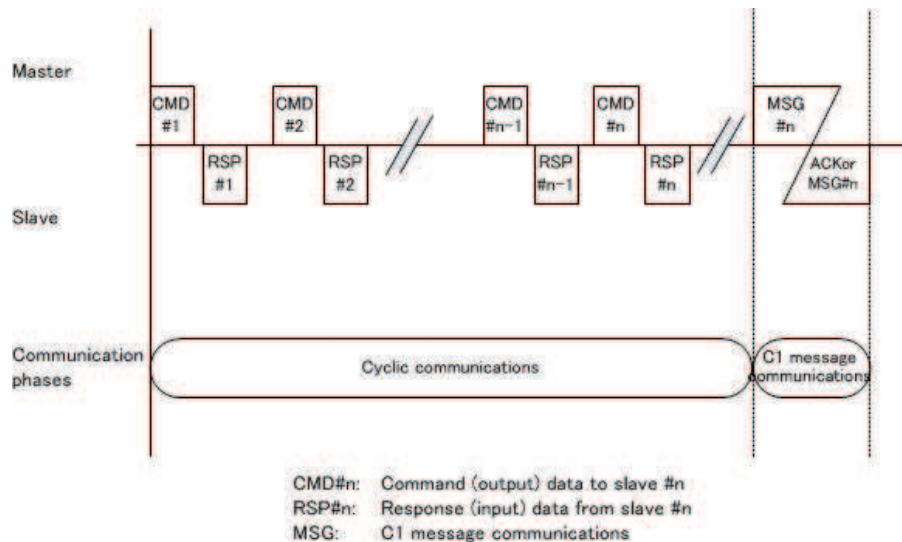


Figure 6 – Timing chart example of acyclic communication

4.4 Service assumed from PhL

4.4.1 General requirement

There are two types of Ph-service which DLE required. One is defined in IEC 61158-2, Type 24 and the other is defined in ISO/IEC 8802-3, Clause 6.

Both PHY requires the following interface elements;

- Transmit Machine
- Receive Machine
- Serializer
- Deserializer

4.4.2 DL_Symbols

The PhL Interface Data Units present at the DLL-PhL interface shall be DL_symbols. DL_symbol shall have one of the following values:

- a) ZERO corresponds to a binary "0";
- b) ONE corresponds to a binary "1".

4.4.3 Assumed primitives of PhS

The PhS is assumed to provide the following two categories of primitives to the Type 24 DL-protocol.

- a) Service primitives for transmitting and receiving frames to / from other peer DLEs.
- b) 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:

- c) Transfer of Data to the corresponding DLE
 - 1) PLS_DATA request
 - 2) PLS_DATA indication
- d) Indication from the local PhL
 - 3) PLS_CARRIER indication
 - 4) PLS_SIGNAL indication
 - 5) PLS_DATA_VALID indication

4.5 Local parameters, variable, counters, timers

4.5.1 Overview

This specification 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. 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 timers shall be initialized to inactive;
- c) all queues shall be initialized to empty.

DL-management may change the values of configuration variables.

4.5.2 Variables, parameters, counters and timers to support DLE function

4.5.2.1 V(MA), P(MA)

This variable is used by the CTC to record station address of this station. This variable shall be implemented by all stations. Its range is 1 to $2^{16}-1$. When the station adopts short format DLPDU, the lower 8 bits of this variable is effective.

4.5.2.2 V(Tcycle), P(Tcycle)

This variable is used by the CTC to record transmission period of cyclic communication. This variable shall be implemented by all stations. The time that a set value indicates depends on V(Tunit). Its range is 1 000 to 64 000.

4.5.2.3 V(Nmax_slaves), P(Nmax_slaves)

This variable is used by the CTC to record the number of connectable slave stations. Its range is 1 to 62.

4.5.2.4 V(Cyc_sel), P(Cyc_sel)

This variable is used by the DLM to record the selection of transmission mode, which is cyclic or acyclic. The value is listed at Table 5.

Table 5 – List of the values of variable Cyc_sel

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

4.5.2.5 V(Nmax_dly_cnt), P(Nmax_dly_cnt)

This variable is used by the DLM to record maximum-measurement-count, which limits the number of delay measurement execution. This variable is implemented only by the C1 master adopts configurable time slot. Its default value is 2. Its range is 2 to 31.

4.5.2.6 V(IO_sz), P(IO_sz)

This variable is used by the CTC to hold and designate the data size of send and receive frame, which is transferred in I/O data exchange band. Its range is 8 to 64. When CTC adopts fixed-width time slot, its value shall be same for all stations.

4.5.2.7 V(Pkt_sz), P(Pkt_sz)

This variable is used by message segmentation machine to record the message packet size of cyclic transmission. Its range is 4 to 500. When CTC adopts fixed-width time slot, its value shall be equal to V(IO_sz).

4.5.2.8 V(Nmax_retry), P(Nmax_retry)

This variable is used by the CTC to record maximum-retry-count, which limits the number of retries in the I/O data exchange retry band. This variable is implemented only by the C1 master. Its default value is 0, meaning retry are not permitted. Its range is 0 to 62.

4.5.2.9 V(Tslot), P(Tslot)

This variable is used by the CTC to hold and designate the value of the timeout time for I/O data exchange to each station. This variable shall be implemented by C1 master and C2 master. Its range is 0 to less than V(Tcycle). The time that a set value indicates depends on V(Tunit). When CTC adopts fixed-width time slot, its value shall be same for all stations.

4.5.2.10 V(Tunit), P(Tunit)

This variable is used by the CTC to record the unit of a set value of the variable concerning time, when the CTC adopts configurable time slot. Table 6 shows its range. This variable shall be implemented only by the CTC which adopts configurable time slot. CTC which adopts fixed-width time slot shall not this variable, and shall use 250 ns as time unit for all variables concerning time.

Table 6 – List of the values of variable Tunit

Value	Definition	Tcycle
0	10 ns	31,25 µs to 500 µs (See NOTE)
1	100 ns	More than 500 µs to 4 ms
2	1 µs	More than 4 ms to 64 ms
NOTE Value 0 is default.		

4.5.2.11 V(Tidly), P(Tidly)

This variable is used by the CTC to record the timing of event, which is issued periodically to synchronize DLS-user. This variable shall be implemented by all stations, which adopt configurable time slot. The value is delay time from the start of cyclic transmission. Its range is 0 to less than V(Tcycle). The time that a set value indicates depends on V(Tunit).

4.5.2.12 V(Tc2_dly), P(Tc2_dly)

This variable is used by the CTC to record the timing to start C2 message communication. This variable shall be implemented by C1 master and C2 master, which adopt configurable time slot. The value is delay time from the end of cyclic transmission. Its range is 0 to less than V(Tcycle). The time that a set value indicates depends on V(Tunit).

4.5.2.13 V(Tmsg), P(Tmsg)

This variable is used by the CTC to record the time period for message communication. This variable shall be implemented by C1 master and C2 master. Its range is 0 to less than V(Tcycle). The time that a set value indicates depends on V(Tunit). When CTC adopts fixed-width time slot, its value shall be same for all stations.

4.5.2.14 V(Twrpt)

This variable is used by the SRC to record the time period for transmission delay measurement. This variable shall be implemented by C2 master and slave. Its range is V(Tslot) x 3 to less than 64 ms. The default value is 500 µs. The time that a set value indicates depends on V(Tunit).

4.5.2.15 V(IO_MAP), P(IO_MAP)

This variable is used by the DLM and CTC to record the information of the slaves and C2 master which to be connected in the network. See IEC 61158-3-24, 5.3.2.2.13 for the details.

4.5.2.16 V(Sts_STI), P(Sts_STI)

This variable is used by the DLM to hold the connection status of the stations which to be connected in the network. See IEC 61158-3-24, 5.3.3.2.2.1 for the details.

4.5.2.17 V(Sts_Err), P(Sts_Err)

This variable is used by the DLM to hold the error factor which occurred in the DLE.

4.5.2.18 V(Fc2msg)

This variable is used by the CTC to hold the presence of C2 message communication bandwidth in cyclic transmission mode. This variable shall be implemented by C1 master and C2 master. Its value is 0 or 1. The value shall be set to 1 when C1 message communication bandwidth is assigned, and set to 0 when it is not assigned.

4.5.2.19 V(Nslave)

This variable is used by the CTC to hold and designate slave number, which is being processed in the current time slot. This variable shall be implemented by C1 master and C2 master. Its range is 0 to V(Nmax_slaves). The value is reset to zero at the start of each cycle of cyclic transmission. And it is incremented when I/O data exchange to a slave is executed.

4.5.2.20 V(Nretry)

This variable is used by the CTC to hold and designate the element of retry list, which is being processed in the current time slot. The value is reset to zero at the start of each cycle of cyclic