

Fieldbus —

Part 4: Specification for Data link protocol

ICS 25.040.40; 35.100.20

NO COPYING WITHOUT BSI PERMISSION EXCEPT AS PERMITTED BY COPYRIGHT LAW

BSI
Documents

AVA

Document Sharing Hub

Committees responsible for this Draft for Development

The preparation of this Draft for Development was entrusted to Technical Committee AMT/7, Monitoring and control aspects of advanced manufacturing technology, upon which the following bodies were represented:

ABB Kent plc
Cegelec Industrial Controls Ltd.
Department of Trade and Industry
Fisher-Rosemount Ltd.
Foxboro Great Britain
Institution of Electrical Engineers
Measurement Technology Ltd.
Process Automation and Computer Systems Ltd.
Schneider Ltd.
Siemens Automation plc

This Draft for Development, having been prepared under the direction of the Advanced Manufacturing Technology Assembly, was published under the authority of the Standards Board and comes into effect on 15 October 1996

© BSI 05-2000

The following BSI reference relates to the work on this Draft for Development:
Committee reference AMT/7

ISBN 0 580 26499 8

Amendments issued since publication

Amd. No.	Date	Comments

Contents

	Page
Committees responsible	Inside front cover
Foreword	ii
1 Scope	1
1.1 Notation used to show the subset	1
1.2 Conformance to Full set	1
2 Overview	1
3 Architecture	1
4 References	2
4.1 Reference notation	2
5 Overview of the DL-protocol	2
5.7 Local parameters, variables, counters, timers and queues	3
5.7.1 Parameters, variables, counters, timers and queues to support the Basic class	3
5.7.2 Parameters and timers to support a DLS-user's request	3
5.7.3 Queues to support a DL-address-based DL-scheduling	3
5.7.4 Variables and timers to support a DLCEP	4
5.7.5 Variables and timers to support the Link Master class	4
5.7.6 Variables and timers to support the Bridge class	5
6 Common DLPDU structure, encoding and elements of procedure	5
7 DLPDU-specific structure, encoding and elements of procedure	5
8 DLPDU-parameter structure and encoding	16
8.1 Structure and encoding of EC-PARAMETERS	16
8.2 Structure and encoding of DC-PARAMETERS	16
8.6 Structure and encoding of TD-parameters	17
9 DL-service elements of procedure	18
9.1 Operation of the DL(SAP)-address, buffer and queue management services	18
9.2 Operation of the connection-mode services	18
9.2.1 Operation of the DLCEP establishment and DLCEP release services	18
9.2.2 Operation of the DLC data transfer services	28
9.2.3 Operation of the DLC subscriber query service	39
9.3 Operation of the connectionless-mode services	39
9.3.1 Operation of the connectionless data transfer with local-DLE-confirmation service	40
9.4 Operation of the scheduling guidance services	40
9.4.1 Operation of the DL-time service	40
9.4.2 Operation of the compel-service service	41
10 Other DLE elements of procedure	42
11 Implementation profiles	45
11.1 Implementation Profiles for DD 238 subset	45
Annex A Structure and definition of DL-addresses	46
Annex B DL-support sub-protocol	47
Figure 1 — Data Link Layer and the DD 238 Architecture	2
Table 1 — Summary structure of DLPDUs included in this subset	5
Table A.5 — predefined flat non-local DL-addresses	46
Table A.6 — predefined flat link-local DL-addresses	47
Table A.7 — predefined node-local DL-addresses	47
Table B.37 — Element-description	50

Foreword

This Part of DD 238 has been prepared by Technical Committee, AMT/7. It supersedes DD 236-4:1996, which is withdrawn.

Portions of this document are owned by Fieldbus Foundation and are being used with their expressed written permission.

This publication contains the following parts:

- *Part 1: Guide to system architecture*; (Equivalent to FF-800 Revision 1.0¹⁾)
- *Part 2: Specification for 31.25 kbit/s Physical layer profile*; (Equivalent to FF-816 Revision 1.0¹⁾)
- *Part 3: Specification for Data link layer services subset*; (Equivalent to FF-821 Revision 1.0¹⁾)
- *Part 4: Specification for Data link protocol*; (Equivalent to FF-822 Revision 1.0¹⁾)
- *Part 5: Specification for Fieldbus access sublayer (Services and protocol)*; (Equivalent to FF-875 Revision 1.0¹⁾)
- *Part 6: Fieldbus Message Specification*; (Equivalent to FF-870 Revision 1.0¹⁾)
- *Part 7: Fieldbus management*;
- *Section 7.1: Specification for System management*; (Equivalent to FF-880 Revision 1.0¹⁾)
- *Section 7.2: Specification for Network management*. (Equivalent to FF-801 Revision 1.0¹⁾)

This Draft for Development is not to be regarded as a British Standard.

It is being issued in the Draft for Development series of publications and is of a provisional nature because the subject matter is still under development requiring wider exposure. It should be applied on this provisional basis, so that information and experience of its practical application may be obtained.

A review of this Draft for Development will be carried out not later than 2 years after its publication. Notification of the start of the review period, with a request for the submission of comments from users of this Draft for Development, will be made in an announcement in the appropriate issue of *BSI Update*.

According to the replies received, the responsible BSI Committee will judge whether the Draft for Development can be converted into a British Standard or what other action should be taken.

Observations which it is felt should receive attention before the official call for comments will be welcomed.

These should be sent to the Secretary of BSI Technical Committee AMT/7 at BSI, 389 Chiswick High Road, London, W4 4AL, giving the document reference and clause number and proposing, where possible, an appropriate revision of the text.

¹⁾ Available from the Fieldbus Foundation, 9390 Research Boulevard, Suite II-250, Austin, Texas 78759, USA.

Disclaimer of warranties

This document is provided on an “as is” basis and may be subject to future additions, modifications, or corrections depending on the results of field trial testing. BSI and the Fieldbus Foundation hereby disclaims all warranties of any kind, express or implied, including any warranty of merchantability or fitness for a particular purpose, for this document. In no event will they be responsible for any loss or damage arising out of or resulting from any defect, error or omission in this document or from anyone’s use of or reliance on this document.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 50 and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

The purpose of this part of DD 238 is to define the Data Link Layer protocol. The Fieldbus Data Link protocol specification in this document is a subset of the specifications described in the IEC Data Link layer. This subset is selected to provide the services defined in DD 238-3 Data Link layer services. In addition, this subset includes node initialization, link initialization, address assignment, time-synchronous scheduling, and “Token-passing”. This document specifies:

- a) the elements of procedure to describe the interactions between a DL-service (DLS) provider and a DLS-user for all service primitives;
- b) the structure of the Fieldbus Data Link (DL) Protocol Data Units used for the transfer of data and control information, and their representation as Physical Interface Data Units;
- c) the interactions among two or more DL-entities (DLEs) through the exchange of Fieldbus Data Link Protocol Data Units.

The base document is IEC/CDV 1158-4 (65C/161/CDV). The base document and this document together form the complete specifications.

1.1 Notation used to show the subset

Every section and subsection of the base document belongs to one of the following three categories for the purpose of including it in this subset:

- Included — Y: the entire section or subsection and its subsections, if any, are included in this subset,
- Included — No: the entire section or subsection and its subsections, if any, are excluded from this subset,
- Included (partially) — Y: part of the section or subsection is included in this subset; the text in this document specifies what parts are excluded and what parts are included. For most sections of this category, the specifications applicable to this subset is reprinted from the base document.

1.2 Conformance to Full set

This subset of Data Link layer protocol is selected to support only the services defined in DD 238-3. Therefore, this subset may not interoperate completely with the devices of a bigger subset or full set of IEC/CDV 1158-4 (65C/161/CDV). However, it is possible, and permitted to implement a bigger subset of IEC/CDV 1158-4 (65C/161/CDV), such that a device with a bigger subset interoperates completely with the devices which implement only this subset.

2 Overview

This subset includes three level model of DLL [IEC/CDV 1158-4: section 5.1]. The higher-level is specified as elements of procedure. Only the procedures to support the services subset DD 238-3 are part of this subset. This subset includes all three functional classes — Basic, Link Master and Bridge, specified in IEC/CDV 1158-4: section 5.6]. All functions and DLPDUs supported by these three classes as specified in IEC/CDV 1158-4: Table 1 are part of this subset, except as specified below:

- Transmission and reception of RC DLPDU;
- Transmission and reception of Compel Acknowledge (CA) and Exchange Data (ED);
- Transmission and reception of Execute Sequence (ES);
- Transmission and reception of Wakeup (WK);
- The FDC (Fraction Duty Cycle) DLE;
- Update of Bridge routing table based on received DLPDU.

3 Architecture

The Data Link Services are provided by the Data Link Protocol which are described in this document. The relationship between DD 238 Specifications for Fieldbus Data Link, Fieldbus Physical Service, and other layers is illustrated in Figure 1. The interface between Data Link Layer Management Entity and the Data Link Layer and the local Network Manager Agent is not specified, because this interface is local to DLE and it does not affect InterOperability.

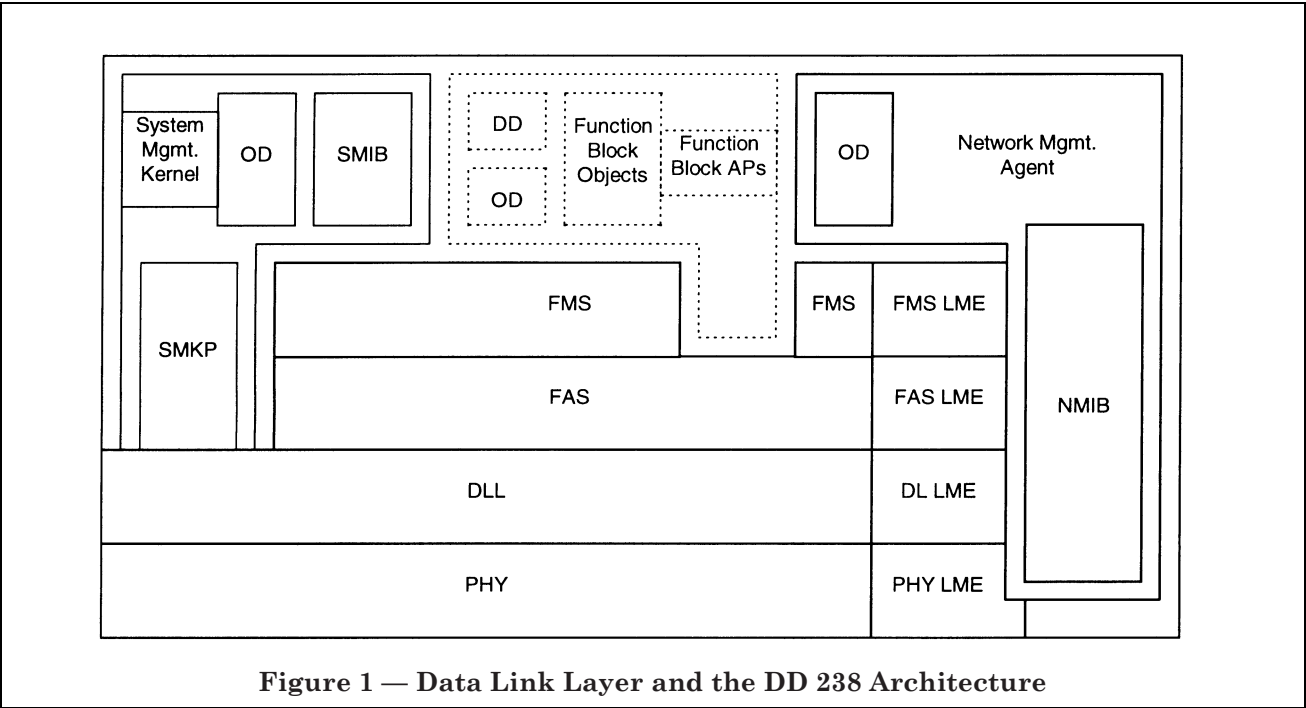


Figure 1 — Data Link Layer and the DD 238 Architecture

4 References

IEC/CDV 1158-3 (65C/160A/CDV), *Digital data communications for measurement and control — Field bus for use in industrial control systems — Part 3: Data link service definition.*
IEC/CDV 1158-4 (65C/161/CDV), *Digital data communications for measurement and control — Field bus for use in industrial control systems — Part 4: Data link protocol specification.*

DD 238 Fieldbus
Part 3 Specification for data link services subset

4.1 Reference notation

This document specifies the subset of IEC Data Link Layer protocol by reference. The notation used is [IEC/CDV 1158-4: section number].

5 Overview of the DL-protocol

	Included	Included (partially)	Comments
5.1 Three-level model of the DLL (including all subsections)	Y		
5.2 Service provided by the DLL		Y	This section is the summary of service definitions. See DD 238-3 for details
5.3 DL-addresses	Y		
5.4 Service assumed from the Physical Layer (including all subsections)	Y		
5.5 Functions of the DLL (including all subsections)		Y	All types of functions specified in each subsections are included, but only to the extent necessary required by the services of DD 238-3.
5.6 Functional classes (including all subsections)	Y		

5.7 Local parameters, variables, counters, timers and queues

5.7.1 Parameters, variables, counters, timers and queues to support the Basic class

	Included	Included (partially)	Comments
5.7.1.1 V(ST) slot-time	Y		
5.7.1.2 V(PhLO) per-DLPDU-PhL-overhead	Y		
5.7.1.3 V(MRD) maximum-response-delay	Y		
5.7.1.4 V(IRRd) immediate-response-recovery-delay	Y		
5.7.1.5 V(MRC) maximum-retry-count		Y	Number of retries is always 0 for this subset.
5.7.1.6 V(NRC) network-repeat-count		Y	Number of retries is always 0 for this subset.
5.7.1.7 V(NDL) network-DLPDU-lifetime		Y	Network-DLPDU-lifetime is always 0 for this subset.
5.7.1.8 V(TN) this-node	Y		
5.7.1.9 V(TL) this-link	Y		
5.7.1.10 V(MEP) DL-MAC-address-embedding-prefix		Y	This variable is not used by the protocol.
5.7.1.11 C(RD) remaining-duration counter	Y		
5.7.1.12 V(MID) minimum-inter-DLPDU-delay	Y		
5.7.1.13 T(IRRd) immediate-response-recovery-delay monitor	Y		
5.7.1.14 V(RA) reply-address	Y		
5.7.1.15 V(OTA) outstanding-transaction-array	No		Not required, because V(MRC) = 0
5.7.1.16 V(LTI) last-transaction-index	No		Not required, because V(MRC) = 0
5.7.1.17 Q(US) unscheduled-service queue		Y	References to user requests per clause a.1), a.3) and a.4) only; clauses a.2), b) and c) do not apply to this subset.
5.7.1.18 V(RID) random identifier	Y		
5.7.1.19 C(NT) node-time counter	Y		
5.7.1.20 V(LSTO) local-link-scheduling-time-offset	Y		
5.7.1.21 V(DLTO) DL-time-offset	Y		
5.7.1.22 V(TQ) time-quality	Y		
5.7.1.23 V(MD) measured-delay	Y		
5.7.1.24 V(LN) LAS-node	Y		
5.7.1.25 V(TSC) time-synchronization-class	Y		
5.7.1.26 T(TDP) time-distribution-period monitor	Y		
5.7.1.27 V(TSL) time-source-link	Y		

5.7.2 Parameters and timers to support a DLS-user's request

	Included	Included (partially)	Comments
5.7.2.2 P _U (SDU) DLSDU request parameter	Y		
5.7.2.3 P _U (MCD) maximum-confirm-delay parameter	Y		
5.7.2.4 T _U (MCD) maximum-confirm-delay monitor	Y		

5.7.3 Queues to support DL-address-based DL-scheduling

	Included	Included (partially)	Comments
5.7.3.1 Q _A (UR) user-request queue	Y		

5.7.4 Variables and timers to support a DLCEP

	Included	Included (partially)	Comments
5.7.4.1 $V_C(ST)$ DLCEP state	Y		
5.7.4.2 $V_C(NP)$ negotiated DLCEP parameters	Y		
5.7.4.3 $V_C(N)$ next sequence number to assign to a DLSDU	Y		
5.7.4.4 $V_C(R)$ maximum non-transmittable DLSDU sequence number	No		Not required for DLCEP data delivery features of this subset
5.7.4.5 $V_C(A)$ maximum acknowledged DLSDU sequence number		Y	Only for CLASSICAL and DISORDERED Peer DLC
5.7.4.6 $V_C(M)$ maximum transmitted DLSDU sequence number	Y		
5.7.4.7 $V_C(MS)$ maximum transmitted DLSDU segment number	No		Max DLSDU size is restricted to one segment
5.7.4.8 $V_{C,K}(SS)$ segments to send		Y	Number of segments is always one; only for CLASSICAL and DISORDERED Peer DLC
5.7.4.9 $T_{C,K}(SS)$ sent-segments monitor	Y		
5.7.4.9.1 $T_C(SS)$ simplified sent-segments monitor	Y		
5.7.4.10 $V_C(L)$ last-reported DLSDU sequence number	Y		
5.7.4.11 $V_C(H)$ highest-detected DLSDU sequence number	Y		
5.7.4.12 $V_C(HS)$ highest-detected segment number of the highest-detected DLSDU sequence number		Y	Max DLSDU size is restricted to one segment
5.7.4.13 $V_{C,K}(MRS)$ missing received segments		Y	Number of segments is always one; only for CLASSICAL and DISORDERED Peer DLC
5.7.4.14 $V_{C,K}(RRS)$ retransmission-request required segments		Y	Number of segments is always one; only for CLASSICAL and DISORDERED Peer DLC
5.7.4.15 $T_{C,K}(RRS)$ retransmission request monitor	No		Not required for DLCEP data delivery features of this subset
5.7.4.16 $T_C(RAS)$ residual activity stimulus	Y		
5.7.4.17 $T_C(RAM)$ residual activity monitor	Y		
5.7.4.18 $V_C(TNA)$ DL-time of last network access	Y		
5.7.4.19 $V_B(TW)$ DL-time of last buffer write	Y		
5.7.4.20 $V_B(TP)$ DL-time of production	No		Time-of-production is not included in this subset.
5.7.4.21 $V_B(TS)$ Timeliness-status of buffer write	Y		

5.7.5 Variables and timers to support the Link Master class

	Included	Included (partially)	Comments
5.7.5.1 $V(DTA)$ delegation-address	Y		
5.7.5.2 $V(LL)$ local-link live-list	Y		
5.7.5.3 $V(TCL)$ token-circulation list	Y		
5.7.5.4 $V(ENRL)$ expected-non-response list	No		Fraction Duty Cycle DLE is not included in this subset.
5.7.5.5 $V(MST)$ maximum-scheduled-traffic	No		LAS does not construct the schedule for this subset.
5.7.5.6 $V(MSO)$ maximum-scheduling-overhead	Y		
5.7.5.7 $V(DMDT)$ default-minimum-token-delegation-time	Y		
5.7.5.8 $V(DTHT)$ default-token-holding-time	Y		
5.7.5.9 $V(LTHT)$ link-maintenance-token-holding-time	Y		
5.7.5.10 $V(MTHA)$ maximum-token-holding-time-array	Y		
5.7.5.11 $V(TTRT)$ target-token-rotation-time	Y		
5.7.5.12 $V(ATRT)$ actual-token-rotation-time	Y		
5.7.5.13 $V(RTHA)$ remaining-token-holding-time-array	Y		
5.7.5.14 $V(NTHN)$ next-token-holding-node	Y		
5.7.5.15 $V(FUN)$ first-unpolled-node	Y		
5.7.5.16 $V(NUN)$ number-of-consecutive-unpolled-nodes	Y		
5.7.5.17 $P(TRD)$ token-recovery-delay	Y		
5.7.5.18 $V(TDP)$ time-distribution-period	Y		
5.7.5.19 $V(MICD)$ maximum-inactivity-to-claim-LAS-delay	Y		
5.7.5.20 $V(LDDP)$ LAS-data-base-distribution-period	Y		

5.7.6 Variables and timers to support the Bridge class

	Included	Included (partially)	Comments
5.7.6.1 V(ML) maximum-link	Y		

6 Common DLPDU structure, encoding and elements of procedure

All sub-sections of IEC/CDV 1158-4: section 6 are included in this subset.

7 DLPDU-specific structure, encoding and elements of procedure

This section specifies the low-level of path-access-and scheduling functions by describing the protocol for all types of DLPDUs. The DLPDUs shown in Table 7.1 are included in this subset. The subsections “7.x.4.3 Additional actions required of a Bridge class DLE” apply only for forwarding the DLPDU. The bridge function of this subset does not include updating its routing tables based on the received DLPDU.

Table 1 — Summary structure of DLPDUs included in this subset

DLPDU class	frame control	DL-addresses			parameters	user data
		destination	source	2nd source		
EC 1	1111 LF00	[HL.]N.S	[HL.]N.S	[HL.]N.S	EC-p	o-DLSDU
EC 2	1110 LF00		[HL.]N.S	[HL.]N.S	EC-p	o-DLSDU
DC 1	0111 LF00	[HL.]N.S	[HL.]N.S		DC-p	o-DLSDU
DC 2	0110 LF00		[HL.]N.S		DC-p	o-DLSDU
CD 1	1111 LFPP	[HL.]N.S	[HL.]N.S		—	—
CD 2	1011 LFPP	[HL.]N.S	—		—	—
DT 1	1101 LFPP	[HL.]N.S	[HL.]N.S		SD-p	o-DLSDU
DT 2	1001 LFPP	[HL.]N.S	—		SD-p	o-DLSDU
DT 3	0101 LFPP		[HL.]N.S		SD-p	o-DLSDU
DT 5	0101 0F00		[PDA]		SD-p	o-DLSDU
SR	0001 0F11	[PSA]	N		o-SR-p	—
CT	0001 0F00	—	—		—	—
TD	0001 0F01	—	N		TD-p	—
RQ	1100 0F00	N.0	N.0		RQ-p	—
RR	1101 0F00	N.0	N.0		RR-p	—
PN	0010 0110	N	—		PN-p	—
PR	0010 0111	—	—		—	SPDU
PT	0011 0FPP	N	—		DD-p	—
RT	0011 0100	—	[DTH]		—	—
RI	0010 0000	—	[DTH]		DD-p	—
CL	0000 0001	—	N		—	—
TL	0000 0110	N	—		—	SPDU
Idle	0001 0F10	—	—		—	o-DLSDU

LEGEND:

L indicates the length of the associated DL-addresses (0 = SHORT, 1 = LONG)

F indicates final use of a token, or that a sequence should be finished rather than restated

PP specifies the priority of the DLPDU and any passed token

shading indicates a logically non-existent field

— indicates a logically existent field whose contents are required to be null

[HL.]N.S is a four-octet LONG DL-address (HLNS) when L = 1 or a two-octet SHORT DL-address (NS) with HL=00 implied when L = 0

N is a one-octet NODE DL-address

N.0 is the two-octet SHORT DL-address form of a one-octet NODE DL-address

[PDA] is the implied DL-address equal to the explicit destination DL-address of the immediately prior DLPDU on the link, which must have been a CD DLPDU

[PSA] is the implied DL-address equal to the implied or explicit source Db-address of the immediately prior DLPDU on the link

o-indicates optional field contents

xx-p indicates xx-class DLPDU parameters

DLSDU is a DL Service Data Unit

SPDU is a Support Protocol Data Unit

	Included	Included (partially)	Comments
7.1 Establish Connection (EC) DLPDU	Y		
7.2 Disconnect Connection (DC) DLPDU	Y		
7.3 Reset Connection (RC) DLPDU	No		DLC Reset is not part of the services included in this subset.
7.4 Compel Acknowledgment (CA) DLPDU	No		Acknowledgment from the remote DLE is not required for the services included in this subset.
7.5 Compel Data (CD) DLPDU		Y	See the text for details.
7.6 Exchange Data (ED) DLPDU	No		DL-Unitdata Exchange service is not included in this subset., and it is not necessary to support two way data exchange for connection-oriented data transfer.
7.7 Data (DT) DLPDU		Y	See the text for details.
7.8 Status Response (SR) DLPDU		Y	See the text for details.
7.9 Compel Time (CT) DLPDU	Y		
7.10 Time Distribution (TD) DLPDU	Y		
7.11 Round-Trip-Delay Query (RQ) DLPDU		Y	Only local LAS, 0400 ₁₆ , as destination address is included.
7.12 Round-Trip-Delay Reply (RR) DLPDU		Y	Only the LAS DLE is required to send RR DLPDU for this subset.
7.13 Probe Node DL-address (PN) DLPDU	Y		
7.14 Probe Response (PR) DLPDU	Y		
7.15 Pass Token (PT) DLPDU		Y	See the text for details.
7.16 Execute Sequence (ES) DLPDU	No		The schedule is executed only by the LAS.
7.17 Return Token (RT) DLPDU	Y		
7.18 Request Interval (RI) DLPDU	Y		
7.19 Claim LAS (CL) DLPDU	Y		
7.20 Transfer LAS (TL) DLPDU		Y	See the text for details.
7.21 Wakeup (WK) DLPDU	No		Fraction Duty Cycle (FDC) DLE is not included in this subset.
7.22 Idle (IDLE) DLPDU	Y		
7.23 Spare DLPDU's	Y		
7.24 Reserved (can't use) DLPDU's	Y		

7.5 Compel Data (CD) DLPDU

In IEC/CDV 1158-4: section 7.5, the COMPEL DATA (CD) DLPDU is used by a DLE to request the transfer of user data from another DLE and the destination address of a CD can be DLCEP or DLSAP. In this subset, CD is used only by the LAS or by a subscriber to request the transfer of user data from a publishing DLCEP.

	Included	Included (partially)	Comments
7.5.1 Structure of the CD DLPDU's		Y	No SD-parameter
7.5.2 Content of the CD DLPDU		Y	Only DLCEP-address as destination
7.5.2.1 Content of the CD DLPDU when specifying a destination DLSAP-address	No		
7.5.2.2 Content of the CD DLPDU when specifying a destination DLCEP-address		Y	Only publisher's DLCEP-address as destination is included. See text for details
7.5.3 Sending the CD DLPDU		Y	Destination is not DLSAP-address, there is no immediate retry. See text for details.
7.5.4 Receiving the CD DLPDU		Y	Only publisher's DLCEP-address as destination is included, there is no immediate retry. CD with peer's DLCEP-address as destination address is ignored by the receiving DLE. See text for details.
7.5.4.1 Actions required of all DLEs		Y	a), b) are not included; c) and d) apply only to publisher; e) is included. See text for details.
7.5.4.2 Additional actions required of a Link-Master class or Bridge class DLE	Y		
7.5.4.3 Additional actions required of a Bridge class DLE		Y	There is no immediate retry. See text for details.
7.5.4.4 Additional actions required of the current LAS DLE	Y		

7.5.1 Structure of the CD DLPDU

All formats, but with null SD-parameter are included in this subset.

7.5.2 Content of the CD DLPDU

The destination address shall be DLCEP-address. The source address, if present shall be subscriber's DL-address.

7.5.2.1 Content of the CD DLPDU when specifying a destination DLSAP-address

This section does not apply.

7.5.2.2 Content of the CD DLPDU when specifying a destination DLCEP-address

When the first address is a DLCEP-address, as in [7.5.2 b)] and [7.5.2 c)], then

- a) this DLPDU shall request state information from the addressed DLCEP, and shall request that DLS-user data be included in the reply DLPDU, and
- b) the second address, if present, shall be a subscriber DLCEP's calling-DLSAP-address of the same DLC as the destination publisher DLCEP-address; and
- c) the SD-parameters field shall not be present; and
- d) the user data shall be null.

NOTE 3 Formats 1L and 1s are used for subscriber-to-publisher [7.5.2 c)] communications when the DLPDU-authentication attribute is SOURCE. Formats 2L and 2s are used for subscriber-to-publisher communications when the DLPDU-authentication attribute is ORDINARY.

7.5.3 Sending the CD DLPDU

A CD DLPDU may be selected for transmission on the link when

- a) the sending DLE holds a scheduler token or delegated token which is the dominant token on the local link, and
- b) the remaining allocated duration of token usage, C(RD), permits completion of the transactions prior to expiration of the token, where the transaction consists of sending the CD DLPDU that requires an immediate reply, and awaiting a worst-case SR DLPDU or worst-case permitted DT reply DLPDU containing DLS-user data.

If the DLE holds a delegated token, and no additional use of that token after sending this DLPDU and awaiting its immediate reply is needed at that time, then the DLE may set the final-token-use subfield of the CD DLPDU to the value FINAL; else that subfield shall have the value NOT-FINAL.

Each explicit DL-address in the CD DLPDU shall be delocalized [6.2.2] before transmission.

After sending a CD DLPDU, the sending DLE shall monitor the local link for a reply as specified in [6.2.7.1].

The permissible reply DLPDU is either,

- a DT DLPDU without a destination DL-address, or
- an SR DLPDU.

NOTE 1 The received DLPDU is processed as specified in [7.7.4] and [7.8.4].

NOTE 2 These DL-management reports may take the form of incrementing a DL-management error counter.

7.5.4 Receiving the CD DLPDU

Each DL-address in the DLPDU shall be delocalized [6.2.2] upon reception.

A received CD DLPDU shall be treated as follows by the receiving DLE:

7.5.4.1 Actions required of all DLEs

NOTE 1 The clause c) is included only for publisher DLCEP. For this subset, CD addressed to peer DLCEP is ignored.

- c) If the destination DL-address specified by the DLPDU designates an active DLCEP-address of a DLC for which the receiving DLE
 - is a publisher, and the DLL priority of the DLCEP is not equal to the priority specified in the received DLPDU, then the receiving DLE shall initiate a reply within a period of maximum-response-delay slot-times, $V(MRD) \times V(ST)$ octet-durations, of receipt of the CD DLPDU. The reply DLPDU shall be a DT DLPDU in the format negotiated for the DLC for the selected direction of transmission, and shall contain SD-parameters appropriate to the sending DLCEP, but shall not contain DLS-user-data.

— is a peer, then the receiving DLE shall ignore the received DLPDU.

d) If c) does not apply, and the destination DL-address specified by the DLPDU designates an active DLCEP-address of a DLC for which the receiving DLE is a publisher, then

2) The receiving DLE shall initiate a reply within a period of maximum-response-delay slot-times, $V(MRD) \times V(ST)$ octet-durations, of receipt of the CD DLPDU. The reply DLPDU shall be a DT DLPDU in the format negotiated for the DLC for the selected direction of transmission, shall contain SD-parameters appropriate to the sending DLCEP, and shall contain DLS-user-data if any was available and waiting for transmission or retransmission from the DLCEP.

e) If the destination DL-address specified by the DLPDU designates an active DLCEP-address of a DLC for which the receiving DLE is a subscriber, then

2) The receiving DLE shall record the destination DL-address from the received CD DLPDU in $V(RA)$ for subsequent association with the expected immediate reply DT DLPDU, which should be the next DLPDU received.

3) The receiving DLE shall monitor the local link for a reply and then act based on the result of that monitoring, all as specified in [6.2.7.3].

7.5.4.3 Additional actions required of a Bridge class DLE

i) If the destination DL-address specified in the DLPDU is one which the bridge should forward but which the bridge DLE itself would not otherwise receive, then the bridge shall form and send an SR DLPDU,

— within a period of maximum-response-delay slot-times, $V(MRD) \times V(ST)$ octet-durations, of receipt of the CD DLPDU,

— with status indicating whether or not the bridge was able to buffer the received DLPDU.

ii) If the destination DL-address specified in the DLPDU is one which the bridge should forward, and the bridge was able to receive and buffer the DLPDU without error, then the received DLPDU shall be forwarded with modification of the frame-control field in the forwarded DLPDU as appropriate [6.1.1.3].

It is a protocol error for a bridge DLE which will forward the received CD DLPDU to not send an SR reply DLPDU when a reply is required.

NOTE At most one bridge DLE on the local link should be forwarding the received CD DLPDU.

7.7 DATA (DT) DLPDU

A DATA (DT) DLPDU is used to transfer a limited amount of transparent user data from one DLS-user to one or more other DLS-users; to acknowledge the transfer of such data; and to assist in the synchronization of DLCEPs and of DLS-users.

It is also used by a DLE to send an SPDU to one or more other DLEs.

	Included	Included (partially)	Comments
7.7.1 Structure of the DT DLPDU		Y	Format 4 is not included.
7.7.2 Content of the DT DLPDU		Y	See subsections and the text for details.
7.7.2.1 Content of the DT DLPDU when specifying a destination DL(SAP)-address		Y	Clause d) is not included.
7.7.2.2 Content of the DT DLPDU when specifying a destination or source DLCEP-address		Y	Subscriber to publisher DT DLPDU is not included.
7.7.3 Sending the DT DLPDU		Y	See subsections and the text for details.
7.7.3.1 Transmission when the reply token is dominant		Y	Only CD DLPDU with publisher's DLCEP-address as destination address is included.
7.7.3.2 Transmission when the delegated token is dominant	Y		
7.7.3.3 Transmission when the scheduler token is dominant	Y		
7.7.4 Receiving the DT DLPDU		Y	See subsections and the text for details.
7.7.4.1 Actions required of all DLEs		Y	See subsections and the text for details.
7.7.4.1.1 Actions required when the reply token was not dominant at start-of-reception		Y	Clause b) is not included. In clause c), subscriber to publisher DT DLPDU is not included.
7.7.4.1.2 Actions required when the reply token was dominant at start-of-reception and the receiving DLE sent the CD DLPDU which created the reply token		Y	Clauses a), b) and c) are not included.
7.7.4.1.3 Actions required when the reply token was dominant at start-of-reception and the receiving DLE did not send the CD DLPDU which created the reply token		Y	Only CD DLPDU with publisher's DLCEP-address as destination address is included.
7.7.4.2 Additional actions required of a Link-Master class or Bridge class DLE	Y		
7.7.4.3 Additional actions required of a Bridge class DLE	Y		
7.7.4.3.1 Actions required when the reply token was dominant at start-of-reception and the receiving bridge DLE forwarded, but did not originate, the CD DLPDU which created the reply token	No		This is not included, because it applies only if the destination of CD DLPDU was DLSAP-address.
7.7.4.4 Additional actions required of the current LAS DLE	Y		

7.7.1 Structure of the DT DLPDUs

All formats, except format 4 of DT DLPDU are included in this subset.

7.7.2 Content of the DT DLPDU

The frame control field shall be encoded as specified in Table 10.

Either the DL-addresses shall be

- a) the first a group DL-address and the second a DLSAP-address, or
- b) all DLSAP-addresses, or
- c) all DLCEP-addresses, or

7.7.2.1 Content of the DT DLPDU when specifying a destination DL(SAP)-address

When the first address is a group DL-address as in [7.7.2 a)], then

- a) If the DLPDU format is format 1L or 1S, then
 - 1) the DLPDU is being used to implement the unitdata transfer service, and
 - 2) the DL(SAP)-role for the destination DLSAP-address shall be GROUP; and
 - 3) the DL(SAP)-role for the source DLSAP-address shall be BASIC; and
 - 4) the SD-parameters field shall be null; and
 - 5) the user data shall be a single DLSDU whose size is limited to the maximum size for the priority specified in [7.7.1.1 b)], and shall not be null.
- b) No other DLPDU format may be used.

When the addresses are DLSAP-addresses as in [7.7.2 b)], then

- c) If the DLPDU format is format 1L or 1S, then
 - 1) this DLPDU is being used to implement the unitdata transfer service, and
 - 2) the DL(SAP)-role for the destination DLSAP-address shall be BASIC; and
 - 3) the DL(SAP)-role for the source DLSAP-address shall be BASIC; and
 - 4) the SD-parameters field shall be null; and
 - 5) the user data shall be a single DLSDU whose size is limited to the maximum size for the priority specified in [7.7.1.1 b)], and shall not be null.
- e) No other DLPDU format may be used.

7.7.2.2 Content of the DT DLPDU when specifying a destination or source DLCEP-address

When the first address is a DLCEP-address, as in [7.7.2 c)], then

- a) this DLPDU can convey a single DLSDU
 - from one peer DLCEP to its corresponding peer DLCEP, or
 - from a publisher DLCEP to its corresponding subscriber DLCEPs,
 and
- b) the second address, if present,
 - shall be the peer DLCEP-address of the same DLC as the destination DLCEP-address; and
- c) the SD-parameters field shall specify state information for the addressed DLCEP, and the contents of this field shall be as described in [8.4.2]; and

NOTE 1 The size and structure of this field is dependent on the QoS attributes associated with the DLCEP addressed by the destination DL-address specified in this DLPDU, and is determined during DLCEP establishment.

- d) the user data shall specify those octets of a DLSDU consistent with the negotiated DLSDU size and the segmentation information specified in the accompanying SD-parameters, and may be null.

NOTE 1 Formats 1L, 2L, 1S and 2S are used for peer-to-peer communications; 1L is used when the DLPDU-authentication attribute is SOURCE or MAXIMAL, 1S is used when the DLPDU-authentication attribute is SOURCE, 2L and 2S are used when the DLPDU-authentication attribute is ORDINARY.

Formats 3L and 3S are used for publisher-to-subscriber communications when the DLPDU-authentication attribute is ORDINARY or SOURCE.

The specific format to be used (of formats 1L to 3S) is determined as part of DLCEP establishment.

NOTE 2 Format 5 can be used instead of formats 2s and 3S, respectively, only when the sending DLE holds a reply token and when the DLPDU-authentication attribute is ORDINARY.

7.7.3 Sending the DT DLPDU

A DT DLPDU may be selected for transmission on the link when the sending DLE

- a) has just received a reply token in a CD DLPDU, permitting a single transmission of a DT or SR DLPDU, or
- b) holds a scheduler token or delegated token which is the dominant token on the local link, and when the remaining allocated duration of token usage, C(RD), permits completion of the DT DLPDU's transmission prior to expiration of the token.

Each explicit DL-address in the DLPDU shall be delocalized [6.2.2] before transmission.

7.7.3.1 Transmission when the reply token is dominant

a) A DT DLPDU may be sent on the link when the sending DLE has received a CD DLPDU addressed — to one of its active DLCEP-addresses for which it has a publisher DLCEP, and the sending DLE is replying as specified by [7.5.4.1], by forming as an immediate reply a DT DLPDU which may include a DLSDU which was already buffered at that responding DLE at the time of the CD DLPDU's reception.

When an immediate reply to a CD DLPDU is required, as specified in a), then the replying DLE shall send a reply DT DLPDU within a period of maximum-response-delay slot-times, $V(MRD) \times V(ST)$ octet-durations, of receipt of the requesting CD DLPDU.

The final-token-use subfield of the reply DT DLPDU shall have the same value as that in the requesting CD DLPDU.

Each explicit DL-address in the reply DT DLPDU shall be delocalized [6.2.2] before transmission.

It is a protocol error for the addressed DLE to not send a DT reply DLPDU when a reply is required.

NOTE At most one DLE on the local link should be sending a reply to the received CD DLPDU. That reply shall be a DT DLPDU.

7.7.3.2 Transmission when the delegated token is dominant

A DT DLPDU may be sent on the link when the sending DLE holds a delegated token which is the dominant token on the local link, and when the remaining allocated duration of token usage, $C(RD)$, permits completion of the DLPDU's transmission prior to expiration of the token.

If no additional use of that token after sending this DLPDU is needed at that time, then the DLE may set the final-token-use subfield of the DT DLPDU to the value FINAL; else that subfield shall have the value NOT-FINAL.

Each explicit DL-address in the DLPDU shall be delocalized [6.2.2] before transmission.

7.7.3.3 Transmission when the scheduler token is dominant

The LAS DLE may send a DT DLPDU on the link when both the remaining allocated duration of token usage before the next scheduled activity, and the remaining allocated duration of scheduler token usage for link maintenance, which is $V(LTHT)$ octet-durations minus the amount of link capacity used for link maintenance during the current cycle of "circulating the token", permits completion of the DLPDU's transmission prior to expiration of the token.

Each explicit DL-address in the DLPDU shall be delocalized [6.2.2] before transmission.

7.7.4 Receiving the DT DLPDU

Each DL-address in the DLPDU shall be delocalized [6.2.2] upon reception.

A received DT DLPDU shall be treated as follows by the receiving DLE:

7.7.4.1 Actions required of all DLEs

7.7.4.1.1 Actions required when the reply token was not dominant at start-of-reception

- a) If the received DT DLPDU has format 1L or 1S, and its destination DL-address designates a DL(SAP)-address of the receiving DLE, then the received DLPDU shall be forwarded to the DLE's upper-level functions [9.3] for further processing.
- c) If the received DT DLPDU
 - 1) has format 1L, 1S, 2L or 2S, and its destination DL-address designates a DLCEP-address designating a peer DLCEP of the receiving DLE, or
 - 2) has format 3L or 3S, and its source DL-address designates a DLCEP-address designating a subscriber DLCEP of the receiving DLE,
 then the received DLPDU shall be forwarded to the DLE's upper-level functions [9.2] for further processing.
- d) If the received DT DLPDU has format 1L or 1S, and its destination DL-address designates NODE.0 DL-address, $V(TN).0$, of the receiving DLE's DL-support functions, then the received DLPDU shall be forwarded to the DLE's upper-level functions [10.3] for further processing.
- e) If none of a) or c) or d) apply, then the DT DLPDU shall be reported to local DL-management as an unexpected response, and shall be discarded.

NOTE This report may take the form of incrementing a DL-management error counter.

7.7.4.1.2 Actions required when the reply token was dominant at start-of-reception and the receiving DLE sent the CD DLPDU which created the reply token

d) If the received DT DLPDU has format 3L or 3S, and its source DL-address designates the publisher's DLCEP-address of a subscriber DLCEP of the receiving DLE, and this source DL-address is equal to the destination DL-address from the immediately-prior CD DLPDU, then

- the DLE shall consider the prior transmission to have been error-free, and
- the received DT DLPDU shall be forwarded to the DLE's upper-level functions [9.2] for further processing.

e) If the received DT DLPDU has format 5, and the explicit destination DL-address from the immediately-prior CD DLPDU was a DLCEP-address of a subscriber DLCEP of the receiving DLE, then

- the DLE shall consider the prior transmission to have been error-free, and
- the received DT DLPDU shall be forwarded to the DLE's upper-level functions [9.2] for further processing, with its implied source DLCEP-address assumed to be the explicit destination DL-address from that immediately-prior CD DLPDU.

f) If none of d) through e) apply, then the DT DLPDU shall be reported to local DL-management as an unexpected response, and shall be discarded.

NOTE This report may take the form of incrementing a DL-management error counter.

7.7.4.1.3 Actions required when the reply token was dominant at start-of-reception and the receiving DLE did not send the CD DLPDU which created the reply token

a) If the received DT DLPDU has format 3L or 3S, and its source DL-address designates a DLCEP-address of a subscriber DLCEP of the receiving DLE, and this source DL-address is equal to the destination DL-address, V(RA), from the immediately-prior CD DLPDU, then

- the DLE shall consider the prior transmission to have been error-free, and
- the received DT DLPDU shall be forwarded to the DLE's upper-level functions [9.2] for further processing.

b) If the received DT DLPDU has format 5, and the explicit destination DL-address from the immediately-prior CD DLPDU was the publisher's DLCEP-address of a subscriber DLCEP of the receiving DLE, then

- the DLE shall consider the prior transmission to have been error-free, and
- the received DT DLPDU shall be forwarded to the DLE's upper-level functions [9.2] for further processing, with its implied source DLCEP-address assumed to be the explicit destination DL-address from that immediately-prior CD DLPDU.

7.7.4.2 Additional actions required of a Link-Master class or Bridge class DLE

none

7.7.4.3 Additional actions required of a Bridge class DLE

a) If the first DL-address specified in the DLPDU is an explicit DL-address to which the bridge should forward the DLSDU and the bridge was able to buffer the DLPDU without error, then the DLPDU shall be forwarded with modification of the frame-control field in the forwarded DLPDU as appropriate [6.1.1.3].

c) Otherwise, if a) does not apply, then the DLE shall not forward the DLPDU.

7.7.4.4 Additional actions required of the current LAS DLE

If the final-token-use subfield of the received DLPDU has the value FINAL, then the LAS DLE shall

- a) assume that the current use of the delegated token is terminated as if the token had been returned by an RT [7.17] DLPDU whose final-token-use subfield specified the value FINAL; and
- b) assume that the scheduler token is again dominant on the local link and resume active operation as the LAS.