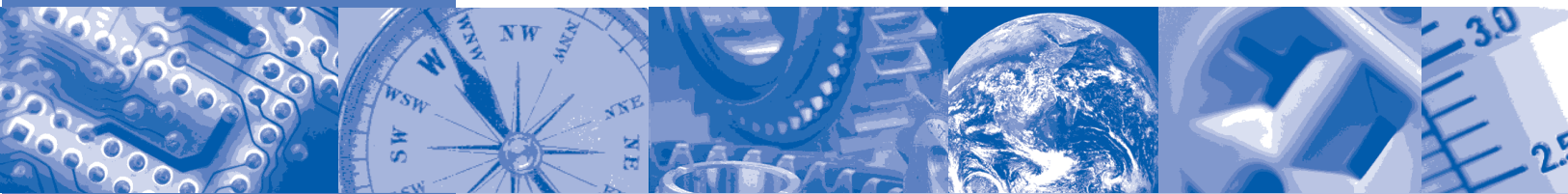


ANSI/ISA–50.02, Part 2–1992

Formerly ANSI/ISA–S50.02, Part 2–1992



Fieldbus Standard for Use in Industrial Control Systems Part 2: Physical Layer Specification and Service Definition



ISA–The Instrumentation,
Systems, and
Automation Society

Approved 17 May 1994



Documents
Document Sharing Hub

ANSI/ISA-50.02, Part 2-1992, Fieldbus Standard for Use in Industrial Control Systems,
Part 2: Physical Layer Specification and Service Definition

ISBN 1-55617-317-2

Copyright © 1992 by the Instrument Society of America. All rights reserved. Printed in the United States of America. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means (electronic, mechanical, photocopying, recording, or otherwise), without the prior written permission of the publisher.

ISA
67 Alexander Drive
P.O. Box 12277
Research Triangle Park, North Carolina 27709

Preface

This preface is included for informational purposes and is not part of ANSI/ISA-50.02, Part 2-1992.

This standard has been prepared as part of the service of ISA toward a goal of uniformity in the field of instrumentation. To be of real value, this document should not be static, but should be subject to periodic review. Toward this end, the Society welcomes all comments and criticisms, and asks that they be addressed to the Secretary, Standards and Practices Board, ISA, 67 Alexander Drive, P. O. Box 12277, Research Triangle Park, NC 27709, Telephone (919) 549-8411, Fax (919) 549-8288, e-mail: standards@isa.org.

ISA Standards and Practices Department is aware of the growing need for attention to the metric system of units in general, and the International System of Units (SI) in particular, in the preparation of instrumentation standards. The Department is further aware of the benefits to U.S.A. users of ISA standards of incorporating suitable references to the SI (and the metric system) in their business and professional dealings with other countries. Toward this end, this Department will endeavor to introduce SI-acceptable metric units in all new and revised standards to the greatest extent possible. *The Metric Practice Guide*, which has been published by the Institute of Electrical and Electronics Engineers as ANSI/IEEE Std. 268 1982, and future revisions, will be the reference guide for definitions, symbols, abbreviations, and conversion factors.

It is the policy of ISA to encourage and welcome the participation of all concerned individuals and interests in the development of ISA standards. Participation in ISA standards-making process by an individual in no way constitutes endorsement by the employer of that individual, of ISA, or of any of the standards that ISA develops.

This standard has been developed in cooperation with IEC SC65C/WG6, "Message data format for information transferred on process and control data highways." ISA committee and the IEC working group held concurrent meetings and have harmonized the developing drafts throughout the standards process. The IEC draft is currently at the Draft International Standard stage.

The following people served as members of ISA Subcommittee SP50.02:

NAME	COMPANY
M. Zielinski, Chairman	Rosemount, Inc.
J. Elias, Editor	Honeywell, Inc.
C. Akiyama	Yokogawa Electric Corporation
T. Bowker	Action Instruments, Inc.
P. Burton	ERA Technology, Ltd.
P. Certiat	Telemecanique
J. Geer	ITT Barton
F. Houvig	Drexelbrook Engineering Company
J. Howard	The Foxboro Company
K. Kakizakai	Fuji Electric Company, Ltd.
M. Kogure	Hitachi, Ltd.
H. Landet	Center for Industrial Research



F. McKenna
E. Miller, Jr.
B. Neve
P. Patel
T. Phinney
R. Lloyd
D. Simpson
B. Squires
G. Tapperson
T. Tottori
C. Vaidya

BP International, Ltd.
South West Research Institute
PACS, Ltd.
Del Mar Scientific
Honeywell, Inc.
AMP, Inc.
Masoneilan-Dresser
Measurement Technology, Ltd.
Fisher Controls International, Inc.
M-System Company, Ltd.
National Semiconductor

The following people served as members of ISA Committee SP50:

NAME

COMPANY

C. Langford, Chairman
C. Gross, Managing Director
K. Lindner, Managing Director
C. Akiyama
W. Baker
T. Bozarth
P. Burton
E. Butteriss
R. Caro
R. Crowder
E. Delahostria
U. Dobrich
B. Dumortier
P. Early
S. Glaser
B. Gross
A. Gupta
B. Hampton
J. Howard
M. Kazahaya
R. Ketcham
R. Lasher
J. Lesnau
T. Madden
A. McCauley, Jr.
P. Noury
E. Pageler
P. Patel
D. Serang
E. Skabowski

E. I. du Pont de Nemours & Company
Dow Chemical Company
Endress & Hauser GmbH & Company
Yokogawa Electric Corporation
Bailey Controls Company
Honeywell, Inc.
ERA Technology, Ltd.
Bechtel Company
Arthur D. Little, Inc.
Ship Star Associates, Inc.
Allen-Bradley Company
Siemens AG
Telemecanique
Texas Instruments, Inc.
Dow Chemical Company
General Motors Corporation
ABB Kent-Taylor, Inc.
Shell Oil Company
The Foxboro Company
Fischer & Porter Company
Union Carbide Corporation
Exxon Company USA
Dow Chemical Company
Exxon Company USA
Chagrin Valley Controls, Inc.
CEGELEC
Fisher Controls International, Inc.
Del Mar Scientific
Moore Products Company
Chevron USA

C. Thurwachter
N. Tobol
C. Williams
G. Winchester
M. Zielinski

Square D Company
Ronan Engineering
Eastman Kodak Company
National Electrical Manufacturers Assoc.
Rosemount, Inc

In addition to the members of the SP50 and SP50.02 listed above, significant contributions were made by other participants during the development of this document and other portions of the emerging field bus standard. These additional contributors are recognized below:

NAME	COMPANY
J. Aliperti	Ave Sernambetiba
P. Brett	Honeywell, Inc.
A. Capel	Comgate Engineering, Ltd.
B. Casey	Square D Company
J. Cobb	Rosemount, Inc.
H. Danmeyer	Mead Corporation
L. de Souza	SMAR
P. Griem, Jr.	Honeywell, Inc.
G. Hammer	Siemens AG
W. Hawkins	Rosemount, Inc.
D. Hewitson	Ronan Engineering Company
V. Jacobson	Ronan Engineering Company
F. Jaye	Johnson Yokogawa Corporation
B. Kasner	Consultant
K. Krivoshein	Fisher Controls International, Inc.
M. Kross	Bailey Controls Company
T. Kuusisto	Valmet
A. Lesh	AMP, Inc.
A. Melo	Macromicro
M. Melton	Hoechst Celanese Corporation
E. Messano	Valtek, Inc.
N. Miller	Digital Equipment Corporation
O. Mirabella	Instituto di Informatica e
D. Modell	Texas Instruments, Inc.
G. Nachev	IsoMatic Lab
M. Newman	Cornell University
H. Obara	Telemecanique
H. Ostling	Johnson Yokogawa
H. Overgaauw	Delft Instruments
G. Palazot	EDF
M. Patz	Softing GmbH
G. Pinkowski	Krohne GmbH & Company
D. Rundle	AMP, Inc.
F. Russo	ENEL



J. Scarlett
Y. Shimanuki
C. Thurston
J. Warrior
J. Weiss
R. Wing
G. Wood
W. Wright
D. Wroblewski

Honeywell, Inc.
Toshiba Corporation
Union Carbide Corporation
Rosemount, Inc.
Electric Power Research Institute
Proctor & Gamble Company
Consultant
Moore Products
Bailey Controls Company

This published standard was approved for publication by ISA Standards and Practices Board in September 1992.

NAME

COMPANY

J. Rennie, Vice President
W. Weidman, Vice President Elect
H. Baumann
C. Gross
H. Hopkins
A. Iverson
K. Lindner
G. McFarland
E. Nesvig
R. Prescott
D. Rapley
R. Reimer
R. Webb
J. Whetstone
M. Widmeyer
C. Williams
M. Zielinski
D. Bishop*
P. Bliss*
W. Calder*
B. Christensen*
L. Combs*
N. Conger*
T. Harrison*
R. Jones*
R. Keller*
O. Lovett, Jr.*
E. Magison*
R. Marvin*

Factory Mutual Research Corporation
Gilbert Commonwealth, Inc.
H. D. Baumann & Associates, Ltd.
Dow Chemical Company
Utility Products of Arizona
Lyondell Petrochemical Company
Endress & Hauser GmbH & Company
ABB Power Plant Controls
ERDCO Engineering Corporation
Moore Products Company
Rapley Engineering Services
Allen-Bradley Company
Pacific Gas & Electric Company
National Institute of Standards & Tech.
The Supply System
Eastman Kodak Company
Rosemount, Inc.
Chevron USA
Consultant
The Foxboro Company
Consultant
Retired/Consultant
Consultant
FAMU/FSU College of Engineering
Consultant
Consultant
Consultant
Honeywell, Inc.
Roy G. Marvin Company

*Directors Emeriti

A. McCauley, Jr.*
W. Miller*
J. Mock*
G. Platt*
C. Reimann*
K. Whitman*
J. Williams*

Chagrin Valley Controls, Inc.
Retired/Consultant
The Supply System
Retired/Consultant
National Bureau of Standards
ABB Combustion Engineering
Consultant



www.instrumatsociety.org

Contents

1	Scope	13
2	Normative references	13
3	Definitions	14
4	Symbols and abbreviations	16
5	Data Link—Physical Layer Interface	17
6	Station Management—Physical Layer Interface	21
7	DCE Independent Sublayer (DIS)	23
8	DTE-DCE interface	23
9	Medium Dependent Sublayer (MDS): Wire media	35
10	MDS - MAU interface: Wire media	39
11	Medium Attachment Unit (MAU): 31,25 Kbit/s, voltage mode, wire medium	41
12	Medium Attachment Unit (MAU): 1,0 Mbit/s, voltage-mode, wire medium	55
13	Medium Attachment Unit (MAU): current mode, wire medium	69
14	Medium Attachment Unit (MAU): 2,5 Mbit/s, voltage mode, wire medium	81
Annex A. Biography and references (Informative)		94
Annex B. IEC connector specification (Normative)		94
Annex C. Cable specifications and trunk and spur lengths for the 31, 25 Kbit/s voltage-mode MAU (Informative)		102

This document is Part 2 of a set of eight, which together provide a complete fieldbus standard.
The other parts are as follows:

Part 1: Introductory Guide

Part 3: Data Link Service Definition

Part 4: Data Link Protocol Specification

Part 5: Application Service Definition

Part 6: Application Protocol Specification

Part 7: Fieldbus Management

Part 8: Conformance Testing

Introduction

A fieldbus is a digital, serial, multidrop, data bus for communication with low level industrial control and instrumentation devices such as transducers, actuators and local controllers. The Physical Layer specified in this part of ISA-S50.02 provides for transparent transmission of data units between Data Link Layer entities across physical connections.

The Physical Layer receives data units from the Data Link Layer, adds preamble and delimiters, provides encoding and transmits the resulting physical signals to the transmission medium at one node. Signals are then received at one or more other nodes, decoded and stripped of preamble and delimiters, before being passed to the Data Link Layer of the receiving device.

Currently this part of ISA-S50.02 only specifies wire media. The common characteristics for wire media are as follows:

- a) digital data transmission;
- b) self-clocking;
- c) half-duplex communication (bidirectional but in only one direction at a time);
- d) Manchester coding.

The major variations for these media are two modes of coupling and three signaling speeds as follows:

- 1) voltage mode (parallel coupling), 31,25 kbit/s;
- 2) voltage mode (parallel coupling), 1,0 Mbit/s;
- 3) current mode (serial coupling), 1,0 Mbit/s;
- 4) voltage mode (parallel coupling), 2,5 Mbit/s.

The voltage mode variations 1), 2), and 4) may be implemented with inductive coupling using transformers. This is not mandatory if the isolation requirements of this part of ISA-S50.02 are met by other means.

Alternative media (e.g., coaxial cable, optical fiber, and radio transmission) and speeds are not included in this edition of this part of ISA-S50.02.

The Physical Layer provides the options:

- i) no power via the bus conductors; not intrinsically safe;
- ii) power via the bus conductors; not intrinsically safe;
- iii) no power via the bus conductors; intrinsically safe;
- iv) power via the bus conductors; intrinsically safe.

A fieldbus communication element is considered to be implemented in two parts, the Data Terminal Equipment (DTE) and the Data Communication Equipment (DCE). The DTE includes only one part of the Physical Layer, the DCE Independent Sublayer (DIS). The DIS transfers Interface Data Units (octets) across a Data Link Layer-Physical Layer interface that is not exposed to the user. The DIS then passes the Interface Data as a serial stream of binary

Physical Layer Service Data Units (bits) across the DTE-DCE interface, which may optionally be exposed to the user, to a Medium Dependent Sublayer (MDS).

Three alternative types of MDS are currently envisaged; one for wire media, one for optical media, and one for radio. The MDS adds preamble plus start delimiter before the data block, adds an end delimiter after the data block and encodes the data. In the reverse direction it decodes signals received via the medium, removing preamble and delimiters and providing signal quality error checking.

Serial encoded signals are passed across an interface, which may optionally be exposed, to a Medium Attachment Unit (MAU), which transmits and receives Physical Layer signals via the medium. A general model of the Physical Layer is shown in Figure 1.

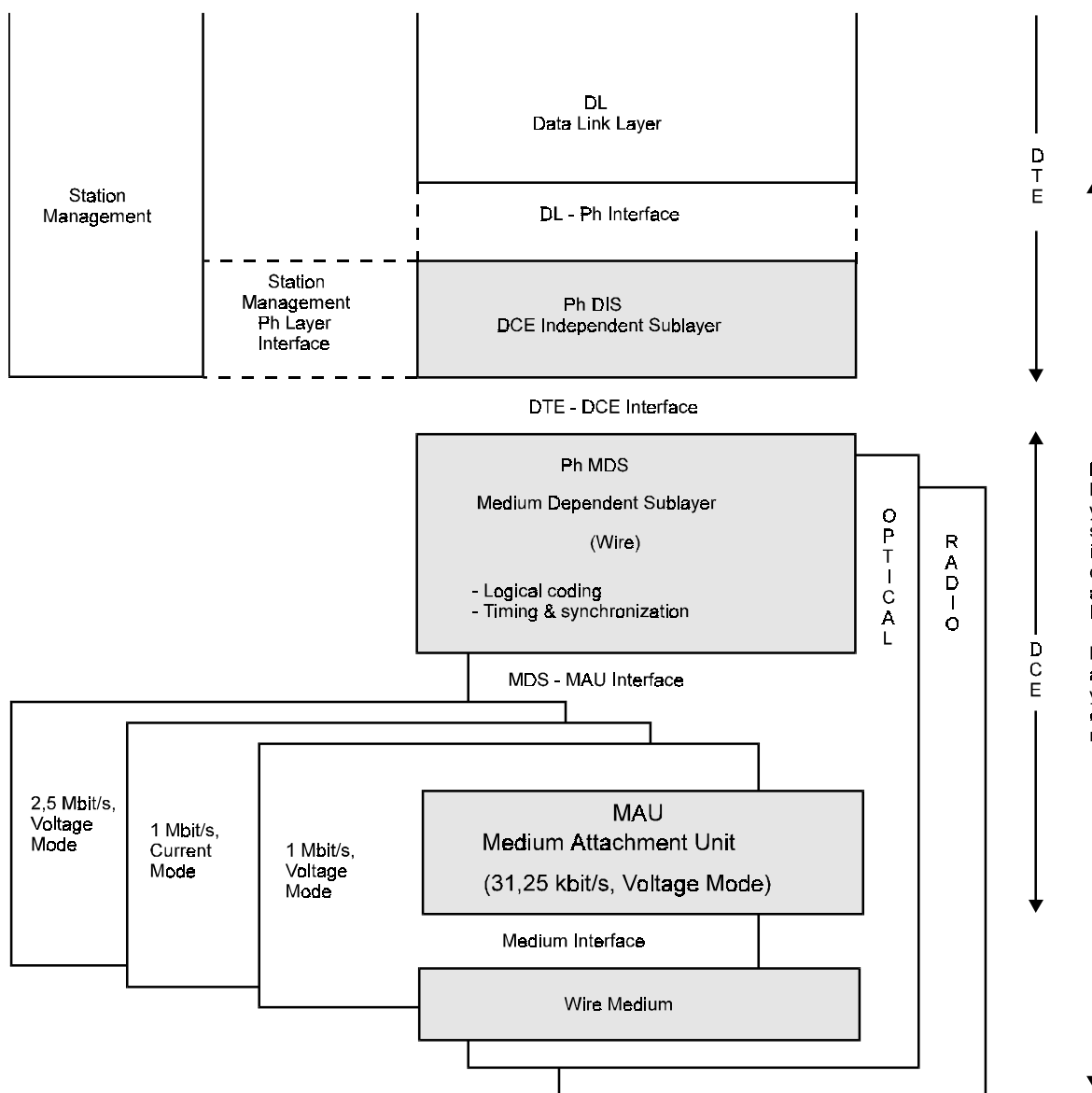


Figure 1—General model of Physical Layer

1 Scope

This part of ISA-S50.02 specifies the requirements for fieldbus component parts. It also specifies the media and network configuration requirements necessary to ensure agreed levels of:

- a) data integrity before Data Link Layer error checking;
- b) interoperability between devices at the Physical Layer.

The Fieldbus Physical Layer conforms to layer 1 of the OSI 7-layer model as defined by ISO 7498 with the exception that frame delimiters are in the Physical Layer.

This part of ISA-S50.02 should be read in conjunction with Part 1, Introductory Guide, Part 3, Data Link Service Definition, and Part 7, Fieldbus Management. The conformance testing requirements will be contained in Part 8 of ISA-S50.02.

2 Normative references

The following standards contain provisions that, through reference in this text, constitute provisions of this part of ISA-S50.02. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this part of ISA-S50.02 are encouraged to investigate the possibility of applying the most recent editions of the standards listed below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISA-S50.02/IEC 1158-1, *Fieldbus—Part 1: Introductory Guide (under consideration)*

ISA-S50.02/IEC 1158-3, *Fieldbus—Part 3: Data Link Service Definition (under consideration)*

ISA-S50.02/IEC 1158-4, *Fieldbus—Part 4: Data Link Protocol Specification (under consideration)*

ISA-S50.02/IEC 1158-5, *Fieldbus—Part 5: Application Service Definition (under consideration)*

ISA-S50.02/IEC 1158-6, *Fieldbus—Part 6: Application Protocol Specification (under consideration)*

ISA-S50.02/IEC 1158-7, *Fieldbus—Part 7: Fieldbus Management (under consideration)*

ISA-S50.02/IEC 1158-8, *Fieldbus—Part 8: Conformance Testing (under consideration)*

IEC 1131-2: 1993, *Programmable controllers—Part 2: Equipment characteristics.*

IEC 255-4: 1976, *Single input energizing quantity measuring relays with dependent specified time*

IEC 529: 1989, *Classification of degrees of protection provided by enclosures*

IEC 760: 1989, *Flat, quick-connect terminations*

IEC 801-1: 1984, *Electromagnetic compatibility for industrial-process measurement and control equipment—Part 1: General introduction*

IEC 801-2: 1984, *Electromagnetic compatibility for industrial-process measurement and control equipment—Part 2: Electrostatic discharge requirements*

IEC 801-3: 1984, *Electromagnetic compatibility for industrial-process measurement and control equipment—Part 3: Radiated electromagnetic field requirements*

IEC 801-4: 1988, *Electromagnetic compatibility for industrial-process measurement and control equipment—Part 4: Electrical fast transient/burst requirements*

IEC 807-3: 1990, *Rectangular connectors for frequencies below 3 MHz*

ISO 7498: 1984, *Information Processing Systems—Open Systems Interconnection—Basic Reference Model*

ISO/IEC 10022: 1990, *Information technology—Open System Interconnection—Physical Service Definition*

NOTE—A list of standards referred to for information only in this part of ISA-S50.02 is given in Annex A.

3 Definitions

For the purpose of this part of ISA-S50.02, the following definitions apply together with those in ISO 7498.

3.1 activity: The presence of a signal or noise at the input terminals of a fieldbus device that is of a level that is above the receiver signal level threshold of that device.

3.2 barrier: Physical entity that limits current and voltage into a hazardous area in order to satisfy Intrinsic Safety requirements.

3.3 bus: The trunk and all devices connected to it.

3.4 communication element: Part of a fieldbus device that communicates with other elements via the bus.

3.5 connector: Coupling device employed to connect the medium of one circuit or communication element with that of another circuit or communication element.

NOTE—This definition is taken from IEEE Std 100-1984, modified for this part of ISA-S50.02.

3.6 coupler: Physical interface between trunk and spur or trunk and device.

3.7 Data Communications Equipment (DCE): The embodiment of the media, modulation, and coding-dependent portion of a fieldbus-connected device, comprising the lower portions of the Physical Layer within the device.

3.8 Data Terminal Equipment (DTE): The embodiment of the media, modulation, and coding-independent portion of a fieldbus-connected device, comprising the uppermost portion of the Physical Layer and all higher layers within the device.

3.9 delimiter: Flag that separates and organizes items of data.

NOTE—This definition is taken from IEEE Std 100-1984.

3.10 device: Physical entity connected to the fieldbus that is composed of at least one communication element (the network element) and may have a control element and/or a final element (transducer, actuator, etc.).

3.11 frame: A set of consecutive digit time slots in which the position of each digit time slot can be identified by reference to a framing signal.

NOTE—This definition is taken from IEEE Std 100-1984.

3.12 intrinsic safety: Design methodology for a circuit or an assembly of circuits in which any spark or thermal effect produced under normal operating and specified fault conditions is not capable under prescribed test conditions of causing ignition of a given explosive atmosphere.

NOTE—This definition is taken from EN 50 020 :1977 (Intrinsically safe electrical apparatus).

3.13 isolation: Physical and electrical arrangement of the parts of a signal transmission system to prevent electrical interference currents within or between the parts.

NOTE—This definition is taken from IEEE Std 100-1984.

3.14 jabber: Continuous transmission on the medium due to a faulty device.

3.15 Manchester encoding: Means by which separate data and clock signals can be combined into a single, self-synchronizing data stream, suitable for transmission on a serial channel.

3.16 medium: Cable, optical fiber, or other means by which communication signals are transmitted between two or more points.

NOTE—In this part of ISA-S50.02 "media" is used only as the plural of medium.

3.17 network: All of the media, connectors, and associated communication elements by which a given set of communicating devices are interconnected.

3.18 node: End-point of a branch in a network or a point at which one or more branches meet.

NOTE—This definition is taken from the IEC Multilingual Dictionary of Electricity.

3.19 repeater: Device used to extend the range over which signals can be correctly transmitted and received for a given medium.

3.20 segment: The section of a fieldbus that is terminated in its characteristic impedance. Segments are linked by repeaters to form a complete fieldbus.

3.21 separately powered device: Device that does not receive its operating power via the fieldbus signal conductors.

3.22 shield: Surrounding earthed metallic layer to confine the electric field within the cable and to protect the cable from external electrical influence.

NOTE—Metallic sheaths, armors, and earthed concentric conductors may also serve as a shield.

3.23 spur: Branch line (i.e., a link connected to a larger one at a point on its route) that is a final circuit.

NOTE—This definition is taken from IEEE Std 100-1984.

3.24 transceiver: Combination of receiving and transmitting equipment in a common housing employing common circuit components for both transmitting and receiving.

NOTE—This definition is taken from IEEE Std 100-1984 (modified for non-radio use).

3.25 transmitter: Transmit circuitry of a communication element.

3.26 trunk: Main communication highway acting as a source of main supply to a number of other lines (spurs).

NOTE—This definition is taken from IEEE Std 100-1984 (modified).

4 Symbols and abbreviations

4.1 Symbols: For the purpose of this part of ISA-S50.02, the following symbols apply:

<u>Symbol</u>	<u>Definition</u>	<u>Units</u>
f_r	Frequency corresponding to the bit rate	hertz (Hz)
N+	Non-data symbol—positive	none
N–	Non-data symbol—negative	none
P	Nominal period of octet transmission	seconds
V_{DD}	The most positive supply level	volts (V)
V_{IH}	Minimum high-level input voltage	volts (V)
V_{IL}	Maximum low-level input voltage	volts (V)
V_{OH}	Minimum high-level output voltage	volts (V)
V_{OL}	Maximum low-level output voltage	volts (V)
Z	Impedance	ohms (Ω)
Z_0	Characteristic impedance (of cable)	ohms (Ω)

4.2 Abbreviations: The following abbreviations are used in this part of ISA-S50.02:

CTS	Clear To Send signal (from DCE)
DCE	Data Communication Equipment
DIS	DCE Independent Sublayer
DL	Data Link—Approximately Layer 2 of the OSI model (ISO 7498)
DLE	Data Link Entity
DLL	Data Link Layer—Defined in ISO 7498
DTE	Data Terminal Equipment
EMI	Electromagnetic Interference
IDU	Interface Data Unit—Defined in ISO 7498
I.S.	Intrinsic Safety—Certification method for use of electrical equipment in flammable atmospheres

kbit/s	Thousand bits per second
LbE	Loopback Enable signal (to MAU)
MAU	Medium Attachment Unit—For wire media, MAU = transceiver
Mbit/s	Million bits per second
MDS	Medium Dependent Sublayer
NRZ	Non-return-to-zero code—High level = logic 1, Low level = logic 0
Ph	Physical—Approximately Layer 1 of the OSI model (ISO 7498)
PhE	Physical layer Entity—Defined in ISO 7498
PhL	Physical layer—Defined in ISO 7498
PhICI	Physical layer Interface Control Information—Defined in ISO 7498
PhID	Physical layer Interface Data—Defined in ISO 7498
PhIDU	Physical layer Interface Data Unit—Defined in ISO 7498
PhPCI	Physical layer Protocol Control Information—Defined in ISO 7498
PhPDU	Physical layer Protocol Data Unit—Defined in ISO 7498
PhS	Physical layer Service—Defined in ISO 7498
PhSAP	Physical layer Service Access Point—Defined in ISO 7498
PhSDU	Physical layer Service Data Unit—Defined in ISO 7498
pk	Peak
pk-pk	Peak-to-peak
RDF	Receive Data and Framing signal (from DCE)
RFI	Radio Frequency Interference
RTS	Request To Send signal (to DCE)
RxA	Receive Activity signal (from DCE)
RxC	Receive Clock signal (from DCE)
RxS	Receive Signal (from MAU)
TxC	Transmit Clock signal (from DCE)
TxD	Transmit Data signal (to DCE)
TxE	Transmit Enable signal (to MAU)
TxS	Transmit Signal (to MAU)
SDU	Service Data Unit—Defined in ISO 7498

5 Data Link—Physical Layer Interface

This clause defines the required Physical Service (PhS) primitives and constraints on their use.

NOTES

- 1 The requirements for a Fieldbus Data Link Layer are specified in ISA-S50.02, Part 4. Services at the interface between the Data Link Layer and Physical Layer are specified in 5.1 and 5.2.
- 2 The Data Link—Physical interface is a virtual service interface between virtual machines; there are no requirements for physical signal lines as the standard does not require this interface to be exposed.

5.1 Required services: PhIDUs shall be transferred between the Data Link Layer and the Physical Layer in accordance with the requirements of ISO 7498 as shown in Figure 2.

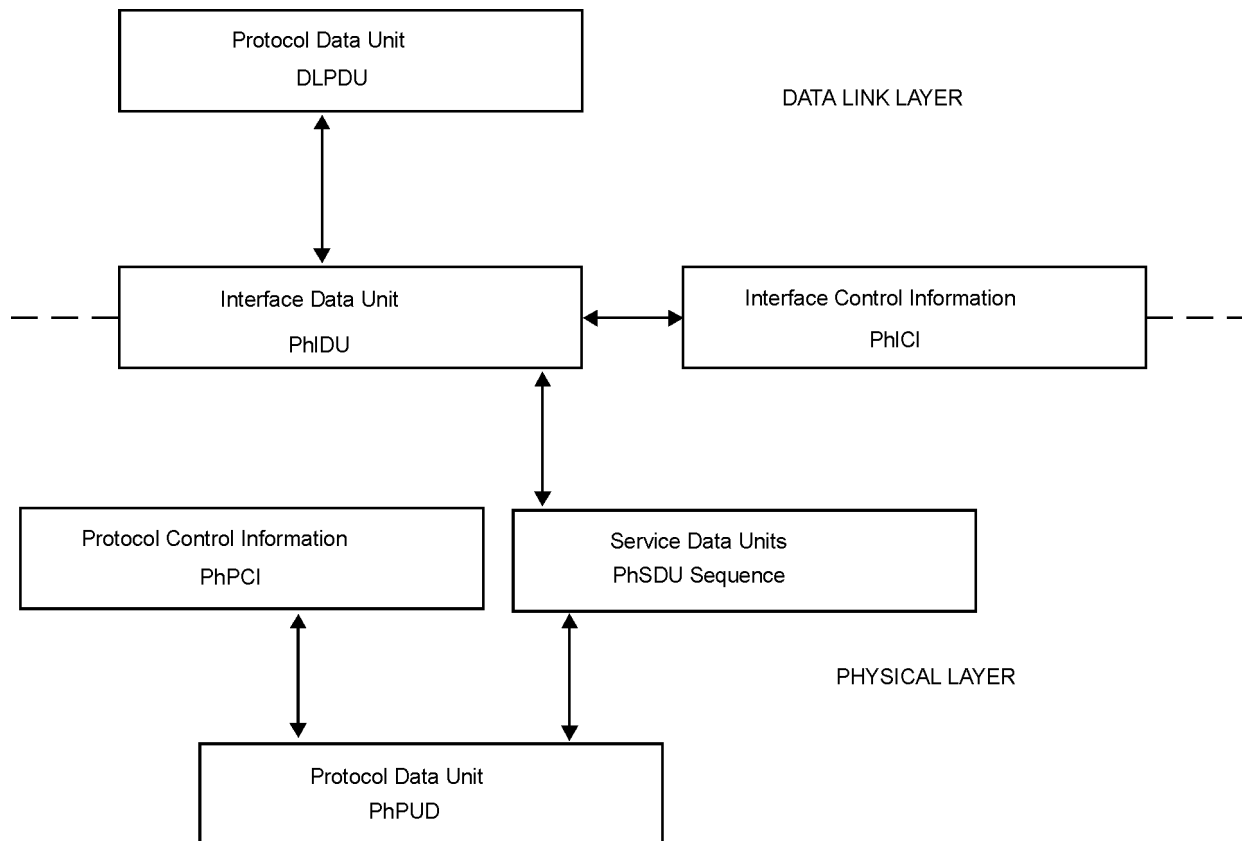


Figure 2—Mapping between data units across the DL-Ph interface

NOTES

1 These services provide for the interchange of PhIDUs between a Data Link Layer entity and its associated Physical Layer entity. Such a transfer is part of a transaction between cooperating Data Link Layer entities. The services listed in this section are the minimum that can jointly provide the means by which cooperating Data Link Layer entities can coordinate their transmission and their exchange of data on the shared communication medium.

2 Proper layering requires that an (N+1)-layer entity not be concerned with, and that an (N)-service interface not overly constrain, the means by which an (N)-layer provides its (N)-services. Thus the Ph-service interface does not require DLEs to be aware of internal details of the PhE (e.g., preamble, postamble, and frame delimiter signal patterns, number of bits per baud) and should not prevent the PhE from using appropriate evolving technologies.

5.1.1 Primitives of the PhS: The granularity of PhS-user data exchanged at the PhL-DLL interface is one octet.

5.1.1.1 Ph-Characteristics indication: The PhS shall provide the following service primitive to report essential PhS characteristics (which may be used in DLL transmission, reception, and scheduling activities):

Ph-CHARACTERISTICS indication (minimum-data-rate, framing-overhead)

where

minimum-data-rate—shall specify the effective minimum rate of data conveyance in bits/second, including any timing tolerances.

NOTE—A PhE with a nominal data rate of 1 Mbit/s $\pm$ 0,01% would specify a minimum data rate of 0,9999 Mbit/s.

framing-overhead—shall specify the maximum number of bit periods (where period is the inverse of the data rate) used in any transmission for PhPDUs that do not directly convey data (e.g., PhPDUs conveying preamble, frame delimiters, postamble, inter-frame "silence," etc.).

NOTE—If the framing overhead is F and two DL message lengths are L_1 and L_2 , the time to send one message of length $L_1 + F + L_2$ will be at least as great as the time required to send two immediately consecutive messages of lengths L_1 and L_2 .

5.1.1.2 PhS transmission and reception services: The PhS shall provide the following service primitives for transmission and reception:

Ph-DATA request (class, data)

Ph-DATA indication (class, data)

Ph-DATA confirm (status)

where

class—shall specify the PhCI component of the PhIDU. For a Ph-DATA request, its possible values shall be:

START-OF-ACTIVITY—transmission of the PhPDUs that precede Ph-user data shall commence;

DATA—the single-octet value of the associated data parameter shall be transmitted as part of a continuous correctly-formed transmission; and

END-OF-DATA-AND-ACTIVITY—the PhPDUs that terminate Ph-user data shall be transmitted after the last preceding octet of Ph-user data, culminating in the cessation of active transmission.

For a Ph-DATA indication, its possible values shall be:

START-OF-ACTIVITY—reception of an apparent transmission from one or more PhEs has commenced;

DATA—the associated data parameter was received as part of a continuous correctly formed reception;

END-OF-DATA—the ongoing continuous correctly formed reception of Ph-user data has concluded with correct reception of PhPDUs implying END-OF-DATA;

END-OF-ACTIVITY—the ongoing reception (of an apparent transmission from one or more PhEs) has concluded, with no further evidence of PhE transmission; and

END-OF-DATA-AND-ACTIVITY—simultaneous occurrence of END-OF-DATA and END-OF-ACTIVITY.

data—shall specify the PhID component of the PhIDU. It consists of one octet of Ph-user-data to be transmitted (Ph-DATA request) or which was received successfully (Ph-DATA indication).

status—shall specify either success or the locally detected reason for inferring failure.

The Ph-DATA confirm primitive shall provide the critical physical timing feedback necessary to inhibit the DLE from starting a second transmission before the first is complete. The final Ph-DATA confirm of a transmission shall not be issued until the PhE has completed the transmission.

5.1.2 Notification of PhS characteristics: The PhE has the responsibility for notifying the DLE of those characteristics of the PhS that may be relevant to DLE operation. The PhE shall do this by issuing a single Ph-CHARACTERISTICS indication primitive at each of the PhE's PhSAPs at PhE startup.

5.1.3 Transmission of Ph-user-data: The PhE shall determine the timing of all transmissions. When a DLE transmits a sequence of PhSDUs, the DLE shall send the sequence of PhSDUs by making a well-formed sequence of Ph-Data requests, consisting of a single request specifying START-OF-ACTIVITY, followed by 3 to 300 consecutive requests, inclusive, specifying DATA, each conveying a PhSDU, and concluded by a single request specifying END-OF-DATA-AND-ACTIVITY.

The PhE shall signal its completion of each Ph-DATA request, and its readiness to accept a new Ph-DATA request, by issuing a Ph-DATA confirm primitive; the status parameter of the Ph-DATA confirm primitive shall convey the success or failure of the associated Ph-DATA request. A second Ph-DATA request shall not be issued by the DLE until after the Ph-DATA confirm corresponding to the first request has been issued by the PhE.

5.1.4 Reception of Ph-user-data: The PhE shall report a received transmission with a well-formed sequence of Ph-DATA indications, which shall consist of either

- a) a single indication specifying START-OF-ACTIVITY; followed by consecutive indications specifying DATA, each conveying a PhSDU; followed by a single indication specifying END-OF-DATA; and concluded by a single indication specifying END-OF-ACTIVITY; or
- b) a single indication specifying START-OF-ACTIVITY; followed by consecutive indications specifying DATA, each conveying a PhSDU; followed by a single indication specifying END-OF-DATA-AND-ACTIVITY; or
- c) a single indication specifying START-OF-ACTIVITY; optionally followed by one or more consecutive indications specifying DATA, each conveying a PhSDU; and concluded by a single indication specifying END-OF-ACTIVITY.

This last sequence is indicative of an incomplete or incorrect reception. Detection of an error in the sequence of received PhPDUs, or in the PhE's reception process, shall disable further Ph-DATA indications with a class parameter specifying DATA, END-OF-DATA, or END-OF-DATA-AND-ACTIVITY until after both the end of the current period of activity and the start of a subsequent period of activity have been reported by Ph-DATA indications specifying END-OF-ACTIVITY and START-OF-ACTIVITY, respectively.

6 Station Management-Physical Layer Interface

NOTES

- 1 This interface provides services to the Physical Layer that are required for initialization and selection of options.
- 2 One of the objectives of the Physical Layer is to allow for future variations such as radio, fiber optics, redundant channels (e.g., cables), different modulation techniques, etc. A general form of Station Management-Physical Layer Interface is specified that provides the services required by implementations of these variations. Services provided by this interface are specified in 6.1 and 6.2. The standard does not require this interface to be exposed.
- 3 The complete set of management services can only be used when the device is directly coupled to the medium. In the case of actively coupled equipment (e.g., active coupler, repeater, radio/telephone modem, opto-electronics etc.) some of the services can be implicit to the active coupler. Moreover, each device can use a subset of the described primitives.

6.1 Required services:

The minimum service primitive for Physical Layer (PhL) management shall be:

- a) Ph-RESET request—reset of the Ph-Layer.

The following additional services may be provided:

- b) Ph-SETVALUE request / Ph-SETVALUE confirm—set parameters;
- c) Ph-GETVALUE request / Ph-GETVALUE confirm—read parameters;
- d) Ph-EVENT indication—report Ph-Layer events.

6.2 Service primitive requirements:

6.2.1 Ph-RESET request: This primitive has no parameter. Upon reception of this primitive the Physical Layer shall reset all its functions.

6.2.2 Ph-SETVALUE request (parameter name, new value): If this primitive is used it shall allow Station Management to modify the parameters of the Physical Layer. Standard parameter names and value ranges are given in [Table 1](#). The value assumed for each parameter at reset shall be the first of those shown for the parameter.

Table 1—Parameter names and values for Ph-SETVALUE request

Parameter name	Range of values
Interface mode	• FULL_DUPLEX
	• HALF_DUPLEX
Loop-back mode	• DISABLED • in MDS at DTE - DCE interface • in MAU near line connection
Preamble extension	• 0..7 (preamble extension sequences)
Post-transmission gap extension	• 0..7 (gap extension sequences)
Maximum inter-channel signal skew	• 0..7 (gap extension sequences)
Transmitter output channel <i>N</i> ($1 \leq N \leq 8$)	• ENABLED • DISABLED
Receiver input channel <i>N</i> ($1 \leq N \leq 8$)	• ENABLED • DISABLED
Preferred receive channel	• NONE • 1..8

NOTES

- 1 Not all implementations require every parameter, and some may need more.
- 2 Each DCE standard specifies both the basic and extension sequences of PhPDUs to be sent as preamble. These extension sequences are always prefixed to the basic sequence.
- 3 Each DCE standard specifies the lengths of both the basic and extension sequences of post-transmission gap during which the transmitter should be silent.
- 4 From the above, the default value at reset is minimum preamble (no extension), minimum post-transmission gap (no extension), full-duplex interface mode, not in loopback, with all transmit and receive channels enabled, and with no preferred receive channel.

6.2.3 Ph-SETVALUE confirm (status): This primitive has a single parameter indicating the status of the request: Success or Failure. If this primitive is used it shall acknowledge completion of the Ph-SETVALUE request in the Physical Layer.

6.2.4 Ph-GETVALUE request (parameter name): If this primitive is used it shall allow the Station Management to read the parameters of the Physical Layer. The parameter shall have one of the names given in [Table 1](#).

6.2.5 Ph-GETVALUE confirm (current value): This primitive is the response of the Physical Layer to the Ph-GETVALUE request. If this primitive is used it shall have a single parameter reporting either the failure of the request — Failure — or the present value of the requested parameter. The current value shall be one of those permitted by 6.2.2.

6.2.6 Ph-EVENT indication (parameter name): If this primitive is used it shall notify the Station Management of a Physical Layer parameter modification that has not been requested by the Station Management. The parameter shall have one of the names and values given in [Table 2](#), based on names specified in clause 8.

NOTE—Additions to [Table 2](#) are possible if required by specific implementations.

Table 2—Parameter names for Ph-EVENT indication

Parameter name
DTE fault
DCE fault

7 DCE Independent Sublayer (DIS)

NOTES

1 The Physical Layer entity is partitioned into a Data Terminal Equipment (DTE) component and a Data Communication Equipment (DCE) component. The DTE component interfaces with the Data Link Layer entity and forms the DCE Independent Sublayer (DIS). It exchanges Interface Data Units across the DL-Ph interface defined in clause 5, and provides the basic conversions between the PhIDU "at-a-time" viewpoint of the DL-Ph interface and the bit serial viewpoint required for physical transmission and reception.

2 This sublayer is independent of all the Physical Layer variations, including encoding and/or modulation, speed, voltage/current/optical mode, medium etc. All these variations are grouped under the designation Data Communication Equipment (DCE).

The DIS shall sequence the transmission of the PhID as a sequence of serial PhSDUs. Similarly, the DIS shall form the PhID to be reported to the Data Link Layer from the sequence of received serial PhSDUs.

The PhID shall be converted to a sequence of PhSDUs for serial transmission in octets up to a maximum of 300 octets. A PhSDU representing more significant octets of the PhID shall be sent before or at the same time as a PhSDU representing less significant octets and such that within each octet, a PhSDU representing a more significant bit will be transmitted before or at the same time as a PhSDU representing a less significant bit. On reception, each sequence of PhSDUs shall be converted to PhID such that, in the absence of errors, the PhIDU indicated to the receiving Data Link Layer entity shall be unchanged from the PhIDU whose transmission was requested by the originating Data Link Layer entity.

3 This is a guarantee of transparency.

8 DTE-DCE interface

NOTES

1 The Physical Layer entity is partitioned into a Data Terminal Equipment (DTE) component containing the MIS and higher layers and a Data Communication Equipment (DCE) component containing the MDS and lower sub-layers. The DTE-DCE interface connects these two physical components.

2 It is not mandatory for the DTE-DCE interface, or any other interface, to be exposed.

3 The DTE-DCE interface is a functional and electrical, but not mechanical, interface that supports a set of services. Each of these services is implemented by a sequence of defined signaling interactions at the interface.

8.1 Services: The following services, defined in this sub-clause, shall be supported by the DTE-DCE interface:

- a) DTE to DCE reset service;

- b) DTE to DCE configuration service;
- c) DTE to DCE message transmission service;
- d) DCE to DTE fault notification service;
- e) DCE to DTE media-activity indication service;
- f) DCE to DTE message reporting service.

8.1.1 DTE to DCE reset service: This service shall provide a means by which the DTE, at any time, can reset the DCE to its initial (power-on) state.

8.1.2 DTE to DCE configuration service: This service shall provide a means by which the DTE can configure various characteristics of the DCE, including those characteristics that station management can adjust via PhSETVALUE requests (see Table 1). It also shall provide a DCE-optional means by which the DTE can initiate reporting of DCE status by preemptive use of the DCE to DTE message reporting service.

8.1.3 DTE to DCE message transmission service: This service shall provide a means by which the DTE can transmit a message through the DCE to either the connected medium (media), or back to the DTE, or both, as determined by the current operational values of the parameters specified in Table 1. The DCE shall provide the pacing for this service.

This service is invoked upon receipt of a PhDATA request specifying START-OF-ACTIVITY at the PhL service interface and runs until receipt of and completion of the PhDATA request specifying END-OF-DATA-AND-ACTIVITY.

8.1.4 DCE to DTE fault notification service: This service shall provide a means by which the DCE, at any time, can report a fault. The specific nature of the fault is not reported by this service but may be determinable by use of the DTE to DCE configuration service to initiate a DCE-optional DCE status report.

8.1.5 DCE to DTE media-activity indication service: This service shall provide a means by which the DCE reports the inferred detection, on any of its connected media for which receiving is enabled (see Table 1), of signaling from itself or other Ph-layer entities. While loopback is enabled, this service reports only the signaling of the DCE itself.

When the DTE-DCE interface is in half-duplex mode and loopback is not enabled, this service need not report media activity resulting directly from the DTE to DCE message transmission service.

8.1.6 DCE to DTE message reporting service: This service shall provide a means by which the DCE reports the receipt of a sequence of PhPDUs from any one of the connected media for which receiving is enabled. This service terminates with an indication of whether the sequence of received PhPDUs was well formed. Errors in the sequence, including number of PhPDUs such that they could not have been a correct transmission resulting from an invocation of the DCE to DTE message transmission service shall be reported as a malformed (erroneous) sequence.

NOTE—Errors in the octet alignment of a received end delimiter with respect to the preceding start delimiter (i.e., not separated by an integral number of octets of data bits) is to be reported as a malformed sequence.

When the DTE-DCE interface is in half-duplex mode and loopback is not enabled, this service need not report the message transmitted by the DCE to DTE message transmission service.

8.2 Interface signals: If the DTE-DCE interface is exposed it shall provide the signals specified in Table 3.

Table 3—Signals at DTE-DCE interface

Signal	Abbreviation	Source
Transmit Clock	TxC	DCE
Request to Send	RTS	DTE
Clear to Send	CTS	DCE
Transmit Data	TxD	DTE
Receive Clock	RxC	DCE
Receive Activity	RxA	DCE
Receive Data and Framing	RDF	DCE

The signal levels shall be as shown in Table 4. In general, both sides of the interface shall operate with the same approximate value of V_{DD} . However, it is recognized that a DTE and a DCE with separate power supplies may not both reach operational V_{DD} simultaneously. It is desirable, but not mandatory, that the DTE to DCE reset service be operational when the DCE has not yet reached operational V_{DD} . It is also desirable that the DTE invoke this service whenever its own V_{DD} is below operational margins.

Table 4—Signal levels for an exposed DTE-DCE interface

Symbol	Parameter	Conditions	Limits	Units	Remarks
V_{OL}	Maximum low-level output voltage	$I_{out} = \pm 100 \mu A$ $I_{out} = +1,6 \text{ mA}$	0,1 0,4	V V	See Note 1
V_{OH}	Minimum high-level output voltage	$I_{out} = \pm 100 \mu A$ $I_{out} = -0,8 \text{ mA}$	$V_{DD} - 0,1$ $V_{DD} - 0,8$	V V	See Note 1 See Note 2
V_{IL}	Maximum low-level input voltage		$0,2 V_{DD}$	V	
V_{IH}	Minimum high-level input voltage		$0,7 V_{DD}$	V	See Note 3
NOTES: 1) Provides the capability to drive two typical CMOS loads. 2) CMOS input compatibility with TTL output requires a "pull-up" resistor from signal input to V_{DD} . 3) Compatible with CMOS output for $3,0 \leq V_{DD} \leq 5,5 \text{ V}$. Compatibility with TTL output ($4,75 \text{ V} \leq V_{DD} \leq 5,25 \text{ V}$) requires a "pull-up" resistor from signal input to V_{DD} .					

The timing characteristics of these signals shall be at least equal to those specified for the relevant DCE in the requirements of this part of ISA-S50.02. However, in no case shall the transition time between $0,3 V_{DD}$ and $0,6 V_{DD}$ be greater than either 100 ns or $0,025 P$, whichever is smaller. P is defined as the nominal period of octet transmission—the inverse of the nominal PhSDU rate.

An implementation of the DTE-DCE interface shall function correctly with transmit and receive (TxC and RxC) clock frequencies between 1 kHz and 8,8 times the highest supported PhSDU rate of the DTE or DCE implementation.

NOTE—The PhSDU and equivalent bit data rates available in an implementation are stated in the Protocol Implementation Conformance Statement (PICS).

8.2.1 Transmit Clock (TxC): The Transmit Clock signal (TxC) shall provide the DTE with a continuous timing signal, such that any eight consecutive full cycles of this signal shall have the same octet period as the nominal transmit period for one data octet. The DCE shall source this nominally two-phase signal such that each phase has a duration of at least $0,04 P$.

NOTE—This specification permits TxC to be a continuous, constant-period clock at the nominal bit rate (8 times the nominal octet rate) with a duty cycle of 32% to 68%, or for TxC to be a higher-frequency clock with some cycles omitted and with a duty cycle closer to 50%. This permits, for example, simple clocking in a DCE that recodes each 4 bits into 5 baud; the DCE could have a clock 10 times the nominal octet rate, with a duty cycle of between 40% and 60%, and would omit (the same) two cycles every octet.

TxC supports the DTE to DCE configuration and message transmission services.

8.2.2 Request to Send (RTS): The Request To Send (RTS) signal supports the DTE to DCE reset, configuration, and message transmission services. The DTE shall source this signal. The initial (power-on) and idle (no DTE to DCE service active) state of this signal shall be low.

When referenced to TxC at the DTE-DCE interface, this signal shall have a minimum setup time of the smaller of either 100 ns or $0,025 P$; the hold time shall be zero or greater.

8.2.3 Clear to Send (CTS): The Clear to Send (CTS) signal supports the DTE to DCE configuration and message transmission services. The DCE shall source this signal. The initial (power-on) and idle (no DTE to DCE service active) state of this signal shall be low.

When referenced to TxC at the DTE-DCE interface, this signal shall have a minimum setup time of the smaller of either 100 ns or $0,025 P$; the hold time shall be zero or greater.

8.2.4 Transmit Data (TxD): The Transmit Data (TxD) signal supports the DTE to DCE reset, configuration, and message transmission services. Binary data is transmitted from DTE to DCE during one phase of the latter two services, and during this phase a binary 0 is represented by a low level on TxD and a binary 1 by a high level on TxD, both sampled at the falling edge of TxC.

The DTE shall source this signal. The initial (power-on) and idle (no DTE to DCE service active) state of this signal shall be high.

When referenced to TxC at the DTE-DCE interface, this signal shall have a minimum setup time of the smaller of either 100 ns or $0,025 P$; the hold time shall be zero or greater.

8.2.5 Receive Clock (RxC): The Receive Clock signal (RxC) shall provide the DTE with an intermittent (semicontinuous) nominally two-phase timing signal that defines the timing of information being reported via the RDF signal. The DCE shall source this signal such that, where RxC is defined to be meaningful (see 8.3.6), each phase has a duration of at least $0,04 P$.

NOTE—This specification permits RxC to be a recovered clock at the nominal bit rate (8 times the nominal octet rate) with a duty cycle of 32% to 68%, or to be a higher-frequency clock with some cycles omitted and with a duty cycle closer to 50%. This permits, for example, simple clocking in a DCE that decodes 4 bits from each received 5 baud; the DCE could have a clock 10 times the nominal octet rate, with a duty cycle of between 40% and 60%, and would omit two cycles every octet.

This specification also permits the DCE to omit cycles of RxC during recognition of long end-delimiter sequences of PhPDUs, so that the delimiter can be reported in real time using 8 or fewer cycles of RxC (see 8.3.6).

RxC shall support the DCE to DTE message reporting service.

8.2.6 Receive Activity (RxA): The Receive Activity (RxA) signal shall support the DCE to DTE fault notification, media-activity indication, and message reporting services. The DCE shall source this signal. The initial (power-on) and idle (no DCE to DTE service active) state of this signal shall be low.

8.2.7 Receive Data and Framing (RDF): The Receive Data and Framing (RDF) signal shall

support the DCE to DTE fault notification and message reporting services. Binary data is transmitted from DCE to DTE during some phases of the latter service, and during these phases a binary 0 is represented by a low level on RDF and a binary 1 by a high level on RDF, both sampled at the falling edge of RxC.

The DCE shall source this signal. The initial (power-on) and idle (no DCE to DTE service active) state of this signal shall be high.

When referenced to RxC at the DTE-DCE interface, this signal shall have a minimum setup time of the smaller of either 100 ns or 0,025 *P*; the hold time shall be zero or greater.

8.3 Encoding of services in signals: The services of 8.1 shall be implemented by the following sequences and combinations of the signals of 8.2.

NOTE—Typical transmit and receive sequencing machines are shown in [Figure 3](#). [Figure 3](#) is included in this part of ISA-S50.02 for explanatory purposes and does not imply a specific implementation.

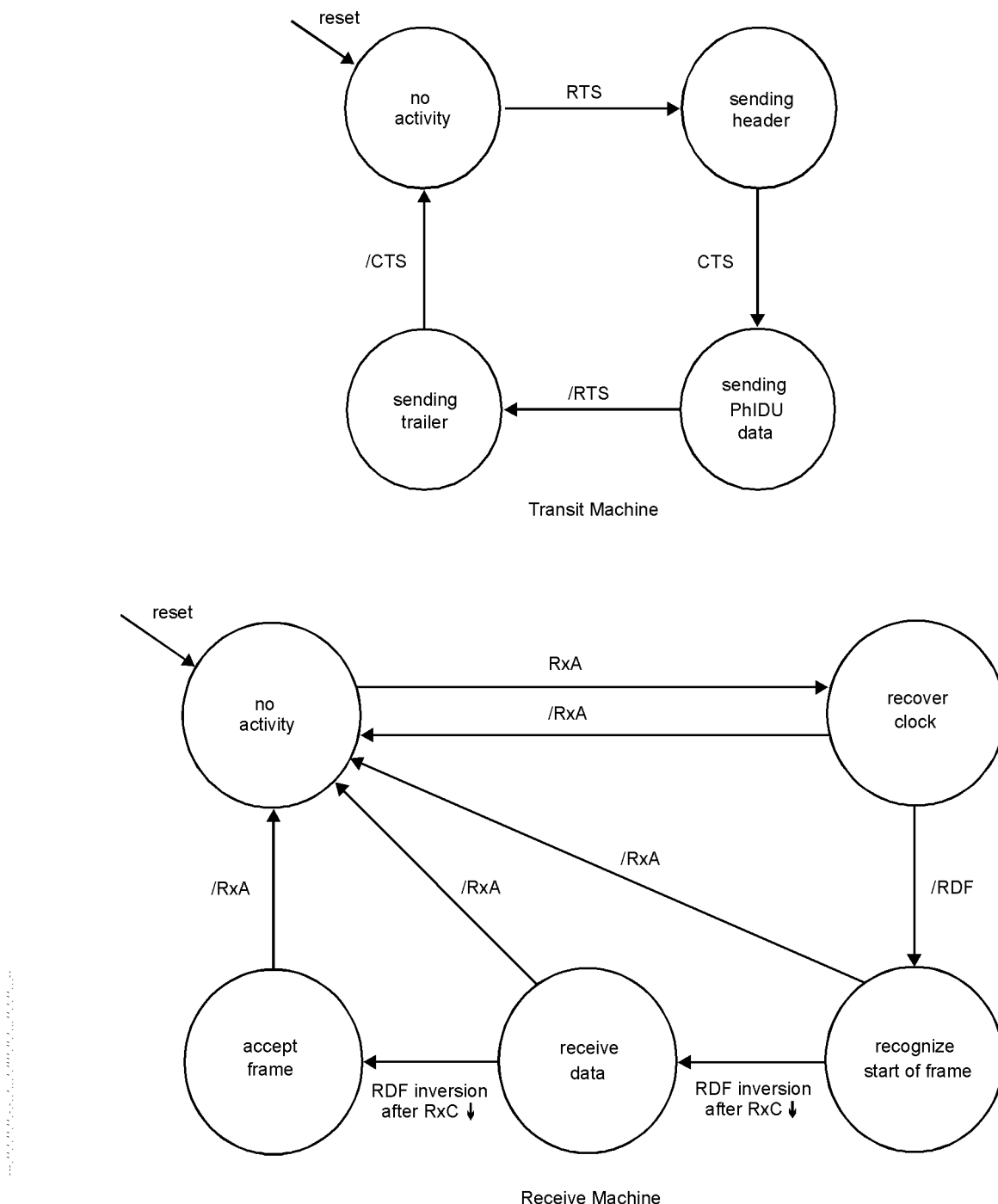


Figure 3—DTE/DCE sequencing machines

8.3.1 DTE to DCE reset service: This service shall be mutually exclusive with the DTE to DCE configuration and message transmission services; at most one of them may be active at any given time. This service may preempt the DTE to DCE configuration and message transmission services at any time.

This service shall be encoded as a simultaneous low level on both RTS and TxD. When asserted by the DTE, this simultaneous low level shall be held for at least the nominal transmission period of two PhSDUs (octets).

NOTES

- 1 This is an asynchronous service and is not referenced to TxC.
- 2 When a DTE is itself being reset, possibly during power-up, it should attempt to reset the DCE even when the DTE's own V_{DD} is below normal operational limits.
- 3 This reset is under the control of the DTE. It does not preclude the existence of a separate reset pin on the DCE.

If the DTE concurrently changes both RTS and TxD during the implementation of either the DTE to DCE configuration or message transmission services, the DTE shall ensure that an interval of at least the minimum required setup time exists between changing the one signal to a high level, and subsequently changing the other signal to a low level, to eliminate potential logic hazards in the DCE's implementation of the DTE to DCE reset service.

8.3.2 DTE to DCE configuration service: This service is mutually exclusive with the DTE to DCE reset and message transmission services; at most one of them may be active at any given time. This service may initiate the DCE to DTE message reporting service to report DCE-internal status. The DTE to DCE reset service may preempt this service at any time.

This service shall be implemented in three phases; each of the latter two phases shall follow immediately upon completion of the prior phase.

NOTE 1—These phases can be implemented as a minor variation on the three phases specified for the DTE to DCE message transmission service. As a result, the DTE to DCE configuration service induces very little added complexity on the DTE and DCE.

- 1) The DTE shall assert (raise) RTS after the falling edge and before the rising edge of TxC. The DCE shall respond by anticipating configuration data.
- 2) When it is ready for configuration data from the DTE, the DCE shall raise CTS before the falling edge of TxC. The DTE shall respond by encoding the first bit of configuration data (high = 1, low = 0) on TxD before the falling edge of the next TxC, and shall continue this process without interruption until between 2 and 200 bits of data (see 8.4) have been so encoded. The DTE shall then assert (raise) TxD and negate (lower) RTS before the falling edge of the next TxC.

NOTE 2—The DTE shall ensure that TxD is raised at least one setup time before RTS is lowered to avoid potential logic hazards in the DCE implementation of the DTE to DCE reset service.

- 3) The DCE shall conclude any necessary reconfiguration before negating (lowering) CTS, which shall occur between two consecutive falling edges of TxC.

Both standardized and extendible configuration messages are defined in 8.4. Standardized messages cover the ranges of application of this interface which are anticipated to be most cost sensitive. Extendible messages permit differing forms of DCE configuration, where required, and can serve to initiate the DCE to DTE message reporting service to report DCE-internal status (a DCE option further described in 8.4).

8.3.3 DTE to DCE message transmission service: This service is mutually exclusive with the DTE to DCE reset and configuration services; at most one of them may be active at any given time. The DTE to DCE reset service may preempt this service at any time.

This service shall be implemented in three phases; each of the latter two phases shall follow immediately upon completion of the prior phase.

- 1) The DTE shall assert (raise) RTS after the rising edge and before the falling edge of TxC. The DCE shall respond by generating and transmitting the appropriate-length sequence of preamble and start delimiter PhPDUs.

- 2) When it is ready for transparent data from the DTE, the DCE shall raise CTS before the falling edge of Tx_C. The DTE shall respond by encoding the first bit of transparent data (high = 1, low = 0) on Tx_D before the next falling edge of Tx_C and shall continue this process without interruption until between 3 and 300 integral octets of data have been so encoded. The DTE shall then assert (raise) Tx_D and negate (lower) RTS before the next falling edge of Tx_C.

NOTE—The DTE shall ensure that Tx_D is raised at least one setup time before RTS is lowered to avoid potential logic hazards in the DCE implementation of the DTE to DCE reset service.

- 3) The DCE shall conclude transmission of all of the encoded transparent data received from the DTE, shall then generate and transmit the appropriate length sequence of end delimiter PhPDUs and shall then cease transmission. The DCE shall then wait an amount of time equal to the configured minimum post-transmission gap (see [Table 1](#)) before negating (lowering) CTS, which shall occur after a falling edge and before the next falling edge of Tx_C.

8.3.4 DCE to DTE fault notification service: This service shall be mutually exclusive with the DCE to DTE media-activity indication and message reporting services; at most one of them may be active at any given time. This service may preempt the DCE to DTE media-activity indication and message reporting services at any time.

This service shall be encoded as a simultaneous low level on both Rx_A and RDF. Once asserted by the DCE, this simultaneous low level shall be held until activation of either the DTE to DCE reset or configuration services.

NOTE—This is an asynchronous service and is not referenced to Rx_C.

The DCE may concurrently change both Rx_A and RDF during the concurrent termination of the DCE to DTE media-activity indication and message reporting services. The DTE is responsible for avoiding any logic hazards induced by this concurrent change.

8.3.5 DCE to DTE media-activity indication service: This service is mutually exclusive with the DCE to DTE fault notification service; at most one of them may be active at any given time. The DCE to DTE fault notification service may preempt this service at any time.

This service shall be encoded as a high level on Rx_A. Once asserted by the DCE, this high level enables recognition of a high-to-low transition on RDF to initiate the DCE to DTE message reporting service. Any subsequent high-to-low transition on Rx_A terminates that DCE to DTE message reporting service.

NOTE—The DCE to DTE media-activity indication service is an asynchronous service and is not referenced to Rx_C.

8.3.6 DCE to DTE message reporting service: This service is mutually exclusive with the DCE to DTE fault notification service; at most one of them may be active at any given time. This service can only occur while the DCE to DTE media-activity indication service is active. The DCE to DTE fault notification service may preempt this service at any time.

8.3.6.1 Non-erroneous reception: This service shall be implemented in four phases when reporting a well-formed message, each of which shall follow immediately upon completion of the prior phase.

The following description applies to DCEs that have end delimiter sequences of eight PhPDUs or less and do not require any extra decoding delay for an FEC (forward error correcting) code. DCEs that do not meet these conditions may introduce extra delay into their decoding and reporting processes so that, with respect to signaling on Rx_C and RDF, they do meet these conditions.

- 1) After detecting received signaling, training on that signaling, and recovering a data clock from that signaling whose nominal octet frequency is the same as TxC, the DCE shall initiate the DCE to DTE message reporting service by sourcing that recovered clock on RxC and then negating (lowering) RDF after the rising edge and before the next falling edge of RxC.

NOTE 1—RxA is already asserted at this time.

- 2) The DCE shall continue training and attempting to match the received signaling against its expected preamble and start delimiter PhPDUs.

If the DCE supports N channels of redundant media, it may report on RDF the identity of the channel from which the signaling is being received by encoding that channel number, in the range 0 to $N-1$, as a binary number that is reported most significant bit first during reception of the last three of those start delimiter PhPDUs. The bits reported on RDF shall be presented in series after successive rising edges of RxC, each before the immediately subsequent falling edge of RxC.

Upon detecting an exact match between the received signaling and the expected start delimiter, the DCE shall invert RDF after the falling edge and before the next rising edge of RxC.

NOTE 2—If the identity of the receiving channel was being reported on RDF, this inversion will occur during the low phase of RxC that immediately follows the high phase (of RxC) during which the last (low-order) bit of the channel number was reported.

- 3) The DCE shall continue reception and attempting to match the received signaling against potential data and expected end delimiter PhPDUs.

The DCE shall report each data bit decoded from the received signaling on RDF. The bits reported on RDF shall be presented in series after successive rising edges of RxC, each before the immediately subsequent falling edge of RxC. In the absence of errors these bits shall be reported in the same order and with the same values as they were transmitted by a peer PhL entity.

NOTE 3—This is a guarantee of transparency.

An end delimiter may be composed of both data and non-data PhPDUs. The DCE may report similarly on RDF each data bit decoded from an end delimiter and may report also on RDF an appropriate number of data values for the non-data PhPDUs decoded from an end delimiter, except that

- a) the total number of "bits" so reported shall be 7 or less, and
- b) upon detecting an exact match between the received signaling and the expected end delimiter, the DCE shall not report on RDF another bit corresponding to the end delimiter's last "bit", but rather shall first assert (raise) RDF after the rising edge and before the next falling edge of RxC, and then shall negate (lower) RDF after the falling edge and before the next rising edge of RxC.

NOTES

4 Most implementations will decode, and report on RDF as data, any initial data PhPDUs in a received end-delimiter sequence. The first non-data PhPDU, and subsequent PhPDUs, need not be reported. However, a final report will be made on RDF, indicating correct end-delimiter recognition.

5 Each reported bit, except the last, is maintained on RDF for a full cycle of Rx C. The last bit is replaced by a high-low sequence, each of which is maintained for just one phase of Rx C.

6 This terminating high-low sequence will occur during the first eight "bit" reports that occur after the last (pre-delimiter) data bit was reported. That last (pre-delimiter) data bit will have been the $8N$ th data bit so reported in this phase, where N should be at least 3 and no greater than 300.

- 4) The DCE shall assert (raise) RDF before the next falling edge of Rx C and shall not initiate another instance of the DCE to DTE message reporting service until after the conclusion of the current DCE to DTE media-activity indication service.

8.3.6.2 Erroneous reception: An error may be detected during any phase of the reception process described in 8.3.6.1. When that occurs, the DCE shall modify its sequencing of those phases as follows.

If the DCE should detect invalid PhPDUs, or an invalid sequence of PhPDUs, or a valid end delimiter sequence of PhPDUs that is not separated from the start delimiter PhPDUs by an integral number of data-octets of PhPDUs; and if the DCE can establish a valid signal on Rx C (for example, by substituting Tx C or some other local signal for the recovered clock source, if necessary); then

- a) if phase 2 has not already been initiated, the DCE shall immediately initiate phase 2;
- b) if phase 2 has not already been concluded, the DCE shall immediately conclude phase 2 as rapidly as possible, ignoring the requirement for matching of the start delimiter PhPDU sequence;
- c) otherwise, the DCE shall immediately negate (lower) RDF after the rising edge and before the next falling edge of Rx C, and then shall assert (raise) RDF after the falling edge and before the next rising edge of Rx C.

NOTE—This sequence permits the DCE to

- enable DTE use of Rx C;
- identify the channel with the erroneous signaling; and
- indicate a reception error.

When the DCE has completed as many of the above steps (a), (b), and (c) as appropriate and possible, the DCE shall immediately initiate phase 4.

8.4 DCE configuration messages: This sub-clause defines both standardized configuration messages and the standardized portion of extendible configuration messages. Standardized messages cover the ranges of application of this interface that are anticipated to be most commonly used. Extendible messages permit differing forms of DCE configuration where required and can serve to initiate the DCE to DTE message reporting service to report DCE-internal status (a DCE option).

Two standardized messages, and two classes of extendible messages, are defined. All messages are transmitted across the interface in the order in which the bits are defined. Integers are transmitted most-significant-bit (MSB) first.

The two standardized messages and two classes of extendible messages are distinguished by the first two data bits of the configuration message, as follows:

- 00—Basic configuration message
- 01—Path-diversity control message
- 10—Extendible configuration message
- 11—Extendible status-report invocation message