
**Information technology —
Telecommunications and information
exchange between systems — High-level
data link control (HDLC) procedures**

*Technologies de l'information — Télécommunications et échange
d'information entre systèmes — Procédures de commande de liaison de
données à haut niveau (HDLC)*

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Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

The main task of the joint technical committee is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

ISO/IEC 13239 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 6, *Telecommunications and information exchange between systems*.

This third edition cancels and replaces the second edition (ISO/IEC 13239:2000), which has been technically revised. It also cancels and replaces ISO/IEC 3309:1993, ISO/IEC 4335:1993, ISO/IEC 7809:1993 and ISO/IEC 8885:1993.

Annex H forms a normative part of this International Standard. Annexes A to G are for information only.

Introduction

This third edition adds a new frame format type to Annex H – Frame format types. This frame format type is used in those environments where additional error protection, identification of both the source and the destination(s), and/or longer frame sizes are needed.

High-level data link control (HDLC) procedures are designed to permit synchronous or start/stop, code-transparent data transmission. The normal cycle of the code-transparent data communication between two data stations consists of the transfer of frames containing information from the data source to the data sink acknowledged by a frame in the opposite direction. Generally, until the data station comprising the data source receives an acknowledgement, it holds the original information in memory in case the need should arise for retransmissions.

In those situations that require it, data sequence integrity between the data source and the data sink is effected by means of a numbering scheme, which is cyclic within a specified modulus and measured in terms of frames. An independent numbering scheme is used for each data source/data sink combination on the data link.

The acknowledgement function is accomplished by the data sink informing the data source of the next expected sequence number. This can be done in a separate frame, not containing information, or within the control field of a frame containing information.

HDLC procedures are applicable to unbalanced data links and to balanced data links.

Unbalanced data links

An unbalanced data link involves two or more participating data stations. For control purposes, one data station on the data link assumes responsibility for the organization of data flow and for unrecoverable data link level error conditions. The data station assuming these responsibilities is known as the primary station in unbalanced connection-mode data links and as the control station in unbalanced connectionless-mode data links, and the frames it transmits are referred to as command frames. The other data stations on the data link are known as the secondary stations in unbalanced connection-mode data links and as the tributary stations in unbalanced connectionless-mode data links, and the frames they transmit are referred to as response frames.

For the transfer of data between the primary/control station and the secondary/tributary stations, two cases of data link control are considered (see figures A and B). In the first case, the data station comprising the data source performs a primary/control station data link control function and controls the data station comprising the data sink that is associated with a secondary/tributary station data link control function, by select-type commands.

In the second case, the data station comprising the data sink performs a primary/control station data link control function and controls the data station comprising the data source that is associated with a secondary/tributary station data link control function, by poll-type commands.

The information flows from the data source to the data sink, and the acknowledgements are always transmitted in the opposite direction.

These two cases of data link control may be combined so that the data link becomes capable of two-way alternate communication, or two-way simultaneous communication.

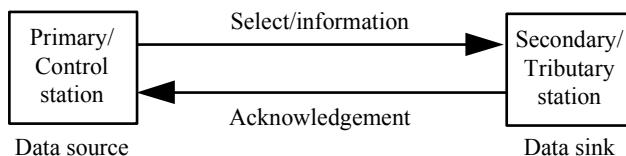


Figure A — Unbalanced data link functions (case 1)

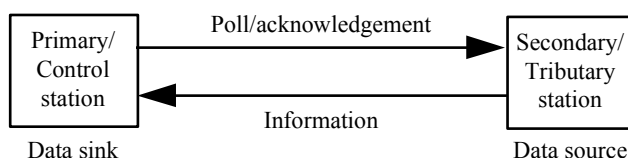


Figure B — Unbalanced data link functions (case 2)

Balanced data links

A balanced data link involves only two participating data stations. For control purposes, each data station assumes responsibility for the organization of its data flow and for unrecoverable data link level error conditions associated with the transmissions that it originates. Each data station is known as a combined station in balanced connection-mode data links and as a peer station in balanced connectionless-mode data links and is capable of transmitting and receiving both command and response frames.

For the transfer of data between combined/peer stations, the data link control functions illustrated in figure C are utilized. The data source in each combined/peer station controls the data sink in the other combined/peer station by the use of select-type commands. The information flows from the data source to the data sink, and the acknowledgements are always transmitted in the opposite direction. The poll-type commands may be used by each combined/peer station to solicit acknowledgements and status responses from the other combined/peer station.

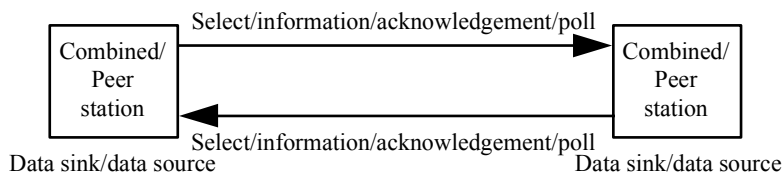


Figure C — Balanced data link functions

Data link configurations

HDLC classes of procedures describe methods of data link operation which permit synchronous or start/stop, code-transparent data transmission between data stations in a variety of logical and physical configurations. The classes are defined in a consistent manner within the framework of an overall HDLC architecture. One of the purposes of this International Standard is to maintain maximum compatibility between the basic types of procedures, unbalanced, balanced and connectionless, as this is particularly desirable for data stations with configurable capability, which may have the characteristics of a primary, secondary, combined, control, tributary, or peer station, as required for a specific instance of communication.

Five fundamental classes of procedures (two unbalanced, one balanced, and two connectionless) are defined herein. The unbalanced classes apply to both point-to-point and multipoint configurations (as illustrated in figure D using the primary/secondary nomenclature) over either dedicated or switched data transmission facilities. A characteristic of the unbalanced classes is the existence of a single primary station at one end of the data link plus one or more secondary stations at the other end(s) of the data link. The primary station alone is responsible for data link management, hence the designation "unbalanced" classes of procedures.

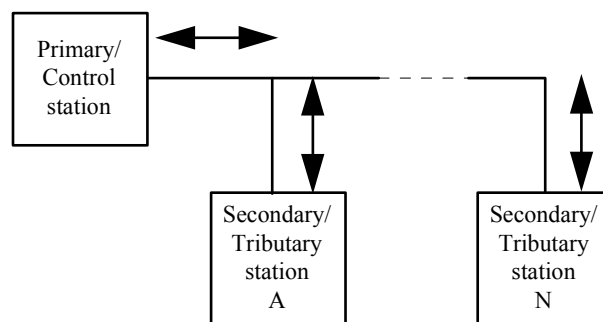


Figure D — Unbalanced data link configuration

The unbalanced connectionless class applies to point-to-point configurations over either dedicated or switched data transmission facilities, or to multipoint configurations over dedicated data transmission facilities (as illustrated in figure D using the control/tributary nomenclature). A characteristic of the unbalanced connectionless class is the existence of a single control station at one end of the data link plus one or more tributary stations at the other end(s) of the data link. The control station is responsible for determining when a tributary station is permitted to send. Neither the control station nor the tributary station(s) support any form of connection establishment/termination procedures, flow control procedures, data transfer acknowledgement procedures, or error recovery procedures, hence the designation "connectionless" class of procedures.

The balanced class applies to point-to-point configurations (as illustrated in figure E using the combined nomenclature) over either dedicated or switched data transmission facilities. A characteristic of the balanced class is the existence of two data stations, called combined stations, on a logical data link, that may share equally in the responsibility for data link management, hence the designation "balanced" class of procedures.

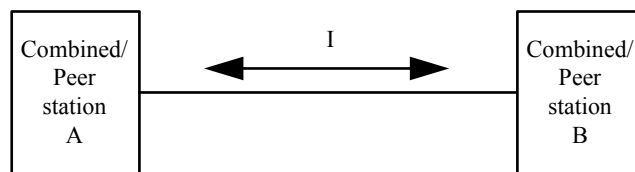


Figure E — Balanced data link configuration

The balanced connectionless class applies to point-to-point configurations over either dedicated or switched data transmission facilities (as illustrated in figure E using the peer nomenclature). A characteristic of the balanced connectionless class is the existence of two data stations, called peer stations, on a data link, that are each independently in control of when they can send. Neither peer station supports any form of connection establishment/termination procedures, flow control procedures, data transfer acknowledgement procedures, or error recovery procedures, hence the designation "connectionless" class of procedures.

For each class of procedures, a method of operation is specified in terms of the capabilities of the basic repertoire of commands and responses that are found in that class.

A variety of optional functions are also listed. Procedural descriptions for the use of the optional functions are defined.

It is recognized that it is possible to construct symmetrical configurations for operation on a single data circuit from the unbalanced classes of procedures which are defined in this International Standard. For example, the combination of two unbalanced procedures (with I frame flow as commands only) in opposite directions would create a symmetrical point-to-point configuration (as illustrated in figure F).

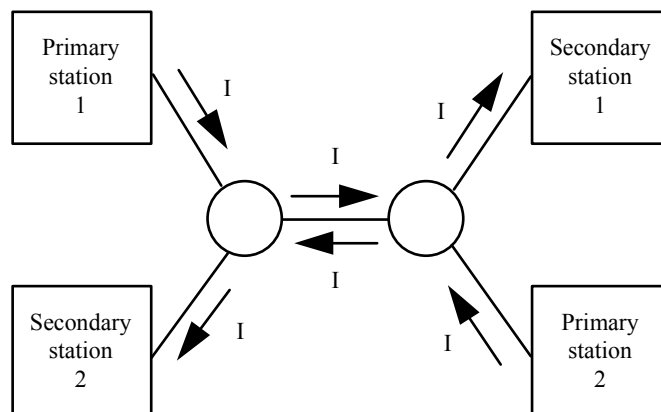


Figure F — Symmetrical data link configuration

These HDLC procedures define the exchange identification (XID) command/response frame as an optional function for exchange of data link information (identification, parameters, functional capability, etc.). The content and format for a general purpose XID frame information field is defined.

These HDLC procedures also specify the parameters and procedures which may be employed by two data stations to mutually determine the data link layer addresses to be used, prior to logical data link establishment.

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Information technology — Telecommunications and information exchange between systems — High-level data link control (HDLC) procedures

1 Scope

This International Standard specifies the frame structures, the elements of procedures, the classes of procedures, the content and format of the general purpose Exchange Identification (XID) frame, and a means for resolution/negotiation of a data link layer address in switched environments for data communication systems using bit-oriented high-level data link control (HDLC) procedures.

NOTE — The use of the phrase “bit-oriented”, referring to the HDLC control procedures, pertains to the allocation of a non-integral number of bits to various subfields used for HDLC control purposes. However, the frame as an entirety may be constructed from octet-oriented units (e.g., start-stop mode) for transmission purposes.

The frame structure portion defines the relative positions of the various components of the basic frame format and the non-basic frame format. The mechanisms used to achieve bit pattern independence (transparency), where and when required, within the frame are also defined. In addition, three frame checking sequences (FCS) are specified; the rules for address field extension are defined; and the addressing conventions available are described.

The elements of procedures portion specifies elements of data link control procedures for synchronous or start/stop, code-transparent data transmission using independent frame numbering in both directions.

These HDLC elements of procedures are defined specifically in terms of the actions that occur on receipt of commands at a secondary station, a tributary station, a peer station, or a combined station.

This International Standard is intended to cover a wide range of applications; for example one-way, two-way alternate or two-way simultaneous data communication between data stations which are usually buffered, including operations on different types of data circuits; for example multipoint/point-to-point, duplex/half-duplex, switched/non-switched, synchronous/start-stop, etc.

The defined elements of procedures are to be considered as a common basis for establishing different types of data link control procedures. This International Standard does not define any single system and should not be regarded as a specification for a data communication system. Not all of the commands or responses are required for any particular system implementation.

The classes of procedures portion describes the HDLC unbalanced classes of procedures, the HDLC balanced class of procedures, and the HDLC connectionless classes of procedures for synchronous or start/stop data transmission.

For the unbalanced classes, the data link consists of a primary station plus one or more secondary stations and operates in either the normal response mode or the asynchronous response mode in a point-to-point or multipoint configuration. For the balanced class, the data link consists of two combined stations and operates in the asynchronous balanced mode in a point-to-point configuration. For the unbalanced connectionless class, the data link consists of a control station plus one or more tributary stations and operates in the unbalanced connectionless-mode in a point-to-point or multipoint configuration. For the balanced connectionless class, the data link consists of two peer stations and operates in the balanced connectionless-mode in a point-to-point configuration. In each class, a basic repertoire of commands and responses is defined, but the capability of the data link may be modified by the use of optional functions.

Balanced operation is intended for use in circumstances which require equal control at either end of the data link. Operational requirements are covered in accordance with the overall HDLC architecture.

The content and format of the Exchange Identification (XID) frame portion builds on the fact that the principal use of the XID frame is to exchange data link information between two or more HDLC stations. For the purpose of this International Standard,

data link information shall include any and all essential operational characteristics such as identification, authentication and/or selection of optional functions and facilities concerning each station. This International Standard defines a single-exchange negotiation procedure for establishing operational characteristics when either one or more stations are capable of providing multiple selections.

This International Standard provides a means for exchanging the necessary information to establish, at a minimum, a data link connection between two correspondents wishing to communicate. It describes a general purpose XID frame information field content and format for that purpose.

It defines encoding for information related to the basic HDLC standards only. Mechanisms are provided to permit the general purpose XID frame information field to be used to negotiate private parameters in a single XID exchange simultaneously with negotiation of the defined basic parameters.

This International Standard does not limit or restrict the use of the XID frame information field from defining other standard formats for use in specific applications.

The following are examples of potential uses of the XID command/response frame interchange:

- a) Identification of the calling and called stations when using circuit switched networks (including switched network backup applications).
- b) Identification of stations operating on non-switched networks requiring identification at start-up.
- c) The XID command frame with an individual, group or all-station address may be used to solicit XID response frame(s) from other station(s) on the data link, prior to or following data link establishment.
- d) Negotiation of the Frame Check Sequence (FCS) to be used for subsequent information interchange, by stations that support both 16-bit FCS and 32-bit FCS capabilities.
- e) Convey higher layer information that may be required prior to data link establishment.
- f) Transmission of an XID response frame at any respond opportunity to request an XID exchange to modify some of the operational parameters (for example, window size) following data link establishment.
- g) Negotiation of the number of protected bits in the frame when an Unnumbered Information with Header check (UIH) frame is used.

The means for resolution/negotiation of a data link layer address in switched environments portion is applicable to data stations employing HDLC balanced classes of procedures which provide the XID command/response capability with the two specific parameter fields, identified below. It is used to select a pair of operational link addresses when preassigned, system designated addresses are not known on an a priori basis; e.g., switched circuited data links. Additional XID frame functions (including the exchange of operational parameters, command/response support, higher layer information, etc.) may be accomplished in conjunction with data link layer address determination or following address determination, with additional XID frame exchanges.

NOTE — Address resolution procedures for situations where the remote DTE does not support XID frames, the "all-station" address, or complete address support capabilities as defined in clause 8 below are not within the scope of this International Standard.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO/IEC 646:1991, *Information technology — ISO 7-bit coded character set for information interchange*

ISO/IEC 2382-9:1995, *Information technology — Vocabulary — Part 9: Data communication*

ISO 7478:1987, *Information processing systems — Data communication — Multilink procedures*

ISO/IEC 7498-1:1994, *Information technology — Open Systems Interconnection — Basic Reference Model: The Basic Model*

ISO/IEC 7776:1995, *Information technology — Telecommunications and information exchange between systems — High-level data link control procedures — Description of the X.25 LAPB-compatible DTE data link procedures*

ISO/IEC TR 10171:2000, *Information technology — Telecommunications and information exchange between systems — List of standard data link layer protocols that utilize high-level data link control (HDLC) classes of procedures, list of standard XID format identifiers, list of standard mode-setting information field format identifiers, and list of standard user-defined parameter set identification values*

3 Definitions, acronyms and abbreviations

3.1 Definitions

For the purposes of this International Standard, the following definitions apply.

3.1.1

abort

a function invoked by a sending primary, secondary, combined, control, tributary or peer station causing the recipient to discard (and ignore) all bit sequences transmitted by the sender since the preceding flag sequence

3.1.2

accept

the condition assumed by a data station (primary, secondary, combined, control, tributary or peer station) upon accepting a correctly received frame for processing

3.1.3

address field (A)

the sequence of eight (or any multiple of eight, if extended) bits identifying the secondary/combined or tributary/peer station sending (or designated to receive) the frame

3.1.4

address field extension

enlarging the address field to include more addressing information

3.1.5

address resolution/negotiation

procedure for exchanging/determining the data link layer identity of each data link layer entity

3.1.6

basic status

a secondary/combined or tributary/peer station's capability to send or receive a frame containing an information field

3.1.7

centralized control

a control in which all the primary or control station functions of the data link are centralized in one data station

3.1.8

combined station

that part of a data station that supports the combined station control functions of the data link

NOTE — The combined station generates commands and responses for transmission and interprets received commands and responses. Specific responsibilities assigned to a combined station include:

- a) initialization of control signal interchange;

- b) organization of data flow;
- c) interpretation of received commands and generation of appropriate responses; and
- d) actions regarding error control and error recovery functions at the data link layer.

3.1.9

command

in data communication, an instruction represented in the control field of a frame and transmitted by the primary/combined/control/peer station, which causes the addressed secondary/combined/tributary/peer station to execute a specific data link control function

3.1.10

command frame

- a) All frames transmitted by a primary/control station.
- b) Those frames transmitted by a combined/peer station that contain the address of the other combined/peer station.

3.1.11

contention mode

a mode of transmission in which a transmitter can send on its own initiative

3.1.12

control escape (CE)

the unique sequence of eight bits (10111110) employed to indicate the following octet has been modified according to the transparency algorithm for start/stop transmission environments

3.1.13

control field (C)

the sequence of eight (or 16/32/64, if extended) bits immediately following the address field of a frame

NOTE — The content of the control field is interpreted by:

- a) the receiving secondary/combined/tributary/peer station, designated by the address field, as a command instructing the performance of some specific function; and
- b) the receiving primary/combined/control/peer station as a response from the secondary/combined/tributary/peer station, designated by the address field, to one or more commands.

3.1.14

control field extension

enlarging the control field to include additional control information

3.1.15

control station

the data station that supports the control station control functions of the data link

NOTE — The control station generates command for transmission and interprets received responses. Specific responsibilities assigned to the control station include:

- a) initialization of control signal interchange, and
- b) organization of data flow.

3.1.16

data communication

see ISO/IEC 2382-9, term 09.01.03

3.1.17**data link**

see ISO/IEC 2382-9, term 09.04.08

3.1.18**data link connection**

see ISO/IEC 7498-1 : 1994

3.1.19**data link layer**

the conceptual layer of control or processing logic existing in the hierarchical structure of a data station (primary, secondary, combined, control, tributary or peer station) that is responsible for maintaining control of the data link

NOTE — The data link layer functions provide an interface between the data station higher layer logic and the data link. These functions include:

- a) transparency;
- b) address/control field interpretation;
- c) command/response generation, transmission and interpretation; and
- d) frame check sequence computation and interpretation.

3.1.20**data transmission**

see ISO/IEC 2382-9, term 09.01.02

3.1.21**duplex transmission**

see ISO/IEC 2382-9, term 09.03.01

3.1.22**exception condition**

the condition assumed by a secondary/combined station upon receipt of a frame which it cannot execute due either to a transmission error or to an internal processing malfunction

3.1.23**flag sequence (F)**

the unique sequence of eight bits (01111110) employed to delimit the opening and closing of a frame

3.1.24**format identifier**

designator of one of 128 different standardized formats or one of 128 user-defined formats of the Exchange Identification (XID) frame information field

3.1.25**frame**

the sequence of address, control, information, and FCS fields, bracketed by opening and closing flag sequences

NOTE — A valid frame is at least 24 bits in length and contains an address field, a control field and a frame check sequence. A frame may or may not include an information field.

3.1.26**frame check sequence (FCS)**

the field immediately preceding the closing flag sequence of a frame, containing the bit sequence that provides for the detection of transmission errors by the receiver

3.1.27

frame format identifier

an optional field in non-basic frame format mode that identifies the format of the frame

3.1.28

group identifier

classifier of data link layer characteristics or parameters by function (for example, address resolution, parameter negotiation, user data)

3.1.29

half-duplex transmission

see ISO/IEC 2382-9, term 09.03.02

3.1.30

header check sequence (HCS)

a check sequence using one of the standard 8, 16, or 32 bit polynomials that is computed over the fields between the opening flag sequence and the HCS field

3.1.31

HDLC-based protocol

a protocol which is a subset of the elements and classes of procedure and optional functions defined in the HDLC standard, and adopted as a standard by ISO or a recognized international standards body (e.g., ITU-T)

3.1.32

higher layer

the conceptual layer of control or processing logic existing in the hierarchical structure of a data station (primary, secondary, combined, control, tributary or peer station) that is above the data link layer and upon which the performance of data link layer functions are dependent; for example device control, buffer allocation, station management, etc.

3.1.33

information field (INFO)

the sequence of bits, occurring between the last bit of the control field and the first bit of the frame check sequence

NOTE — The information field contents of I, UI, and UIH frames are not interpreted at the data link layer.

3.1.34

initiating combined station

a station that sends the initial XID command frame as part of the address resolution process

3.1.35

interframe time fill

the sequence or condition transmitted between frames

3.1.36

intraframe time fill

in start/stop transmission, the sequence or condition transmitted within a frame when the next octet is not available for contiguous transmission immediately following the preceding octet (For synchronous transmission, there is no provision for intraframe time fill)

3.1.37

invalid frame

a sequence of bits, following the receipt of an apparent opening flag sequence, that either

- a) is terminated by an abort sequence; or
- b) contains less than 32 bits before an apparent closing flag sequence is detected

3.1.38**layer parameter**

the specification of data link layer characteristics and parameters, and their values, available or chosen

3.1.39**non-initiating combined station**

a station that waits for the other combined station to send the initial XID command frame as part of the address resolution process

3.1.40**peer station**

the data station that supports the peer station control functions of the data link

NOTE — The peer station generates commands for transmission and interprets received commands and responses.

3.1.41**primary station**

the data station that supports the primary station control functions of the data link

NOTE — The primary station generates commands for transmission and interprets received responses. Specific responsibilities assigned to the primary station include:

- c) initialization of control signal interchange;
- d) organization of data flow; and
- e) actions regarding error control and error recovery functions at the data link layer.

3.1.42**primary/secondary station**

the general case where the station may be either a primary station or a secondary station

3.1.43**private parameter**

an implementation-specific data link layer parameter not defined in the basic HDLC standards

3.1.44**response**

in data communication, a reply represented in the control field of a response frame that advises the primary/combined/control/peer station with respect to the action taken by the secondary/combined/tributary/peer station to one or more commands

3.1.45**response frame**

- f) all frames transmitted by a secondary/tributary station
- g) those frames transmitted by a combined/peer station that contain the address of the transmitting combined/peer station

3.1.46**secondary station**

the data station that executes data link control functions as instructed by the primary station

NOTE — A secondary station interprets received commands and generates responses for transmission.

3.1.47**secondary station status**

the current condition of a secondary station with respect to processing the series of commands received from the primary station

3.1.48

single-exchange negotiation procedure

the initiating station indicates its "menu" of capabilities in its command frame, and the responding station indicates its choices from the menu in its response frame

3.1.49

tributary station

the data station that executes data link control functions as instructed by the control station

NOTE — The tributary station interprets received commands and generates responses for transmission.

3.1.50

two-way alternate data communication

see ISO/IEC 2382-9, term 09.05.03

3.1.51

two-way simultaneous data communication

see ISO/IEC 2382-9, term 09.05.02

3.1.52

unique identifier

a unique bit/character sequence (for example, global telephone number, station identification, or equivalent) associated with each station

3.1.53

unnumbered commands

the commands that do not contain sequence numbers in the control field

3.1.54

unnumbered responses

the responses that do not contain sequence numbers in the control field

3.1.55

user data

the information obtained from or delivered to the user of the data link layer

3.2 Acronyms and abbreviations

The following acronyms and abbreviations are used commonly throughout this International Standard.

A	Address field
ABM	Asynchronous Balanced Mode
ADM	Asynchronous Disconnected Mode
ARM	Asynchronous Response Mode
B	Binary encoded
BAC	Balanced operation Asynchronous balanced mode Class
BCC	Balanced operation Connectionless-mode Class
BCM	Balanced Connectionless Mode
C	Control field
CE	Control Escape
C/R	Command/Response
DLSDU	Data Link Service Data Unit
F	Flag sequence
F	Final bit

FI	Format Identifier
DC1	Device Control One
DC3	Device Control Three
DCE	Data Circuit-terminating Equipment
DISC	Disconnect
DM	Disconnected Mode
DTE	Data Terminal Equipment
E	bit Encoded
FCS	Frame Check Sequence
FRMR	FRaMe Reject
GI	Group Identifier
GL	Group Length
HCS	Header Check Sequence
HDLC	High-level Data Link Control
I	Information frame
IEC	International Electrotechnical Commission
IM	Initialization Mode
INFO	INFormaTion field
ISO	International Organization for Standardization
ITU-T	International Telecommunications Union — Telecommunication Standardization Sector
LAPB	Link Access Procedure Balanced
LSB	Least Significant Bit
M	Modifier function bit
MSB	Most Significant Bit
MT1	Multilink lost frame Timer 1
MT2	Multilink group busy Timer 2
MT3	Multilink reset confirmation Timer 3
MW	Multilink Window size
MX	Multilink guard region window size
N	Number of octets
N(S)	Send sequence Number
N(R)	Receive sequence Number
NA	Not Applicable
NDM	Normal Disconnected Mode
NRM	Normal Response Mode
P	Poll bit
P/F	Poll/Final bit
PI	Parameter Identifier
PL	Parameter Length
Pri	Primary
PV	Parameter Value
RD	Request Disconnect
REJ	REJect
RIM	Request Initialization Mode

RNR	Receive Not Ready
RR	Receive Ready
RSET	ReSET
S	Supervisory frame
S	Supervisory function bit
SABM	Set Asynchronous Balanced Mode
SABME	Set Asynchronous Balanced Mode Extended
SARM	Set Asynchronous Response Mode
SARME	Set Asynchronous Response Mode Extended
SBDPT	Seven-Bit Data Path Transparency
SD	System Defined
Sec	Secondary
SIM	Set Initialization Mode
SM	Set Mode
SNRM	Set Normal Response Mode
SNRME	Set Normal Response Mode Extended
SREJ	Selective REJect
TBD	To Be Determined
TEST	TEST
TR	Technical Report
TWA	Two-Way Alternate
TWS	Two-Way Simultaneous
U	Unnumbered frame
UA	Unnumbered Acknowledgement
UAC	Unbalanced operation Asynchronous response mode Class
UCC	Unbalanced operation Connectionless-mode Class
UCM	Unbalanced Connectionless Mode
UI	Unnumbered Information
UIH	Unnumbered Information with Header check
UNC	Unbalanced operation Normal response mode Class
UP	Unnumbered Poll
V(S)	Send state Variable
V(R)	Receive state Variable
XID	eXchange IDentification
XOFF	Transmitter OFF
XON	Transmitter ON

4 HDLC frame structure

In HDLC, all transmissions are in frames. Frames may be either in basic frame format or in non-basic frame format. Neither the basic nor the non-basic frame format structure includes bits inserted for bit-synchronization (i.e., start or stop elements see 4.3.2) or bits or octets inserted for transparency (see 4.3).

Basic and non-basic frame formats can not be used simultaneously on the same media. See Clause 7.5 for the rules for negotiating from the basic frame format to the non-basic frame format. However, it is possible for different format types of the non-basic frame to exist simultaneously on the same media.

4.1 Frame formats

4.1.1 Basic frame format

Each frame using the basic frame format consists of the following fields (transmission sequence left to right):

Flag	Address	Control	Info.	FCS	Flag
01111110	8 bits	8 bits	*	16 bits	01111110

* An unspecified number of bits which in some cases may be a multiple of a particular character size; for example, an octet.

where

Flag = flag sequence

Address = data station address field

Control = control field

Information = information field

FCS = frame checking sequence field

Frames containing only control sequences form a special case where there is no information field. The format for these frames shall be

Flag	Address	Control	FCS	Flag
01111110	8 bits	8 bits	16 bits	01111110

4.1.2 Non-basic frame format

A frame using the non-basic frame format does not follow the structure of 4.1.1 in one or more ways. For example, a frame using a non-basic frame format —

- instead of having only one address field, has more than one address field (see 4.2.2); or
- instead of an address field consisting of a single octet, has an extended address field consisting of one or more octets (see 4.7.1 and 6.15.7); or
- instead of a basic control field consisting of a single octet, has an extended control field of more than one octet (see 4.7.2 and 6.15.10); or
- instead of a 16-bit FCS, has an 8-bit FCS (see 4.2.5.4 and 6.15.14.2) or a 32-bit FCS (see 4.2.5.3 and 6.15.14.1); or
- instead of being transmitted in synchronous mode, is sent in start/stop mode (see 4 and 6.15.15); or
- instead of having an address field follow the opening flag sequence, has a frame format field following the opening flag sequence; or
- instead of having the information field follow the control field, there may be a header check sequence following the control field.

4.2 Elements of the frame

4.2.1 Flag sequence

All frames shall start and end with the flag sequence. All data stations which are attached to the data link shall continuously hunt for this sequence. Thus, the flag is used for frame synchronization. A single flag may be used as both the closing flag for one frame and the opening flag for the next frame.

4.2.2 Address field(s)

Frames using the basic frame format shall have one address field immediately following the opening flag. Frames using the non-basic frame format may have more than one address field. When more than one address field is used, they shall be present in the frame in a consecutive manner.

In command frames, the address(es) shall identify the data station(s) for which the command is intended. In response frames, the address shall identify the data station from which the response originated.

4.2.3 Control field

The control field indicates the type of commands or responses, and contains sequence numbers, where appropriate. The control field shall be used

- a) to convey a command to the addressed data station(s) to perform a particular operation, or
- b) to convey a response to such a command from the addressed data station.

4.2.4 Information field

Information may be any sequence of bits. In most cases it will be linked to a convenient character structure, for example octets, but, if required, it may be an unspecified number of bits and unrelated to a character structure.

For start/stop transmission there shall be eight (8) information bits between the start element and the stop element. If the information field is other than a multiple of 8 bits, the final remainder less than an octet will require pad bits to complete the octet. The method of providing and unambiguously identifying the pad bits is not a subject of this International Standard.

4.2.5 Frame checking sequencing (FCS) field

4.2.5.1 General

Three frame checking sequences are specified; an 8-bit frame checking sequence, a 16-bit frame checking sequence, and a 32-bit frame checking sequence. The 16-bit frame checking sequence is normally used. The 8-bit frame checking sequence is for use by prior agreement in those cases where short frames are used such that the protection afforded is adequate and/or the overhead of a longer frame checking sequence is of concern. The 32-bit frame checking sequence is for use by prior agreement in those cases that need a higher degree of protection than can be provided by the 16-bit frame checking sequence.

Unless otherwise noted, the frame checking sequence is calculated for the entire length of the frame, excluding the opening flag, the FCS, any start and stop elements (start/stop transmission), and any bits (synchronous transmission) or octets (start/stop transmission) inserted for transparency. In those instances noted where the FCS is calculated over an agreed to, designated portion of the entire frame, the calculation shall begin immediately after the opening flag and continue, over the designated portion of the entire frame, excluding any start and stop elements (start/stop transmission), and any bits (synchronous transmission) or octets (start/stop transmission) inserted for transparency. The length of the designated portion of the frame being protected by the FCS checking mechanism is determined by negotiation or known by a priori knowledge.

NOTES

1. If future applications show that other degrees of protection are needed, different numbers of bits in the FCS will be specified, but they will be an integral number of octets.
2. Explanatory notes on the implementation of the frame checking sequence are given in Annex A.
3. The bits to be protected should include, at a minimum, all of the bits in the address and control fields, and, when used, the frame format field.

4.2.5.2 16-bit frame checking sequence

The 16-bit FCS shall be the ones complement of the sum (modulo 2) of

- a) the remainder of

$$x^k (x^{15} + x^{14} + x^{13} + x^{12} + x^{11} + x^{10} + x^9 + x^8 + x^7 + x^6 + x^5 + x^4 + x^3 + x^2 + x + 1)$$

divided (modulo 2) by the generator polynomial

$$x^{16} + x^{12} + x^5 + 1,$$

where k is the number of bits being protected by the FCS and

- b) the remainder of the division (modulo 2) by the generator polynomial

$$x^{16} + x^{12} + x^5 + 1$$

of the product of x^{16} by the content of the k bits being protected.

As a typical implementation, at the transmitter, the initial content of the register of the device computing the remainder of the division is preset to all ones and is then modified by division by the generator polynomial (as described above) of the address, control and any remaining bits of the designated k bits being protected; the ones complement of the resulting remainder is transmitted as the 16-bit FCS.

At the receiver, the initial content of the register of the device computing the remainder is preset to all ones. The final remainder after multiplication by x^{16} and then division (modulo 2) by the generator polynomial

$$x^{16} + x^{12} + x^5 + 1$$

of the serial incoming protected bits and the FCS will be

0001 1101 0000 1111 (x^{15} through x^0 , respectively) in the absence of transmission errors.

4.2.5.3 32-bit frame checking sequence

The 32-bit FCS shall be the ones complement of the sum (modulo 2) of

- a) the remainder of

$$x^k (x^{31} + x^{30} + x^{29} + x^{28} + x^{27} + x^{26} + x^{25} + x^{24} + x^{23} + x^{22} + x^{21} + x^{20} + x^{19} + x^{18} + x^{17} + x^{16} + x^{15} + x^{14} + x^{13} + x^{12} + x^{11} + x^{10} + x^9 + x^8 + x^7 + x^6 + x^5 + x^4 + x^3 + x^2 + x + 1)$$

divided (modulo 2) by the generator polynomial

$$x^{32} + x^{26} + x^{23} + x^{22} + x^{16} + x^{12} + x^{11} + x^{10} + x^8 + x^7 + x^5 + x^4 + x^2 + x + 1,$$

where k is the number of bits being protected by the FCS and

- b) the remainder of the division (modulo 2) by the generator polynomial

$$x^{32} + x^{26} + x^{23} + x^{22} + x^{16} + x^{12} + x^{11} + x^{10} + x^8 + x^7 + x^5 + x^4 + x^2 + x + 1$$

of the product of x^{32} by the content of the k bits being protected.

As a typical implementation, at the transmitter, the initial content of the register of the device computing the remainder of the division is preset to all ones and is then modified by division by the generator polynomial (as described above) of the address, control and any remaining bits of the designated k bits being protected; the ones complement of the resulting remainder is transmitted as the 32-bit FCS.

At the receiver, the initial content of the register of the device computing the remainder is preset to all ones. The final remainder after multiplication by x^{32} and then division (modulo 2) by the generator polynomial

$$x^{32} + x^{26} + x^{23} + x^{22} + x^{16} + x^{12} + x^{11} + x^{10} + x^8 + x^7 + x^5 + x^4 + x^2 + x + 1$$

of the serial incoming protected bits and the FCS will be

1100 0111 0000 0100 1101 1101 0111 1011 (x^{31} through x^0 , respectively) in the absence of transmission errors.

4.2.5.4 8-bit frame checking sequence

The 8-bit FCS shall be the ones complement of the sum (modulo 2) of

- a) the remainder of

$$x^k (x^7 + x^6 + x^5 + x^4 + x^3 + x^2 + x + 1)$$

divided (modulo 2) by the generator polynomial

$$x^8 + x^2 + x + 1,$$

where k is the number of bits in the frame existing between, but not including, the final bit of the opening flag and the first bit of the FCS, excluding start and stop elements (start/stop transmission), and bits (synchronous transmission) and octets (start/stop transmission) inserted for transparency, and

- b) the remainder of the division (modulo 2) by the generator polynomial

$$x^8 + x^2 + x + 1$$

of the product of x^8 by the content of the frame existing between, but not including, the final bit of the opening flag and the first bit of the FCS, excluding start and stop elements (start/stop transmission), and bits (synchronous transmission) and octets (start/stop transmission) inserted for transparency.

As a typical implementation, at the transmitter, the initial content of the register of the device computing the remainder of the division is preset to all ones and is then modified by division by the generator polynomial (as described above) of the address, control and information fields; the ones complement of the resulting remainder is transmitted as the 8-bit FCS.

At the receiver, the initial content of the register of the device computing the remainder is preset to all ones. The final remainder after multiplication by x^8 and then division (modulo 2) by the generator polynomial

$$x^8 + x^2 + x + 1$$

of the serial incoming protected bits and the FCS, will be “1111 0011” (x^7 through x^0 , respectively) in the absence of transmission errors.

4.2.6 Header check sequence (HCS) field

The HCS field, if present, follows the control field and is either 8, 16, or 32 bits long. This check sequence is applied to only the header, i.e., the bits between the opening flag sequence and the header check sequence. The HCS may be any of the 8, 16, or 32 bit check sequences defined for the HDLC frame check sequence in 4.2.5. The choice of HCS is determined as part of the definition of the frame format and distinguished by the format type subfield in the frame format field. The HCS will use the same polynomial as the FCS and thus will have the same length.

Frames that do not have an information field or have an empty information field, e.g., as with some supervisory frames, do not contain an HCS and FCS, only an FCS.

4.3 Transparency

4.3.1 Synchronous transmission

The transmitter shall examine the frame content between the two flag sequences including the address, control and FCS fields, as well as the frame format and HCS fields, when present, and shall insert a "0" bit after all sequences of 5 contiguous "1" bits (including the last 5 bits of the FCS) to ensure that a flag sequence is not simulated. The receiver shall examine the frame content and shall discard any "0" bit which directly follows 5 contiguous "1" bits.

4.3.2 Start/stop transmission - basic transparency

Two levels of transparency processing are specified for use with start/stop mode transmission. These are seven-bit data path transparency (SBDPT), specified in 4.3.2.1; and control-octet transparency, specified in 4.3.2.2. Control-octet transparency shall always be performed. SBDPT is an option, use or non-use of which is selected for a given data link by means outside the scope of this International Standard (e.g., a priori knowledge, bilateral agreement, heuristic implementation techniques).

4.3.2.1 Seven-bit data path transparency

When SBDPT is selected, the content of each frame, from address field or frame format field, when present, to FCS field inclusive, shall be transferred between sender and receiver as a frame-image derived from the original frame as follows, and as indicated in figure 1.

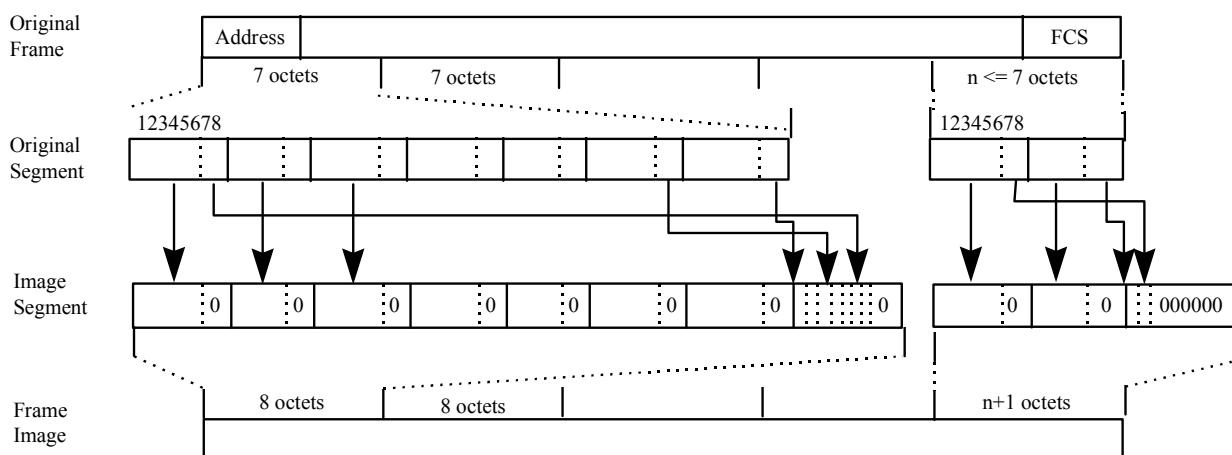


Figure 1 — Original frame to frame-image transition

The sequence of octets making up the frame content is considered as divided into a sequence of contiguous seven-octet segments, with possibly a final segment having length between one and six octets inclusive. These segments are referred to as "original segments."

The frame-image consists of a sequence of image segments defined, in one-to-one correspondence with the original segments, as follows:

- image segments occur in the same order as the corresponding original segments;
- each image segment is one octet longer than its original segment;
- the first part of each image segment is a copy of its original segment, but with the most significant bit (MSB) of each octet set to zero;
- the remaining, final, octet of each image segment has its least significant bit (LSB) set to the value of the MSB of the last octet of the original segment, its next to least significant bit set to the value of the MSB of the next to last octet (if any) of the original segment, and so on;
- in the final octet of each image segment, all higher order bits for which no corresponding octet exists in the original segment are set to zero.

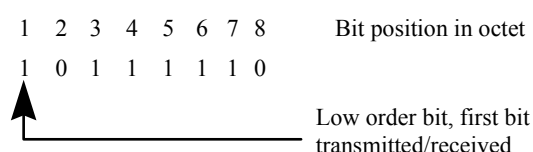
NOTE 1 — At the transmitter, the final octet of each image segment can be generated by shifting left the MSB of each octet in the original segment, in sequence, into an initially zero octet: this achieves the correct bit-positioning both for complete seven-octet segments and any short segment at the end of the frame.

NOTE 2 — The MSB of each image-segment octet is defined as zero only for uniqueness of the mapping: because its value is known and plays no part in the reconstruction of the original segment at the receiver, it need not actually be transferred across data paths that, for example, force parity setting of the MSB of each octet.

4.3.2.2 Control-octet transparency

The following transparency mechanism shall be applied to each frame-image: a frame-image is as defined in 4.3.2.1 when SBDPT is selected, and otherwise is identical to the frame content from address field or frame format field, when present, to FCS field inclusive.

The control escape octet is a transparency identifier that identifies an octet occurring within a frame to which the following transparency procedure is applied. The encoding of the control escape octet is:



The transmitter shall examine the frame-image between the opening and closing flag sequences including the address, control, and FCS fields, as well as the frame format and HCS fields, when present, and, following completion of the FCS calculation, shall:

- Upon the occurrence of the flag or a control escape octet, complement the 6th bit of the octet, and
- Insert a control escape octet immediately preceding the octet resulting from the above prior to transmission.

The receiver shall examine the frame-image between the two flag octets and shall, upon receipt of a control escape octet and prior to FCS calculation:

- Discard the control escape octet, and
- Restore the immediately following octet by complementing its 6th bit.

NOTE — Other octet values may optionally be included in the transparency procedure by the transmitter. Such inclusion shall be subject to prior system/application agreement.

4.3.3 Start/stop transmission - extended transparency

When necessary and by prior agreement between the stations, the transmitter may apply the above transparency procedure (4.3.2) to octets in the groups defined below, in addition to the flag and control escape octets.

4.3.3.1 Flow-control transparency

The flow-control transparency option provides transparency processing for the DC1/XON and DC3/XOFF control characters defined in ISO/IEC 646 (i.e., 1000100x and 1100100x, respectively, where "x" may be either "0" or "1"). This has the effect of assuring that the octet stream does not contain values which could be interpreted by intermediate equipment as flow control characters (regardless of parity).

4.3.3.2 Control-character octet transparency

The control-character octet transparency option provides transparency processing for all octets in which both the 6th and 7th bits are "0" (i.e., xxxxx00x, where "x" may be either "0" or "1") as well as for the DELETE character octet (i.e., 111111x, where "x" may be either "0" or "1"). This has the effect of assuring that the octet stream does not contain values which could be interpreted by intermediate equipment as the control characters or DELETE character defined by ISO/IEC 646 (regardless of parity).

4.3.4 Non-basic frame format transparency

When using the non-basic frame format with the frame format field, the length subfield obviates the need for the bit or octet insertion methods to achieve transparency. This capability is selected by the use of Option 24 described in 6.15.24. The use of the frame format field may be established by a priori agreement or may be selected with the XID or set mode using a negotiation procedure specified in 7.

4.4 Transmission considerations

4.4.1 Order of bit transmission

Addresses, commands, responses, sequence numbers, frame formats, and data link layer information within information fields shall be transmitted low-order bit first (for example, the first bit of the sequence number that is transmitted shall have the weight 2^0).

The order of transmitting user data bits within the information field is not specified in this International Standard.

The FCS and HCS, when present, shall be transmitted to the line commencing with the coefficient of the highest term.

4.4.2 Start/stop transmission

For start/stop transmission, each octet (whether part of the frame structure or inserted by the transparency procedure) is delimited by a start element and a stop element. Mark-hold (continuous logical 1 condition) is used for inter-octet time fill, if required. Typical octet transmission is as shown in figure 2.

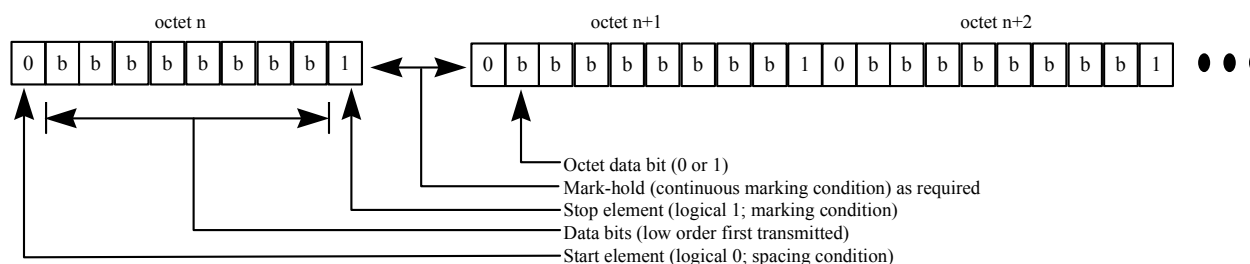


Figure 2 — Typical octet transmission for start/stop transmission

4.5 Inter-frame time fill

4.5.1 Synchronous transmission

Inter-frame time fill shall be accomplished by transmitting either contiguous flags or seven to fourteen contiguous "1" bits, or a combination of both.

Selection of the inter-frame time fill method depends on systems requirements.

4.5.2 Start/stop transmission

Inter-frame time fill shall be accomplished by transmitting continuous mark-hold condition (logical "1" state) or continuous flags, or a combination of both.

4.6 Invalid frame

4.6.1 Synchronous transmission

An invalid frame is defined as one that is not properly bounded by two flags or one which is too short (that is, shorter than 24 bits between flags when using the 8-bit FCS, shorter than 32 bits between flags when using the 16-bit FCS, and shorter than 48 bits between flags when using the 32-bit FCS). Invalid frames shall be ignored. Thus, a frame which ends with an all "1" bit sequence of length equal to or greater than seven bits shall be ignored.

As an example, one method of aborting a frame would be to transmit 8 contiguous "1" bits.

4.6.2 Start/stop transmission

An invalid frame is defined as one that is not properly bounded by two flags or one that is too short (that is, shorter than 3 octets between flags when using the 8-bit FCS, shorter than four octets between flags when using the 16-bit FCS, and shorter than six octets between flags when using the 32-bit FCS, excluding octets inserted for transparency), or one in which octet framing is violated (i.e., a "0" bit occurs where a stop element is expected), or one that ends with a control escape-closing flag sequence. Invalid frames shall be ignored.

4.6.3 Start/stop transmission intra-frame time-out recovery

The intra-frame timeout for start/stop transmission is an optional timeout used for recovering from situations in which excessive periods of time elapse between transmitted octets within a frame. This time-out function (or equivalent) only applies to a frame that is being received. The time-out function (or equivalent) is started once the stop bit of an octet is detected and stopped upon receipt of the start bit of the next octet or when the time-out function (or equivalent) runs out. The duration of the time-out function (or equivalent) normally will be well within 1 second.

If the time-out function (or equivalent) runs out, the data stream is scanned for the next opening flag sequence.

4.7 Extensions

4.7.1 Extended address field

A single octet address field shall normally be used and all 256 combinations shall be available.

However, by prior agreement, the address field range can be extended by reserving the first transmitted bit (low-order) of each address octet which would then be set to binary zero to indicate that the following octet is an extension of the address field. The format of the extended octet(s) shall be the same as that of the first octet. Thus, the address field may be recursively extended. The last octet of an address field is indicated by setting the low-order bit to binary one.

When extension is used, the presence of a binary "1" in the first transmitted bit of the first address octet indicates that only one address octet is being used. The use of address extension thus restricts the range of single octet addresses to 128.

4.7.2 Extended control field

The control field may be extended by one or more octets. The extension methods and the bit patterns for the commands and responses are defined in 5.3 and 5.5.

4.8 Addressing conventions

4.8.1 General

The following conventions shall apply in the assignment of addresses of data stations for which commands are intended.

4.8.2 All-station address

The address field bit pattern 11111111 is defined as the all-station address.

The all-station address shall only be used with command frames, and it shall instruct all receiving data stations to accept and action the associated command frame. Any response to a command with the all-station address shall contain the assigned individual address of the data station transmitting the response.

The all-station address may be used for all-station polling. When there is more than one receiving data station for which a command with the all-station is intended, any responses from these data stations shall not interfere with one another.

NOTE — The mechanism used to avoid overlapping responses to a poll using the all-station address is not specified in this International Standard.

The all-station address may be used to determine the data link layer identification (assigned address) of data station(s) when unknown; for example, in switched or reconfigured situations.

4.8.3 No-station address

The bit pattern 00000000 in the first octet of the extended or non-extended address field is defined as the no-station address.

The no-station address shall never be assigned to a data station.

The no-station address may be used for testing when it is intended that no data station react or respond to a frame containing the no-station address.

4.8.4 Group addresses

In addition to an individual assigned address, one or more data stations may be assigned one or more group addresses. A group address may be used, for example, for

- a) transmitting a frame simultaneously to the assigned group of data stations, or
- b) polling the assigned group of data stations.

Any address field bit pattern, except the all-station address, the no-station address and any individual address already assigned, may be assigned as a group address.

A group address may be used for group polling. When there is more than one data station for which a command with a group address is intended, any responses from these data stations shall not interfere with one another.

NOTE — The mechanism used to avoid overlapping responses to a poll using a group address is not specified in this International Standard.

4.9 Frame format field

This optional field is present only when using the non-basic frame format. When present, it follows the opening flag sequence.

The frame format field is 1, 2, or 3 octets (and may be extended to more) in length and consists of three subfields referred to as the format type subfield, the segmentation subfield and the frame length subfield. The format of the frame format field is as follows:

Table 1 — Frame format field structures

TYPE 0

MSB		LSB	
Format TYPE		FRAME LENGTH	
1 bit		7 bits	

TYPES 1 through 7

MSB		LSB	
Format TYPE		FRAME LENGTH & optional Segmentation subfield	
4 bits		12 bits	

TYPE 8

MSB		LSB
Format TYPE	000	FRAME LENGTH & optional Segmentation subfield
8 bits	3 bits	13 bits

Table 2 — Frame format field encodings

	MSB							LSB												
Type 0	0	L	L	L	L	L	L													
Type 1	1	0	0	0	*	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
Type 2	1	0	0	1	*	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
Type 3	1	0	1	0	*	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
Type 4	1	0	1	1	*	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
Type 5	1	1	0	0	*	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
Type 6	1	1	0	1	*	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
Type 7	1	1	1	0	*	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
Expanded, Type 8	1	1	1	1	0	0	0	0	0	0	0	*	L	L	L	L	L	L	L	L

- L - Length subfield
- * - Optional Segmentation subfield

Note 1 — Specific frame formats are specified in Annex H. As requirements for new frame formats arise Annex H should be amended to include them. Otherwise, all values of the format type subfield are reserved for future standardization.

Note 2 — Some frame format types may use the segmentation subfield. The use of this subfield must be specified as part of its definition. If it is used, it reduces the length of the frame length subfield by one bit.

In the event that a ninth frame format type is needed (i.e., format type 8), then the frame format field is expanded to a three octet field where the four most significant bits of the first octet, starting with the MSB of the field, are all ones (1). The format type subfield is expanded to 8 bits. The 3 most significant bits of the second octet are set to “000”.

4.9.1 Format type subfield

A MSB value of “0” in the frame format field designates it as the one-bit format type subfield, and further implies that the frame format field is a one-octet field. A MSB value of “1” in the frame format field with the first four bits of the frame format field not equal to “1111” designates the frame field as a two-octet field, the four most significant bits of which are the format type subfield. A MSB value of “1” in the frame format field with the first four bits of the frame format field equal to “1111” designates the frame format as a three-octet field, the most significant octet of which is the format type subfield. The frame format field may be extended in this manner if the need arises. The encodings of the types are shown above.

4.9.2 Frame length subfield

If the MSB of the frame format field is “0”, then the frame length subfield is the next 7 bits. If the MSB of the frame format field is “1” and the four most significant bits are not “1111”, then the frame length subfield is the last 12 bits (11 if the optional segmentation subfield is used). If the MSB of the frame format field is “1” and the four most significant bits are “1111”, then the frame length subfield is the last 13 bits (12 if the optional segmentation subfield is used). (The definition of the frame format types shall specify whether or not they use the segmentation subfield and, therefore, have an 11 bit, 12 bit, or 13 bit frame length subfield.)

The value of the frame length subfield is the count of octets in the frame excluding the opening and closing flag sequences. The value of the frame length subfield does not include any bits inserted for transparency. A frame length subfield value of "0" is a means of indicating a frame abort. A frame length subfield value of "1", "2", "3", or "4" shall be interpreted as an invalid frame.

The frame length subfield allows the use of the bit or octet insertion methods for transparency to be avoided, if so desired (see 6.15.24).

4.9.3 Segmentation subfield

The segmentation subfield of 1 bit follows the format type subfield and if present reduces the length subfield by one bit. When the segmentation field is present, the field is used as follows:

- 1) All DLSDUs transmitted shall have the segmentation algorithm applied. The algorithm shall be applied to DLSDUs which fit in a single HDLC frame or those which must be transmitted as a sequence of HDLC frames.
- 2) The final HDLC frame of a DLSDU shall be sent with segmentation subfield set to 0.
- 3) When DLSDUs must be transmitted in multiple HDLC frames, all except the final HDLC frame of the DLSDU shall be sent with their segmentation subfield set to 1.
- 4) The HDLC window sequence numbers guarantee that all segments are sent/received in order and that lost segments can be detected.

5 HDLC elements of procedures

5.1 Data link channel states

5.1.1 Active data link channel state

5.1.1.1 General

A data link channel is in an active state when the primary/control station, a secondary/tributary station or a combined/peer station is actively transmitting a frame, a single abort sequence, or interframe time fill. In the active state, the right to continue transmission shall be reserved.

5.1.1.2 Abort

5.1.1.2.1 Synchronous transmission

Aborting a frame shall be accomplished by transmitting at least seven contiguous "1" bits (with no inserted "0" bits) to end the frame. Receipt of seven contiguous "1" bits shall be interpreted as an abort and the receiving data station shall ignore the frame.

NOTE — If more than seven "1" bits are sent to abort, care should be taken because if 15 or more "1" bits are sent, including those already transmitted at the time of the decision to abort, an idle data link channel state will result.

5.1.1.2.2 Start/stop transmission

Aborting a frame shall be accomplished by transmitting the two-octet sequence "control escape-closing flag". Receipt of this sequence shall be interpreted as an abort and the receiving data station shall ignore the frame.

5.1.3 Interframe time fill

5.1.3.1 Synchronous transmission

Interframe time fill shall be accomplished by transmitting contiguous flags between frames.

5.1.1.3.2 Start/stop transmission

Interframe time fill shall be accomplished by the transmission of either continuous flags or marking condition (logical "1" state) between frames. Selection of the interframe time fill method depends on systems requirements.

5.1.1.4 Intraframe time fill

5.1.1.4.1 Synchronous transmission

There is no provision for time fill within a frame.

5.1.1.4.2 Start/stop transmission

Inter-octet time fill within a frame shall be accomplished by transmitting continuous mark-hold condition (logical "1" state). There is no provision for time fill within an octet (i.e., between the start element and stop element).

NOTE — A receiving station may choose to operate a system-defined time-out function for the purpose of determining excessive inter-octet time fill within a frame. This time-out function, if used, is started when inter-octet time fill is first detected and is stopped (reset) when the mark-hold condition ceases. Actions to be followed upon expiration of the time-out function (e.g., discarding of octets of the frame received thus far) are beyond the scope of the International Standard.

5.1.2 Idle data link channel state

5.1.2.1 Synchronous transmission

A data link channel is in an idle state when a continuous "1" state is detected that has persisted for at least 15 bit times; detection of the idle state at the data link layer shall be considered to indicate that the remote data station has relinquished its right to continue transmission.

5.1.2.2 Start/stop transmission

A data link channel is in the idle state when a continuous mark-hold condition persists for the period of time determined by a system-specified time-out function. The duration of this timer is not a subject of this International Standard.

5.2 Modes

Three operational modes and three non-operational modes are defined.

5.2.1 Operational modes

The three operational modes are:

- a) normal response mode (NRM);
- b) asynchronous response mode (ARM); and
- c) asynchronous balanced mode (ABM).

5.2.1.1 Normal response mode (NRM)

In NRM, which is an unbalanced data link operational mode, the secondary station shall initiate transmission only as the result of receiving explicit permission to do so from the primary station. After receiving permission, the secondary station shall initiate a response transmission. The response transmission shall consist of one or more frames while maintaining an active data link channel state. The last frame of the response transmission shall be explicitly indicated by the secondary station. Following indication of the last frame, the secondary station shall stop transmitting until explicit permission is again received from the primary station.

5.2.1.2 Asynchronous response mode (ARM)

In ARM, which is an unbalanced data link operational mode, the secondary station may initiate transmission without receiving explicit permission to do so from the primary station. Such an asynchronous transmission may contain single or multiple frames and shall be used for information field transfer and/or to indicate status changes in the secondary station (for example, the number of the next expected information frame, transition from a ready to a busy condition or vice versa, occurrence of an exception condition).

5.2.1.3 Asynchronous balanced mode (ABM)

In ABM, which is a balanced data link operational mode, either combined station may send commands at any time and may initiate response frame transmission without receiving explicit permission to do so from the other combined station. Such an asynchronous transmission may contain single or multiple frames and shall be used for information field transfer and/or to indicate status changes in the combined station (for example, the number of the next expected information frame, transition from a ready to a busy condition or vice versa, occurrence of an exception condition).

5.2.2 Non-operational modes

The three non-operational modes are:

- a) normal disconnected mode (NDM);
- b) asynchronous disconnected mode (ADM); and
- c) initialization mode (IM).

The disconnected modes (NDM and ADM) differ from the operational modes in that the secondary/combined station is logically disconnected from the data link; i.e., no information (I) or supervisory frames are transmitted or accepted. The initialization mode (IM) differs from the operational modes in that the secondary/combined station data link control program is either in need of regeneration or is in need of an exchange of the parameters to be used in an operational mode.

These two disconnected modes (NDM and ADM) are provided to prevent a secondary/combined station from appearing on the data link in a fully operational mode during unusual situations or exception conditions since such operation could cause:

- a) unintended contention in ARM;
- b) sequence number mismatch between the primary station and the secondary station, or between combined stations; or
- c) ambiguity in the primary/combined station as to the status of the secondary/other combined station.

A secondary station shall be system predefined as to the condition(s) that causes it to assume a disconnected mode. The disconnected mode (NDM or ADM) shall also be system predefined. A combined station shall be system predefined as to the condition(s) that causes it to assume the asynchronous disconnected mode (ADM).

The secondary station capability in a disconnected mode shall be limited to:

- a) accepting and responding to one of several appropriate mode-setting commands [set normal response mode (SNRM), set asynchronous response mode (SARM), set normal response mode extended (SNRME), set asynchronous response mode extended (SARME), set mode (SM) or set mode (SM) with the mode in the optional information field selected as normal response mode or asynchronous response mode, set initialization mode (SIM), and disconnect (DISC)];
- b) accepting and responding to an exchange identification (XID) command;
- c) accepting and responding to a test (TEST) command;
- d) accepting and responding to an unnumbered poll (UP) command;
- e) transmitting a disconnected mode (DM), request initialization mode (RIM), exchange identification (XID), or request disconnect (RD) response frame at a respond opportunity to solicit a specific action on the part of the primary station;

- f) accepting an unnumbered information (UI) command; and
- g) transmitting a UI response at a respond opportunity.

The capability of a combined station, as a receiver of commands, in the asynchronous disconnected mode, shall be the same as that stated above for a secondary station [appropriate mode setting commands for a combined station include the set asynchronous balanced mode (SABM), set asynchronous balanced mode extended (SABME), set mode (SM) or SM with the mode in the optional information field selected as balanced mode, SIM and DISC commands]. In addition, since the combined station has the ability to transmit commands at any time, the combined station may transmit an appropriate mode setting, XID, UI or TEST command.

A secondary/combined station in a disconnected mode (NDM or ADM) shall, as a minimum capability, be capable of generating the DM response with the F bit set to "1" in response to a command frame received with the P bit set to "1".

A secondary/combined station in a disconnected mode (NDM or ADM) receiving a DISC command shall respond with the DM responses. A secondary/combined station in the initialization mode receiving a DISC command shall respond with the unnumbered acknowledgement (UA) response if it is capable of actioning the command. A secondary/command station in an operational mode receiving a DISC command shall respond with the UA response.

Examples of possible conditions (in addition to receiving a DISC command) which shall cause a secondary/combined station to enter a disconnected mode are:

- a) the secondary/combined station power is turned on, or restored following a temporary loss of power;
- b) the secondary/combined station data link layer logic is manually reset; and
- c) the secondary/combined station terminal is manually switched from a local (home) condition to a connected-on-the-data-link (on-line) condition.

A secondary/combined station in a non-operational mode shall not establish a frame reject exception condition.

5.2.2.1 Normal disconnected mode (NDM)

In NDM, which is an unbalanced data link non-operational mode, the secondary station shall be logically disconnected from the data link and shall, therefore, not be permitted to accept information in I command frames or to transmit information in I response frames. The secondary station shall, however, be permitted to accept information in UI command frames and to transmit information in UI response frames. The secondary station has normal mode respond opportunity and shall initiate a single frame response transmission, indicating its status, as a result of receiving a command frame with the P bit set to "1"; optionally, it may initiate such a response as the result of receiving a UP command with the P bit set to "0".

In this mode, a secondary station shall action only mode setting, XID, UI and TEST commands. Mode setting commands, except the DISC command, that can be actioned shall be responded to with the UA response at the earliest respond opportunity. An XID or TEST command that can be actioned shall be responded to with the XID and TEST response, respectively, at the earliest respond opportunity. Receipt of an implemented mode setting, XID or TEST command that cannot be actioned, or receipt of any other command (except a UI command) with the P bit set to "1", shall cause a secondary station in NDM to respond at the earliest respond opportunity with the DM response, or, if the secondary station determines it is unable to function, with the RIM response. Receipt of a UI command with the P bit set to "1" shall cause a secondary station in NDM to respond at the earliest respond opportunity with a UI response, with a DM response, or with a RIM response. In the case where an implemented mode setting, XID or TEST command has been received but cannot be actioned or a status condition is to be reported, a UP command with the P bit set to "0" shall cause a secondary station in NDM to respond with a DM or RIM response, as appropriate. Any command with the P bit set to "0", other than the implemented mode setting, XID, UI, TEST or UP commands as described above, may be ignored by the secondary station in NDM.

5.2.2.2 Asynchronous disconnected mode (ADM)

In ADM, which is an unbalanced data link or balanced data link non-operational mode, the secondary/combined station shall be logically disconnected from the data link and shall, therefore, not be permitted to accept information in I command frames/I command or response frames, respectively, or to transmit information in I response frames/I command or response frames, respectively. The secondary/combined station shall, however, be permitted to accept information in UI command frames/UI

command or response frames, respectively, or to transmit information in UI response frames/UI command or response frames, respectively. The secondary station, or combined station as a receiver of commands, has asynchronous mode respond opportunity and may initiate a response transmission in two-way alternate exchange upon detection of an idle data link channel state, and in two-way simultaneous exchange at any time. Such a response transmission shall only consist of a UI response frame, a request for a mode setting command (DM), a request for exchange of identification (XID), or a request for initialization (RIM) if the secondary station, or combined station as a receiver of commands, determines it is unable to function. The combined station, as a transmitter of command frames, is also permitted to send a UI command frame at any asynchronous mode respond opportunity.

In this mode a secondary station, or combined station as a receiver of commands, shall action only mode setting, XID, UI and TEST commands. Mode setting commands, except the DISC command, that can be actioned shall be responded to with the UA response at the earliest respond opportunity. An XID or TEST command that can be actioned shall be responded to with the XID or TEST response, respectively, at the earliest respond opportunity. Receipt of an implemented mode setting, XID or TEST command that cannot be actioned, or receipt of any other command (except a UI command) with the P bit set to "1", shall be responded to with a DM response, or, if the secondary station, or combined station as a receiver of commands, determines it is unable to function, with the RIM response. Receipt of a UI command with the P bit set to "1" shall cause a secondary/combined station in ADM to respond at the earliest respond opportunity with a UI response, with a DM response, or with a RIM response. Any command with the P bit set to "0", other than the implemented mode setting, XID, UI, TEST or UP commands as described above, may be ignored by the secondary/combined station in ADM.

Because a combined station is also a generator of commands, it can terminate a disconnected mode at any time by transmitting an appropriate mode setting command (SABM, SABME, SM or SM with the mode in the information field selected as balanced mode, or SIM). Such action can be taken spontaneously or as a result of transmission received from the other combined station (for example, a DM or RIM response).

5.2.2.3 Initialization mode (IM)

In IM, which is an unbalanced data link or balanced data link non-operational mode, a secondary/one combined station data link control program may be initialized or generated by the primary/other combined station action, or other parameters to be used in the operational mode may be exchanged. IM is invoked when the primary/one combined station concludes that a secondary/other combined station is operating abnormally and needs its data link control program corrected, and for upgrading a secondary/other combined station data link control program. Similarly, a secondary/one combined station may determine it is unable to function due to program checks and request IM to obtain a good program from the primary/other combined station.

A secondary/combined station shall enter IM upon sending a UA response, at its system predefined respond opportunity, in response to the receipt of a SIM command. A secondary/combined station may request a SIM command by sending a RIM response. In IM, the primary/one combined station and a secondary/other combined station may exchange information in the predetermined manner specified for that secondary/each combined station (for example, UI or I frames).

IM shall be terminated when a secondary/combined station receives and acknowledges (via a UA response) one of the other mode setting commands, or when entering the disconnected mode caused by internal constraints such as loss of power.

5.3 Control field formats

5.3.1 General

The three formats defined for the basic (modulo 8) control field (see table 3) are used to perform numbered information transfer, numbered supervisory functions and unnumbered control functions and unnumbered information transfer.

Table 3 — Control field formats for modulo 8

Control field format for	Control field bits*							
	1	2	3	4	5	6	7	8
Information transfer command/ response (I format)	0	N(S)			P/F	N(R)		
Supervisory commands/ responses (S format)	1	0	S	S	P/F	N(R)		
Unnumbered commands/ responses (U format)	1	1	M	M	P/F	M	M	M

* N(S) = transmitting send sequence number (bit 2 = low-order bit)

N(R) = transmitting receive sequence number (bit 6 = low-order bit)

S = supervisory function bit

M = modifier function bit

P/F = poll bit — primary station or combined station command frame transmissions/final bit — secondary station or combined station response frame transmissions (1 = poll/final)

The control field may be extended by the addition of a second contiguous octet immediately following the basic control field of I frames and supervisory frames. This capability shall provide for an N(S) and N(R) of modulo 128. Control field extension for the information transfer command/response format (I format), the supervisory command/response format (S format), and the unnumbered command/response format (U format) shall be as shown in table 4.

Table 4 — Control field formats for modulo 128

Control field format for	Control field bits															
	First octet								Second octet							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
I format	0	N(S)							P/F	N(R)						
S format	1	0	S	S	x	x	x	x	P/F	N(R)						
U format	1	1	M	M	P/F	M	M	M								

In table 4, x bits are reserved and set to "0". Bit 2 and bit 10 shall be the low-order bits of the sequence numbers.

The control field may be extended by the addition of three contiguous octets immediately following the basic control field of I frames and supervisory frames. This capability shall provide for an N(S) and N(R) of modulo 32 768. Control field extension for the information transfer command/response format (I format), the supervisory command/response format (S format), and the unnumbered command/response format (U format) shall be as shown in table 5.

Table 5 — Control field formats for modulo 32 768

Control field format for	Control field bits															
	First two octets										Second two octets					
	1	2	3	4	5	6	7	8	9.....16	17	18	32				
I format	0	N(S)										P/F	N(R)			
S format	1	0	S	S	x	x	x	x	x..... x	P/F	N(R)					
U format	1	1	M	M	P/F	M	M	M								

In table 5, the x bits are reserved and set to "0". Bit 2 and bit 18 shall be the low-order bits of the sequence numbers.

The control field may be extended by the addition of seven contiguous octets immediately following the basic control field of I frames and supervisory frames. This capability shall provide for an N(S) and N(R) of modulo 2 147 483 648. Control field extension for the information transfer command/response format (I format), the supervisory command/response format (S format), and the unnumbered command/response format (U format) shall be as shown in table 6.

Table 6 — Control field formats for modulo 2 147 483 648

Control field format for	Control field bits														
	First four octets										Next four octets				
	1	2	3	4	5	6	7	8	9...32	33	34.....	64			
I format	0	N(S)										P/F	N(R)		
S format	1	0	S	S	x	x	x	x	x... x	P/F	N(R)				
U format	1	1	M	M	P/F	M	M	M							

In table 6, the x bits are reserved and set to "0". Bit 2 and bit 34 shall be the low-order bits of the sequence numbers.

5.3.2 Information transfer (I) format

The I format is used to perform an information transfer. The functions of N(S), N(R) and P/F are independent; i.e., each I frame shall have an N(S) sequence number, an N(R) sequence number which may or may not acknowledge additional I frames at the receiving data station, and a P/F bit that may be set to "1" or "0".

5.3.3 Supervisory (S) format

The S format is used to perform data link supervisory control functions such as acknowledging I frames, requesting retransmission of I frames, and requesting a temporary suspension of transmission of I frames. The functions of N(R) and P/F are independent; i.e., each S format frame shall have an N(R) sequence number which may or may not acknowledge additional I frames at the receiving data station, and a P/F bit that may be set to "1" or "0".

5.3.4 Unnumbered (U) format

The U format is used to provide additional data link control functions and unnumbered information transfer. This format shall contain no sequence numbers, but shall include a P/F bit that may be set to "1" or "0". Five "modifier" bit positions are available, this allowing definition of up to 32 additional command functions and 32 additional response functions.

5.4 Control field parameters

5.4.1 Modulus

Each I frame shall be sequentially numbered with a number which may have the value 0 to modulus minus one inclusive (where modulus is the modulus of the sequence number). The modulus equals 8, 128, 32 768, or 2 147 483 648. The sequence numbers cycle through the entire range. The control field formats for modulo 8 are shown in table 3. The control field formats for modulo 128 are shown in table 4. The control field formats for modulo 32 768 are shown in table 5. The control field formats for modulo 2 147 483 768 are shown in table 6.

The maximum number of sequentially numbered I frames that a primary, secondary or combined station may have outstanding (i.e., unacknowledged) at any given time (sometimes known as a "window" size) shall never exceed one less than the modulus of the sequence numbers. This restriction is to prevent any ambiguity in the association of transmitted I frames with sequence numbers during normal operation and/or error recovery action.

NOTE — The number of outstanding I frames may be further restricted by the data station frame storage capability; for example, the number of I frames that can be stored for transmission and/or retransmission in the event of a transmission error. Optimum data link efficiency can only be obtained, however, if the minimum data station frame storage capacity is sufficient for the maximum anticipated round trip transmission delay.

5.4.2 Frame state variables and sequence numbers

5.4.2.1 General

In HDLC operations, each data station shall maintain an independent send state variable $V(S)$ and an independent receive state variable $V(R)$ for the I frames it sends to and receives from another data station. Each secondary station shall maintain a $V(S)$ for the I frames it transmits to the primary station and a $V(R)$ for the I frames it correctly receives from the primary station. In the same manner, the primary station shall maintain an independent $V(S)$ and $V(R)$ for I frames sent to and received from, respectively, each secondary station on the data link. Each combined station shall maintain a $V(S)$ for the I frames it transmits to the other combined station, and a $V(R)$ for the I frames it correctly receives from the other combined station.

5.4.2.2 Send state variable $V(S)$

The send state variable denotes the sequence number of the next in-sequence I frame to be transmitted. The send state variable can take the value 0 to modulus minus one inclusive (where modulus is the modulus of the sequence numbering scheme and the numbers cycle through the entire range). The value of the send state variable shall be incremented by one with each successive I frame transmission, but shall not exceed $N(R)$ of the last received frame by more than modulus minus one.

5.4.2.3 Send sequence number $N(S)$

Only I frames shall contain $N(S)$, the send sequence number of transmitted frames. Prior to transmission of an in-sequence I frame, $N(S)$ shall be set equal to the value of the send state variable.

5.4.2.4 Receive state variable $V(R)$

The receive state variable denotes the sequence number of the next in-sequence I frame expected to be received. The receive state variable can take the value 0 to modulus minus one inclusive (where modulus is the modulus of the sequence numbering scheme and the numbers cycle through the entire range). The value of the receive state variable shall be incremented by one on receipt of an error-free, in-sequence I frame whose send sequence number $N(S)$ equals the receive state variable.

5.4.2.5 Receive sequence number $N(R)$

All I frames and S format frames shall contain $N(R)$ which with the exception of the selective reject (SREJ) supervisory frame with the P/F bit set to "0" shall indicate the $N(S)$ sequence number of the next expected I frame.

With this exception, prior to transmission of an I frame or S format frame, the $N(R)$ shall be set equal to the current value of the receive state variable. The $N(R)$ indicates that the station transmitting the $N(R)$ has correctly received all I frames numbered up to $N(R) - 1$ inclusive.

In the case of the SREJ frame with the P/F bit set to "0", the $N(R)$ indicates only that the I frame with $N(S)$ equal to $N(R)$ has not been received.

As more than one SREJ frame with the P/F bit set to "0" may be outstanding at any one time, it is necessary to ensure that all non-received I frames are ultimately correctly received. This may be achieved by multiple variable counters or by other means.

(See 5.5.2.4 for definition of the use of the SREJ command and response.)

5.4.3 Poll/final (P/F) bit

The poll (P) bit set to "1" shall be used by the primary/combined station to solicit (poll) a response or sequence of responses from the secondary station(s)/combined station.

The final (F) bit set to "1" shall be used:

- a) by a secondary station in NRM to indicate the final frame transmitted as the result of a previous soliciting (poll) command; and
- b) by a secondary station in ARM and by a combined station in ABM to indicate the response frame transmitted as the result of a soliciting (poll) command.

The poll/final (P/F) bit shall serve a function in both command frames and response frames. (In command frames, the P/F bit is referred to as the P bit. In response frames, it is referred to as the F bit.)

5.4.3.1 Functions of the poll bit

5.4.3.1.1 General

The P bit set to "1" shall be used to solicit a response frame with the F bit set to "1" from the secondary/combined station.

On a data link, only one frame with a P bit set to "1" shall be outstanding in a given direction at a given time. Before a primary/combined station issues another frame with the P bit set to "1", it shall have received a response frame from the secondary/combined station with the F bit set to "1". If no valid response frame is obtained within a system-defined time-out period, the retransmission of a command with the P bit set to "1" for error recovery purposes shall be permitted.

5.4.3.1.2 Functions of the poll bit in NRM

In NRM, the P bit shall be set to "1" to solicit response frames from the secondary station. The secondary station shall not transmit until it receives either a command frame with the P bit set to "1" or a UP command.

The secondary station may send I frames upon receipt of an I frame with the P bit set to "1", certain S frames (RR, REJ or SREJ) with the P bit set to "1", a UI command with the P bit set to "1", or a UP command with the P bit set to "1" or "0".

5.4.3.1.3 Functions of the poll bit in ARM and ABM

In ARM and ABM, the P bit set to "1" shall be used to solicit a response, at the earliest respond opportunity, with the F bit set to "1".

NOTE — For example, if the primary/combined station requires positive acknowledgement that a particular command has been received, it sets the P bit in the command to "1". This forces a response from the secondary/combined station as described in 5.4.3.1.6.

5.4.3.2 Functions of the final bit

5.4.3.2.1 General

A response frame with the F bit set to "1" shall be used by the secondary/combined station to acknowledge the receipt of a command frame with the P bit set to "1".

5.4.3.2.2 Functions of the final bit in NRM

In NRM, if the right to transmit was acquired by the receipt of a P bit set to "1", then the secondary station shall set the F bit to "1" in the last frame of its response transmission. If the right to transmit was acquired by the receipt of a UP command with the P bit set to "0", then the secondary station shall set the F bit to "0" in each frame (including the last frame) of its response transmission.

Following transmission of the last frame of its response transmission, the secondary station shall stop transmitting until either a subsequent command frame with a P bit set to "1" is received, or a UP command is received.

5.4.3.2.3 Functions of the final bit in ARM and ABM

In ARM and ABM, the secondary station and the combined station, respectively, may transmit response frames with the F bit set to "0" at any respond opportunity on an asynchronous basis. Following the receipt of a command frame and the P bit set to "1", the secondary/combined station shall initiate transmission of a response frame with the F bit set to "1" at the earliest respond opportunity.

In the case of a two-way simultaneous communication where the secondary/combined station is transmitting when the command frame with the P bit set to "1" is received, the F bit shall be set to "1" in the earliest possible subsequent response frame to be transmitted.

In ARM and ABM, the transmission of a response frame with the F bit set to "1" shall not require the secondary station or the combined station, respectively, to stop transmitting response frames. Additional response frames may be transmitted following the frame which had the F bit set to "1". Thus, in ARM and ABM, the F bit shall not be interpreted as the end of transmission by the secondary station or the combined station, respectively; it shall only be interpreted as indicating the response frame from the secondary/combined station sent as a reply to the previous command frame received with the P bit set to "1".

In ABM, if a combined station receives a command with the P bit set to "1", transmission of a response with the F bit set to "1" shall take precedence over transmission of commands, with the exception of the mode setting commands (SABM or SABME or SM, SIM, DISC) and the reset (RSET) command.

5.4.3.3 Use of the P/F bit to assist in error recovery (see also 5.6.2.1)

5.4.3.3.1 General

As the P and F bits set to "1" are always exchanged as a pair (for every P bit there shall be one F bit, and another P bit shall not be issued until the previous P bit has been matched with an F bit, and, similarly, another F bit shall not be issued until another P bit is received), the N(R) contained in a received frame with a P bit (see 5.6.2.1h) or F bit set to "1" can be used to detect that I frame retransmission is required. This capability provides early detection of I frames not received by the remote data station and indicates the frame sequence number where retransmission shall begin. This capability is referred to as checkpointing. The N(R) of a correctly received I frame or S format frame, except for a SREJ frame with the P/F bit set to "0", shall acknowledge previously transmitted I frames to N(R) - 1 inclusive.

5.4.3.3.2 Checkpointing in NRM

In NRM, the N(R) of a received I, receive ready (RR) or receive not ready (RNR) command/response frame which has the P/F bit set to "1" shall cause the secondary/primary station to initiate appropriate error recovery if the N(R) does not acknowledge at least all I frames transmitted by the secondary/primary station previous to, and concurrent with, the last frame which was transmitted by the secondary/primary station with the F/P bit set to "1".

5.4.3.3.3 Checkpointing in ARM

In ARM, the N(R) of a received I, RR or RNR command/response frame which has the P/F bit set to "1" shall cause the secondary/primary station to initiate appropriate error recovery if the N(R) does not acknowledge at least all I frames transmitted by the secondary/primary station previous to, and concurrent with, the last frame which was transmitted by the secondary/primary station with the F/P bit set to "1".

5.4.3.3.4 Checkpointing in ABM

In ABM, the N(R) of a received I, RR or RNR response frame which has the F bit set to "1" shall cause the received combined station to initiate appropriate error recovery if the N(R) does not acknowledge at least all I frames transmitted by the receiving combined station previous to, and concurrent with, the last frame which was transmitted by the receiving combined station with the P bit set to "1".

5.4.3.4 Summary of P/F bit functions

The applicability of the P/F bit functions in the three operational modes (NRM, ARM, and ABM) and on data links employing two-way alternate and two-way simultaneous data communication is summarized in table 7.

Table 7 — P/F bit functions

Operational mode	NRM		ARM		ABM	
	TWA	TWS	TWA	TWS	TWA	TWS
P/F bit in command/ response	P/F	P/F	P/F	P/F	P/F	P/F
Solicit information	x/	x/				
Last frame indication	x/x	/x				
Solicit supervisory or unnumbered response	x/	x/	x/	x/	x/	x/
Checkpointing	x/x	x/x	x/x	x/x	x/x	x/x

Key:

x indicates that the function is applicable

TWA — two-way alternate

TWS — two-way simultaneous

5.5 Commands and responses

The set of commands and responses is summarized in table 8.

Table 8 — Commands and responses

Information transfer format commands	Information transfer format responses
I - Information	I - Information
Supervisory format commands	Supervisory format responses
RR - Receive ready RNR - Receive not ready REJ - Reject SREJ - Selective reject	RR - Receive ready RNR - Receive not ready REJ - Reject SREJ - Selective reject
Unnumbered format commands	Unnumbered format responses
SNRM - Set normal response mode SARM - Set asynchronous response mode SABM - Set asynchronous balanced mode DISC - Disconnect SNRME - Set normal response mode extended SARME - Set asynchronous response mode extended SABME - Set asynchronous balanced mode extended SIM - Set initialization mode UP - Unnumbered poll UI - Unnumbered information XID - Exchange identification RSET - Reset TEST - Test SM - Set Mode UIH - Unnumbered information with header check	UA - Unnumbered acknowledgement DM - Disconnected mode RIM - Request initialization mode RD - Request disconnect UI - Unnumbered information XID - Exchange identification FRMR - Frame reject TEST - Test UIH - Unnumbered information with header check

5.5.1 Information transfer format command and response

The function of the information, I, command and response shall be to transfer sequentially numbered frames, each containing an information field, across a data link.

The encoding of the I command/response control field shall be as shown in figure 3a for modulo 8 numbering, in figure 3b for modulo 128 numbering, in figure 3c for modulo 32 768 numbering and in figure 3d for modulo 2 147 483 648 numbering.

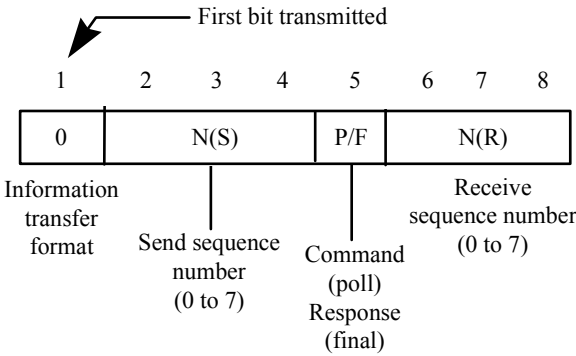


Figure 3a — Information transfer format of control field bits for modulo 8 numbering

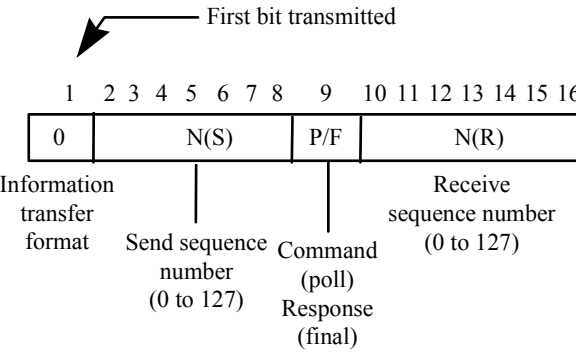


Figure 3b — Information transfer format of control field bits for modulo 128 numbering

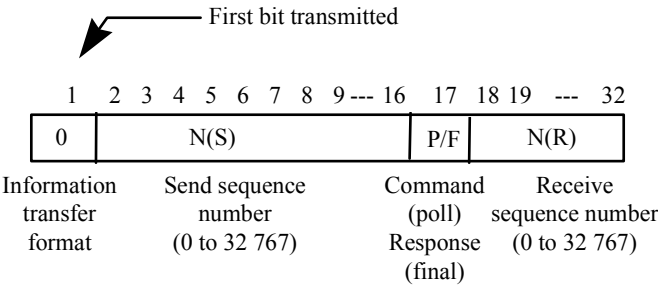


Figure 3c — Information transfer format of control field bits for modulo 32 768 numbering

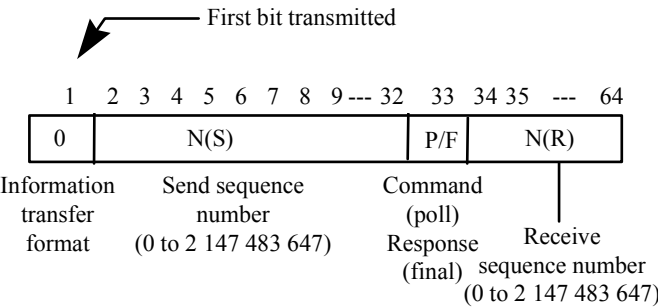


Figure 3d — Information transfer format of control field bits for modulo 2 147 483 648 numbering

The I frame control field shall contain two sequence numbers.

- a) N(S), send sequence number, which shall indicate the sequence number associated with the I frame; and