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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.

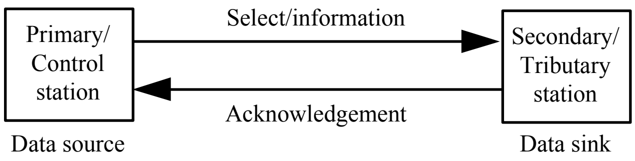


Figure A — Unbalanced data link functions (case 1)

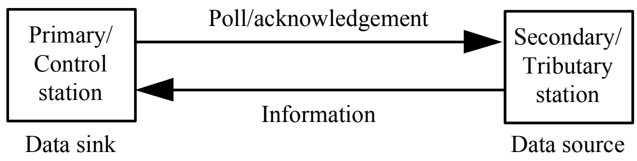


Figure B — Unbalanced data link functions (case 2)

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.

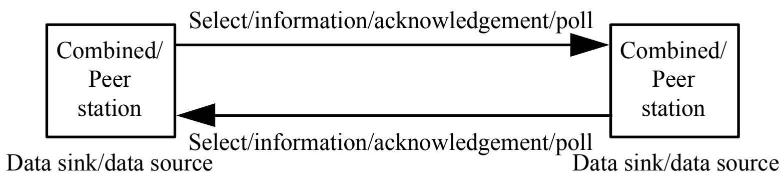


Figure C — Balanced data link functions

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.

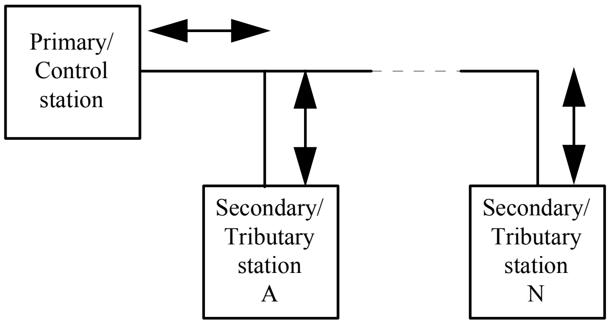


Figure D — Unbalanced data link configuration

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 recorvery 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.

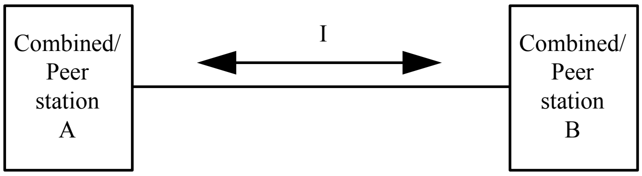


Figure E — Balanced data link configuration

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).

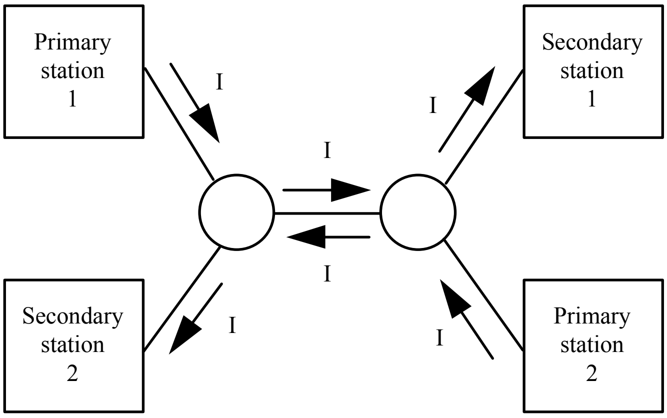


Figure F — Symmetrical data link configuration

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.

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.

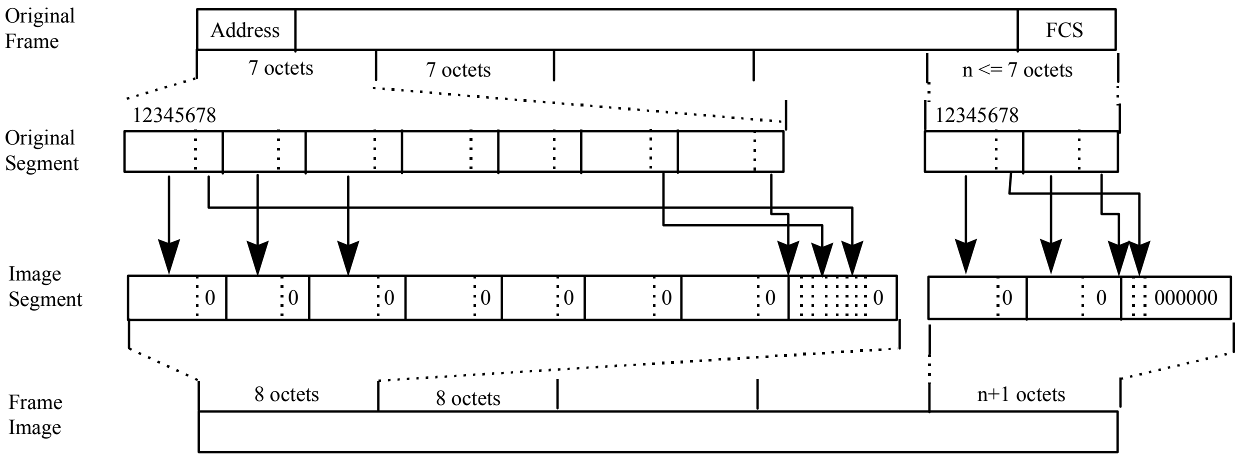


Figure 1 — Original frame to frame-image transition

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:

a) image segments occur in the same order as the corresponding original segments;

b) each image segment is one octet longer than its original segment;

c) 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;

d) 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;

e) 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:

1	2	3	4	5	6	7	8	Bit position in octet
1	0	1	1	1	1	1	0	

Low order bit, first bit transmitted/received (bit 1)

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:

a) Upon the occurrence of the flag or a control escape octet, complement the 6th bit of the octet, and

b) 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:

a) Discard the control escape octet, and

b) 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., 1111111x, 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.

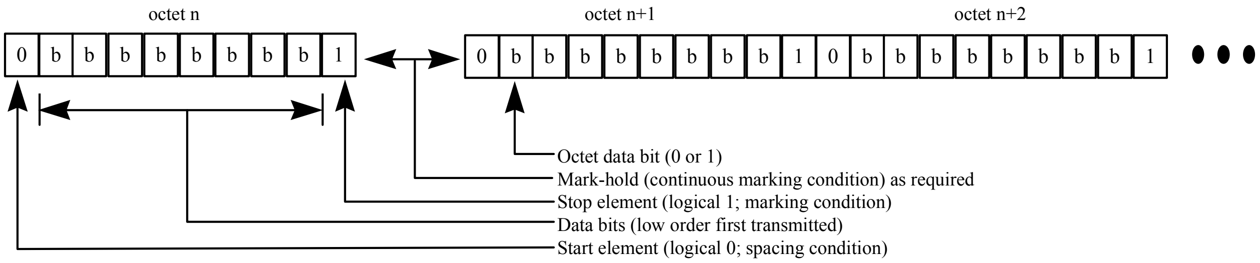


Figure 2 — Typical octet transmission for start/stop transmission

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 indicted 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	L							LSB									
Type 1	1	0	0	0	*	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								
Type 3	1	0	1	0	*	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								
Type 5	1	1	0	0	*	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								
Type 7	1	1	1	0	*	L	L	L	L	L	L	L	L	L	L	L							LSB	
Expanded, Type 8	1	1	1	1	0	0	0	0	0	0	0	*	L	L	L	L	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 included 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.

5.1.1.3 Interframe time fill

5.1.1.3.1 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 or 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 an 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	
Data Communication	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.

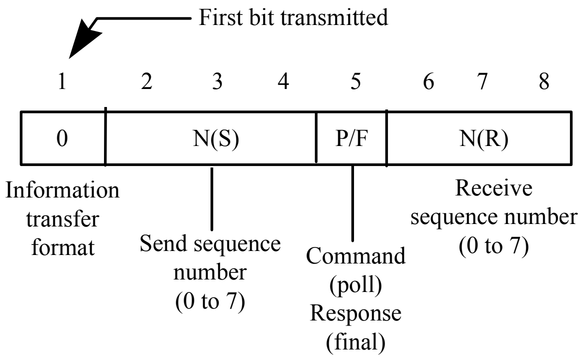


Figure 3a — Information transfer format of control field bits for modulo 8 numbering

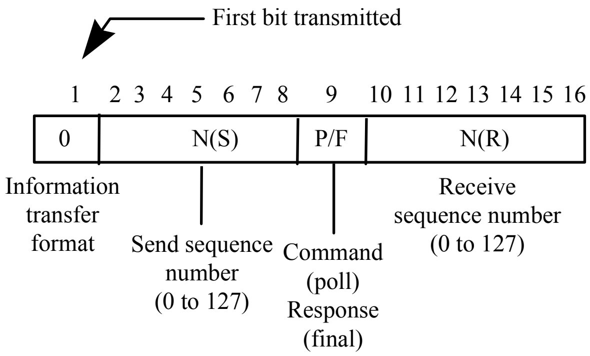


Figure 3b — Information transfer format of control field bits for modulo 128 numbering

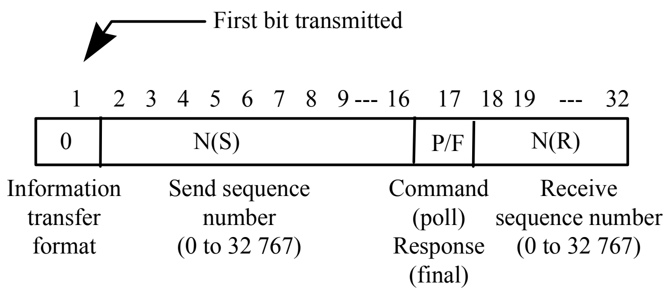


Figure 3c — Information transfer format of control field bits for modulo 32 768 numbering

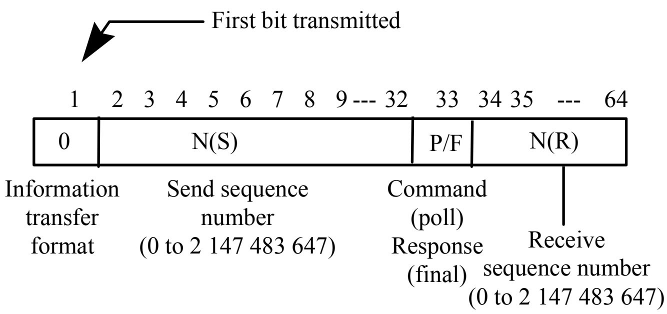


Figure 3d — Information transfer format of control field bits for modulo 2 147 483 648 numbering

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

b) N(R), receive sequence number, which shall indicate the sequence number (as of the time of transmission) of the next expected I frame to be received, and consequently shall indicate that the I frames numbered up to N(R) - 1 inclusive have been received correctly.

(See 5.4.3 for a description of the functions of the P/F bit.)

5.5.2 Supervisory format commands and responses

Supervisory, S, commands and responses shall be used to perform numbered supervisory functions such as acknowledgement, polling, temporary suspension of information transfer, or error recovery.

Frames with the S format control field shall not increment the send state variable at the transmitter or the receive state variable at the receiver. RR, RNR and REJ frames shall not contain an information field. SREJ frames may contain an information field for the purpose of identifying additional I frames in need of retransmission when the multi-selective reject procedure is selected.

The encoding of the S format command/response control field shall be as shown in figure 4a for modulo 8 numbering, in figure 4b for modulo 128 numbering, in figure 4c for modulo 32 768 numbering, and in figure 4d for modulo 2 147 483 648 numbering. In figures 4a thru 4d, the SS bits define the following command and response supervisory functions:

Commands	**SS**	**Responses**
RR - Receive ready	00	RR - Receive ready
REJ - Reject	01	REJ - Reject
RNR - Receive not ready	10	RNR - Receive not ready
SREJ - Selective reject	11	SREJ - Selective reject

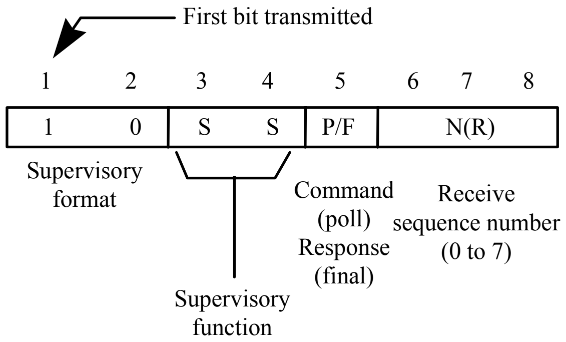


Figure 4a — Supervisory format of control field bits for modulo 8 numbering

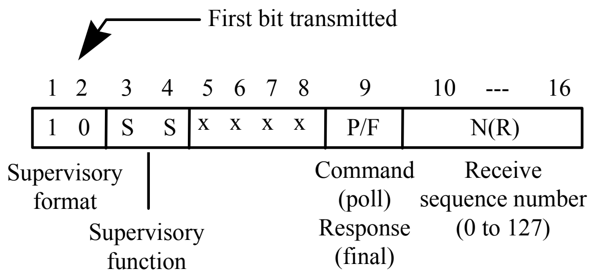


Figure 4b — Supervisory format of control field bits for modulo 128 numbering

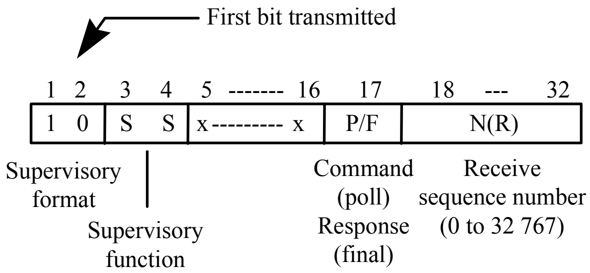


Figure 4c — Supervisory format of control field bits for modulo 32 768 numbering

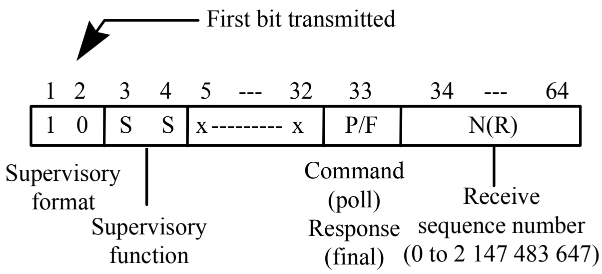


Figure 4d — Supervisory format of control field bits for modulo 2 147 483 648 numbering

An S format frame shall contain an N(R), receive sequence number. Except for the SREJ frame with the P/F bit set to "0", the N(R) shall indicate, at the time of transmission, the sequence number of the next expected I frame to be received, and consequently shall indicate that all received I frames numbered up to N(R) - 1 inclusive have been received correctly.

The primary/combined station may use the S format command frames with the P bit set to "1" to solicit responses from (poll) a secondary/combined station indicating its status.

(See 5.4.3 for a description of the functions of the P/F bit.)

5.5.2.1 Receive ready, RR, (S bits = 00) command and response

The receive ready, RR, frame shall be used by a data station to

a) indicate that it is ready to receive an I frame(s); and

b) acknowledge previously received I frames numbered up to N(R) - 1 inclusive.

When transmitted, the RR frame shall indicate the clearance of any busy condition that was initiated by the earlier transmission of an RNR frame by the same data station. (See 5.6.1.)

5.5.2.2 Reject, REJ, (S bits = 01) command and response

The reject, REJ, frame shall be used by a data station to request retransmission of I frames starting with the frame numbered N(R). I frames numbered N(R) - 1 and below shall be considered as acknowledged. Additional I frames awaiting initial transmission may be transmitted following the retransmitted I frame(s).

With respect to each direction of transmission on the data link, only one REJ exception condition from a given data station to another data station shall be established at any given time. A REJ frame shall not be transmitted until an earlier REJ exception condition or all earlier SREJ exception conditions have been cleared as indicated in 5.6.2.2, 5.6.2.3 and 5.6.2.4.

The REJ exception condition shall be cleared (reset) upon the receipt of an I frame with an N(S) equal to the N(R) of the REJ frame.

5.5.2.3 Receive not ready, RNR, (S bits = 10) command and response

The receive not ready, RNR, frame shall be used by a data station to indicate a busy condition; i.e., temporary inability to accept subsequent I frames. I frames numbered up to N(R) - 1 inclusive shall be considered as acknowledged. The I frame numbered N(R) and any subsequent I frames received, if any, shall not be considered as acknowledged; the acceptance status of these frames shall be indicated in subsequent exchanges.

5.5.2.4 Selective reject, SREJ, (S bits = 11) command and response

The selective reject, SREJ, frame shall be used by a data station to request retransmission of one or more (not necessarily contiguous) I frames. The control field of the SREJ frame shall contain the sequence number of the earliest I frame to be retransmitted (not yet reported by a SREJ frame) and, if the multi-selective reject procedure is invoked, the information field following the control field shall contain the identity of additional I frame(s), if any, in need of retransmission. The identity of additional I frames in need of transmission shall be indicated by either —

a) one entry for every I frame in need of retransmission, or

b) one entry for every standalone I frame in need of transmission plus a span list for every sequence of two or more contiguously numbered I frames in need of retransmission.

A span list identifies the start and the end of a sequence of contiguously numbered I frames in need of retransmission.

When the multi-selective reject procedure is employed without span lists, the information field shall be encoded such that there is one or more octets for each I frame in need of retransmission.

For modulo 8 sequence numbering, the N(R) value for each designed I frame shall occupy bit positions 6-8 of the one-octet field, as per the encoding of the N(R) field of the control field for modulo 8 sequence numbering, with bit positions 1-5 set to zero, as illustrated in figure 5a.

For modulo 128 sequence numbering, the N(R) value for each designated I frame shall occupy bit positions 2-8 of the one-octet field, as per the encoding of the N(R) field in the second octet of the control field for modulo 128 sequence numbering, with bit position 1 set to zero, as illustrated in figure 5b.

For modulo 32 768 sequence numbering, the N(R) value for each designated I frame shall occupy bit positions 2-16 of the two-octet field, as per the encoding of the N(R) field in octets 3-4 of the control field for modulo 32 768, with bit position 1 in the first octet of the two-octet field set to "0", as illustrated in figure 5c.

For modulo 2 147 483 648 sequence numbering, the N(R) value for each designated I frame shall occupy bit positions 2-32 of the four-octet field, as per the encoding of the N(R) field in octets 5-8 of the control field for modulo 2 147 483 768, with bit position 1 in the first octet of the four-octet field set to "0", as illustrated in figure 5d.

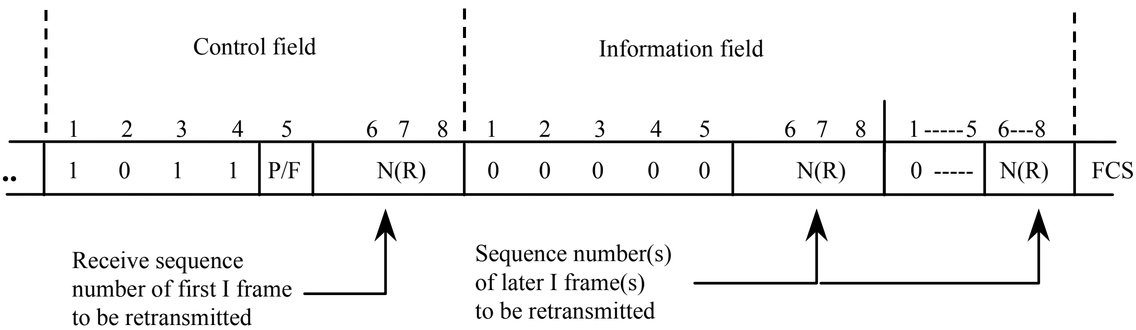


Figure 5a — Control field and information field encoding in SREJ frame for modulo 8 numbering

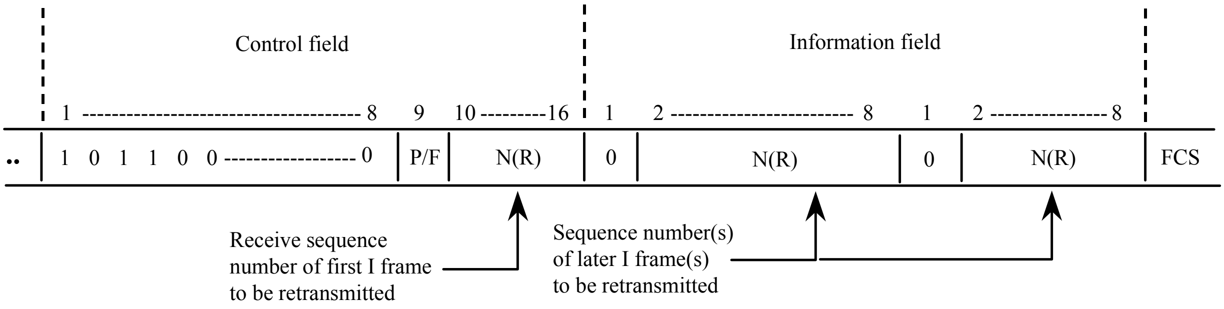


Figure 5b — Control field and information field encoding in SREJ frame for modulo 128 numbering

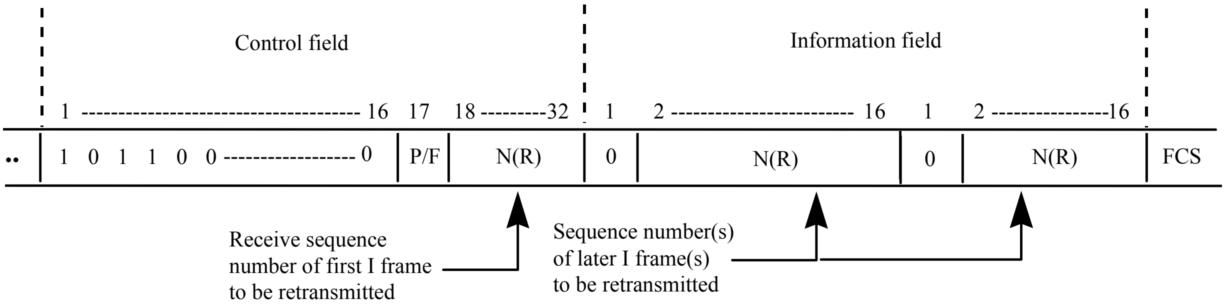


Figure 5c — Control field and information field encoding in SREJ frame for modulo 32 768 numbering

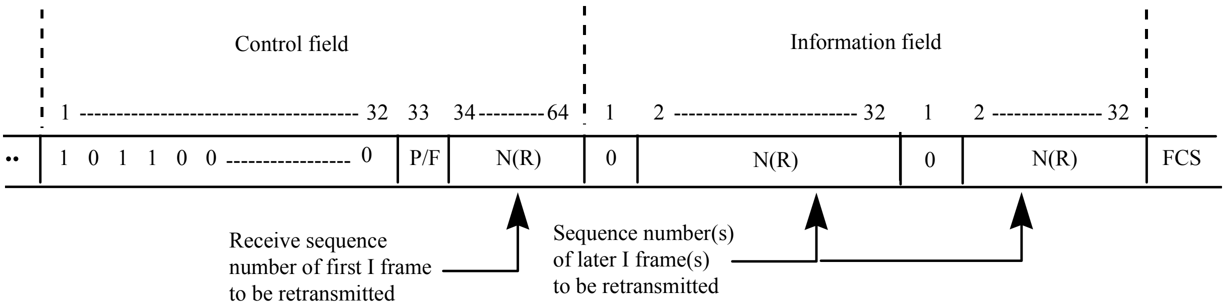


Figure 5d — Control field and information field encoding in SREJ frame for modulo 2 147 483 648 numbering

Any number of octet fields can be included, up to the maximum frame size. Only the I frame numbers in need of retransmission shall be included. If, for example, in the case of modulo 128 sequence numbering, I frames 3, 5, 7, and 18 are being identified for retransmission in a single SREJ frame, I frame number 3 shall be identified in the SREJ control field and I frames 5, 7, and 18 shall be identified, each within an octet of its own, in increasing order in the SREJ frame information field.

When the multi-selective reject option is employed with span lists, the information field shall be encoded such that there is an entry for each standalone I frame in need of retransmission and a span list, consisting of two entries, for each sequence of two or more contiguously numbered I frames in need of retransmission. In the case of standalone I frames, their identity in the information field consists of the appropriate N(R) value preceded by a “0” bit in the entry used, as per figure 5a for modulo 8, figure 5b for modulo 128, figure 5c for modulo 32 768, and figure 5d for modulo 2 147 483 768. In the case of span lists, the identity of the start and end of the contiguous sequence of I frames consists of the appropriate N(R) values with their preceding bit in each case (see figures 5a thru 5d) set to “1”. Hence, individual frames are indicated by having the bit that precedes the N(R) value set to “0”, and a range of contiguous I frames (span list) is indicated by a contiguous pair of indicators (start and end of contiguous sequence) each with the bit that precedes the N(R) value set to “1”. Annex G illustrates examples of the possible encodings of the information field in multi-selective reject frames.

If the P/F bit in the SREJ frame is set to "1", then I frames numbered up to N(R) - 1 inclusive (N(R) being the value in the control field) shall be considered as acknowledged. However, if the P/F bit in the SREJ frame is set to "0", then the N(R) in the control field of the SREJ frame does not indicate acknowledgement of I frames, but rather indicates an outstanding I frame in need of transmission.

Each SREJ exception condition shall be cleared (reset) upon receipt of each I frame with an N(S) equal to the N(R) identified in the SREJ frame control field or information field.

A data station may transmit one or more SREJ frames with the P bit set to "0", each containing one or more different N(R) values, before one or more earlier SREJ exception conditions have been cleared. However, a SREJ frame shall not be transmitted if an earlier REJ exception condition has not been cleared, as indicated in 5.6.2.3 and 5.6.2.4. (To do so would request retransmission of an I frame that would be retransmitted by the REJ operation.) Likewise, a REJ frame shall not be transmitted if one or more earlier SREJ exception conditions have not been cleared, as indicated in 5.6.2.3 and 5.6.2.4. I frames that may have been transmitted following the I frame(s) indicated by a SREJ frame shall not be retransmitted as the result of receiving a SREJ frame. Additional I frames awaiting initial transmission may be transmitted following the retransmission of the specific I frame(s) requested by all of the SREJ frames received.

(See 5.6.2 for N(S) sequence error recovery procedures.)

5.5.3 Unnumbered format commands and responses

Unnumbered, U, commands and responses shall be used to extend the number of data link control functions. Frames transmitted with the U format shall not increment the state variables at either the transmitting or the receiving data station. Five "modifier" bits are provided which allow up to 32 additional command functions and 32 additional response functions to be defined. Fifteen command functions and nine response functions are defined below; all others are reserved.

The encoding of the U format command/response control field shall be as shown in figure 6.

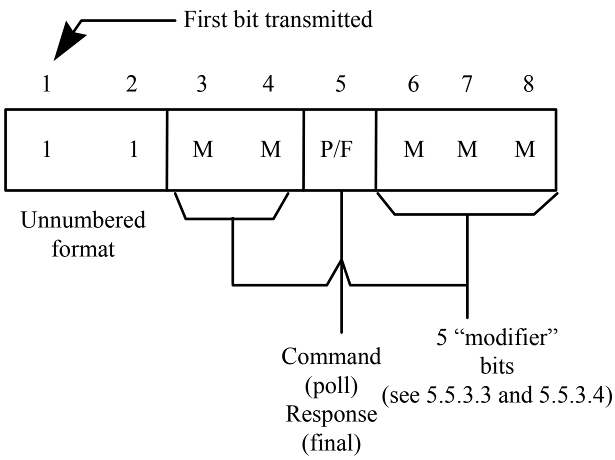


Figure 6 — Unnumbered format of control field bits

(See 5.4.3 for a description of the functions of the P/F bit.)

Several unnumbered commands and responses (i.e., SNRM, SARM, SABM, SNRME, SARME, SABME, SM, UA, DISC, DM, XID) may have an optional information field as defined in 5.5.3.1. The information field for FRMR is defined in 5.5.3.4.2.

5.5.3.1 Information field structure

The general structure of the optional information field is illustrated in figure 7. The first octet of the information field, when present, shall be a format identifier subfield. One or more data link layer subfields may follow the format identifier subfield. These may be followed by a user data subfield.

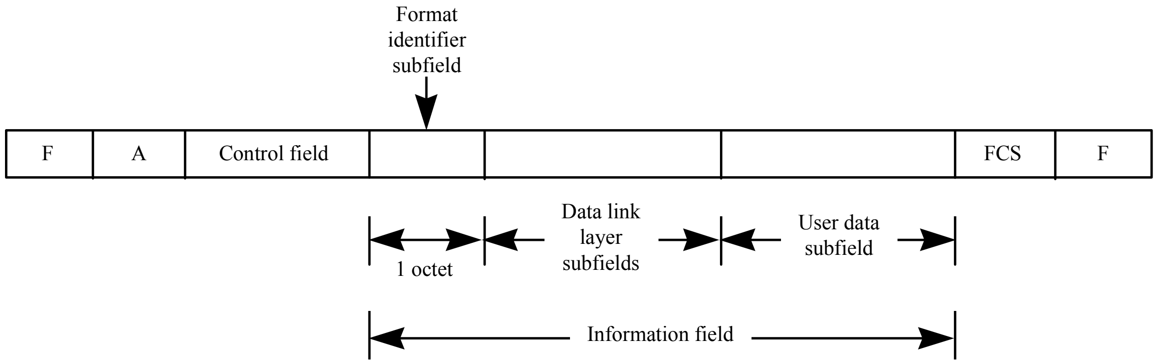


Figure 7 — Format of the optional information field in specified unnumbered commands and responses

5.5.3.1.1 Format identifier subfield

The format identifier subfield is a fixed length of one octet and is illustrated in figure 7.

5.5.3.1.2 Data link layer subfields

The data link layer subfields specify various data link layer characteristics and parameters. The contents of these subfields are generated and consumed by the data link layer logic. The length of these subfields is limited by the maximum length restrictions on the HDLC frame information field, taking into account the lengths of the format identifier subfield and the user data subfield.

A data link layer subfield consists of a group identifier (1 octet), a group length (1 or 2 octets, depending on usage), and a parameter field (n octets). The general structure of a data link layer subfield is illustrated in figure 8.

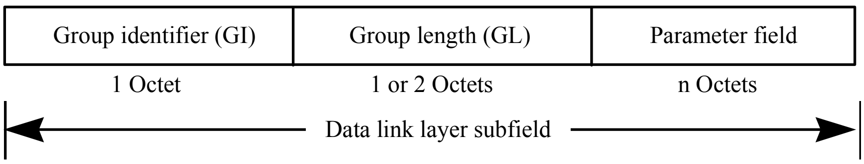


Figure 8 — Data link layer subfield

The group identifier (GI) identifies the function of that data link layer subfield. Five data link layer subfields are defined in this International Standard:

Address resolution;

HDLC parameters;

Mode and modulus;

Multilink parameters; and

User-defined parameters.

The group length (GL) indicates the length of the associated parameter field in octets. The highest order bits in a multi-octet GL are in the first octet transmitted.

NOTE — The group length value does not include the lengths of either itself or its associated identifier.

A group length value of zero indicates that there is no associated parameter field and that all parameters within the subfield specified by the associated group identifier should assume their default values.

Depending on the data link layer subfield, the parameter field may consist of a series of parameter identifier (PI) (1 octet), parameter length (PL) (1 octet), and parameter value (PV) (m octets) sets, one set for each defined data link layer subfield element. For multi-octet PV's that are binary, the higher-order bits are in the first octet transmitted. When this structure is used, a data link layer subfield has the organization depicted in figure 9.

GI	GL	PI	PL	PV	...	PI	PL	PV
		1 Octet	1 Octet	m Octets				

Where

PI: Parameter identifier, expressed as a decimal value

PL: Parameter length, expressed as a decimal value

Figure 9 — General organization of a data link layer subfield using the PI/PL/PV structure

NOTE — The value of PL does not include the lengths of either itself or its associated PI.

A PL value of zero indicates that the associated PV is absent and that the parameter shall assume the default value.

A PI/PL/PV set may be omitted if it is not required for conveying information or if default values for the parameters are to be used. A parameter field containing a PI that is not specified in this International Standard is defined as invalid and shall be ignored (except within the user-defined parameters subfield, in which PIs other than PI=0 may be defined by a prior agreement between the stations). Except where noted, duplicate PIs should not be sent within the same data link layer subfield. The behavior of the receiver upon receipt of duplicate PIs within the same data link layer subfield is not defined in this International Standard.

5.5.3.1.3 User data subfield

The user data subfield contains user information. This data link user information is transported transparently across the data link layer to the user of the data link. The amount of information (number of bits) that can be accommodated is limited only by the maximum length restrictions on the HDLC frame information field, taking into account the lengths of the format identifier subfield and the data link layer subfields.

The user data subfield is composed of a user data identifier (1 octet), and a user data field (n bits).

The user data subfield, therefore, has the organization illustrated in figure 10.

User data identifier	User data field

Figure 10 — User data subfield

5.5.3.1.4 Allowable subfields in unnumbered format command/response frames

The various subfields that may exist in the information field of certain unnumbered format command and response frames are given in table 9.

Table 9 — Allowable subfields/groups in optional information field in specified unnumbered format commands and responses

Commands/ Responses	Subfields						
	Format Identifier	Data Link Layer					User Data
		Address Resolution	HDLC Parameters	Mode & Modulus	Multilink	User-defined Parameters	
DISC	X						X
DM	X		X	X		X	X
SABM	X		X			X	X
SABME	X		X			X	X
SARM	X		X			X	X
SARME	X		X			X	X
SM	X		X	X		X	X
SNRM	X		X			X	X
SNRME	X		X			X	X
UA	X		X	X		X	X
XID	X	X	X		X	X	X

Subfield encodings for those subfields that are identified as being associated with the mode-setting command/response frames are given in 5.5.3.2. The subfield encodings for those subfields that are identified as being associated with the general purpose XID command/response frames are given in 7.2.

5.5.3.2 Information field encoding of mode-setting command/response frames

The format identifier subfield is always the first octet of the optional information field. The data link layer subfields, if present, follow in ascending order according to their GI values. Except where noted, specific data link layer subfields may appear only once. The absence of a particular data link layer subfield should be interpreted to mean default values. The user data subfield, if present, is always the last subfield.

5.5.3.2.1 Format identifier subfield encoding

The format identifier subfield can be encoded to have the capability of designating 256 different formats.

The format identifier subfield used for HDLC-standard, general purpose mode-setting command/response frames as defined in the International Standard shall be encoded as illustrated in figure 11.

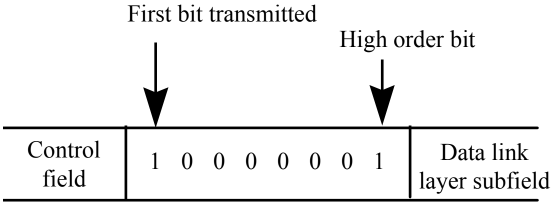


Figure 11 — General purpose format identifier subfield encoding for mode-setting frames

All other values of the mode-setting command/response frame format identifier are reserved for future assignment.

5.5.3.2.2 Data link layer subfield encoding

Figure 12 indicates the GI encodings for the data link layer subfields that are identified as being associated with the mode-setting command/response frames covered in this International Standard.

First bit transmitted ↓ High order bit ↓

1	0	0	0	0	0	0	1	Mode and modulus
0	0	0	0	0	0	0	1	HDLC parameters
0	0	0	0	1	1	1	1	User-defined parameters

Figure 12 — Group identifier encoding for data link layer subfields

The GI encoding of all ones (1111 1111) is not used as a data link layer subfield identifier encoding. It serves as the identifier encoding for the user data subfield.

All GI encodings not assigned in this International Standard (here and in 7.2) are reserved for future use.

NOTES

The HDLC parameters data link layer subfield and the user-defined parameters data link layer subfield may each appear more than once in the information field. This allows the station to convey multiple menus in the information field.

The user-defined parameters identifier is for use to identify parameters outside the scope of the HDLC parameters identifier while making use of those parameters that are explicitly identified under the HDLC parameters identifier.

5.5.3.2.2.1 Mode and modulus

The data link layer subfield associated with the mode and modulus group is illustrated in figure 13.

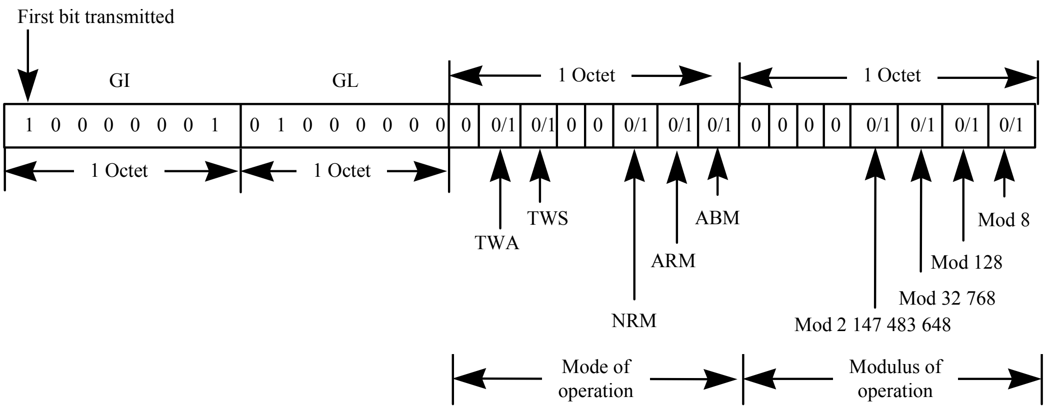


Figure 13 — Mode and modulus group elements

The mode(s) of operation is indicated by setting the corresponding bit(s) to "1". The modulus for operation is indicated by setting the corresponding bit(s) to "1".

5.5.3.2.2.2 Parameter field elements

Table 10 identifies the parameter field elements that are defined here.

Table 10 — Mode-setting data link layer subfield parameter field elements
HDLC parameters (GI = 00000001)

PI	Parameter field element
5	Maximum information field length — transmit
6	Maximum information field length — receive
7	Window size k — transmit
8	Window size k — receive

User-defined parameters (GI = 00001111)

PI	Parameter field element
0	Parameter set identification

The following legend explains the symbols used in tables 11 and 12.

B: Indicates this field is binary encoded.
N: Number of octets.
NA: Not applicable.

Table 11 — HDLC parameters elements

Name	PI	PL	Parameter field element	Code Type	Bit No.	Value
Maximum information field length (transmit)	5	N	Maximum information field length-transmit (bits)	B	NA	B
Maximum information field length (receive)	6	N	Maximum information field length-receive (bits)	B	NA	B
Window size k (transmit)	7	4	Window size k-transmit (frames)	B	NA	B
Window size k (receive)	8	4	Window size k-receive (frames)	B	NA	B

Table 12 — User-defined parameters elements

Name	PI	PL	Parameter field element	Code type	Bit No.	Value
Parameter set identification	0	N	Parameter set identification	NA	NA	(See Note 1)
(Implementor-defined) (See Note 2)	1 to 255	N	(Implementor-defined)	NA	NA	NA

NOTE 1 — Parameter set identification may be from 1 to 255 octets in length. Certain values are listed in ISO/IEC TR 10171.

NOTE 2 — The use of PI/PL/PV encoding in this subfield for PI values other than PI=0 is not required. Such usage is at the discretion of the organization associated with the parameter set identified by PI=0.

5.5.3.2.3 User data subfield encoding

5.5.3.2.3.1 User data identifier encoding

The user data identifier identifies the subfield as the user data subfield. Figure 14 provides its encoding.

First bit transmitted ↓ High order bit ↓

1 1 1 1 1 1 1 1 User data subfield identifier

Figure 14 — User data subfield identifier encoding

5.5.3.2.3.2 User data field

The user data field is transported transparently by the data link and passed to the user of the data link. The encoding of the user data field is the responsibility of the data link user and may be any format that is mutually agreed upon by the data link users involved.

5.5.3.3 Unnumbered commands

The unnumbered command encodings are shown in figure 15.

First bit transmitted (bit 1)

1	2	3	4	5	6	7	8	
1	1	0	0	P	0	0	1	SNRM command
1	1	1	1	P	0	0	0	SARM command
1	1	1	1	P	1	0	0	SABM command
1	1	0	0	P	0	1	0	DISC command
1	1	1	1	P	0	1	1	SNRME command
1	1	1	1	P	0	1	0	SARME command
1	1	1	1	P	1	1	0	SABME command
1	1	1	0	P	0	0	0	SIM command
1	1	0	0	P	1	0	0	UP command
1	1	0	0	P	0	0	0	UI command
1	1	1	1	P	1	0	1	XID command
1	1	1	1	P	0	0	1	RSET command (combined station only)
1	1	0	0	P	1	1	1	TEST command
1	1	0	0	P	0	1	1	SM command
1	1	1	1	P	1	1	1	UIH command

Figure 15 — Unnumbered command control field bit assignments

The SNRM, SARM, SABM, DISC, SNRME, SARME, SABME, SM and SIM unnumbered mode setting commands and the RSET unnumbered resetting command, the XID unnumbered command, and the TEST unnumbered command, shall require the secondary/combined station to acknowledge acceptance by responding with the appropriate unnumbered response frame (a UA response frame, an XID response frame, and a TEST response frame, respectively). If the secondary/combined station receives more than one of the above commands before a respond opportunity occurs, it shall transmit the response appropriate to the first of the received commands at the first respond opportunity. The secondary/combined station transmission of the appropriate response following the receipt of one of these commands shall take precedence over a response for any other previous command which may be waiting for a respond opportunity at the secondary/combined station. Following receipt of one of the above commands, the secondary/combined station may ignore all frames received, except to detect the next respond opportunity, until it has sent a response appropriate to that command. Following receipt of a RSET resetting command, a combined station may discard the information field contained in any I, UI or UIH frames received but shall continue to utilize whatever control information is contained in any frames received [for example N(R), change in busy/not busy status, request for retransmission, indication of an exception condition, etc.] until it has sent a UA response acknowledging receipt of that resetting command.

In two-way alternate communications, a secondary/combined station, following the receipt of a mode setting command, or a combined station, following the receipt of a resetting command, shall transmit a UA response frame at the next respond opportunity. In two-way simultaneous communications, a secondary/combined station which is transmitting concurrent to the receipt of a mode setting command, or a combined station which is transmitting concurrent to the receipt of a resetting command, shall initiate transmission of a UA response frame at the earliest respond opportunity.

If appropriate to the mode of operation, the secondary/combined station may continue transmission following return of the UA response.

The respond opportunity at the secondary/combined station shall be determined by the operational mode setting command (SNRM, SARM, SABM, SNRME, SARME, SABME or SM) that is accepted (i.e., the mode that the secondary/combined station has accepted dictates when the response shall be transmitted), as follows:

a) Upon receipt of a SNRM or SNRME command with the P bit set to "1", the secondary station shall respond with a single UA frame with the F bit set to "1". If the SNRM or SNRME frame has the P bit set to "0", the secondary station shall wait until a command frame is received with the P bit set to "1" and then shall respond with a single UA frame with the F bit set to "1", or shall wait until a UP command is received with the P bit set to "0" and then shall respond with a single UA frame with the F bit set to "0".

b) Upon receipt of a SARM or SARME command with or without the P bit set to "1", the secondary station shall transmit a UA frame:

   1) upon detection of an idle data link channel state in TWA data communication; or

   2) at the earliest respond opportunity in TWS data communication.

   The UA frame shall have the F bit set to "1" if the command has the P bit set to "1". The UA frame may be followed by additional secondary station transmissions, if pending.

c) Upon receipt of a SABM or SABME command, or a RSET command while in ABM, with or without the P bit set to "1", the combined station shall transmit a UA frame:

   1) upon detection of an idle data link channel state in TWA data communication; or

   2) at the earliest respond opportunity in TWS data communication.

   The UA frame shall have the F bit set to "1" if the command has the P bit set to "1". The UA frame may be followed by additional combined station transmissions, if pending.

d) Upon receipt of a SM command, the data station shall behave in accordance with a), b), or c) above, depending on the mode of operation indicated in the information field or known a priori.

In the case of the non-operational mode setting commands (SIM and DISC), the respond opportunity at the secondary/combined station shall be system defined; i.e., a given secondary/combined station shall be system defined to use the normal mode respond opportunity or the asynchronous mode respond opportunity for the response following a SIM or DISC command, as follows:

a) Upon receipt of the SIM command, the secondary/combined station shall respond with the UA response. The UA frame shall have the F bit set to "1" if the SIM command has the P bit set to "1".

b) Upon receipt of the DISC command, the secondary/combined station shall respond with the UA or DM response depending on whether the secondary/combined station was in an operational mode or a disconnected mode, respectively, at the time that the DISC command was received. The UA or DM frame shall have the F bit set to "1" if the DISC command has the P bit set to "1".

If the secondary/combined station cannot accept a mode setting command, or the combined station cannot accept a resetting command, it shall, at its earliest respond opportunity, transmit a DM, FRMR, RD, or RIM response, as appropriate, indicating non-acceptance of the mode setting or resetting command.

5.5.3.3.1 Set normal response mode (SNRM) command

The SNRM command shall be used to place the addressed secondary station in the normal response mode (NRM) where all control fields shall be one octet in length. The secondary station shall confirm acceptance of the SNRM command by transmission of a UA response at the first respond opportunity. Upon acceptance of this command, the secondary station send and receive state variables shall be set to zero.

When this command is actioned, the responsibility for all unacknowledged I frames assigned to data link control reverts to a higher layer. Whether the content of the information field of such unacknowledged I frames is reassigned to data link control for transmission or not is decided at a higher layer.

An information field may be present in the SNRM command. The structure of the information field when present is as indicated in 5.5.3.2 and table 9.

5.5.3.3.2 Set asynchronous response mode (SARM) command

The SARM command shall be used to place the addressed secondary station in the asynchronous response mode (ARM) where all control fields shall be one octet in length. The secondary station shall confirm acceptance of the SARM command by the transmission of a UA response at the first respond opportunity. Upon acceptance of this command, the secondary station send and receive state variables shall be set to zero.

When this command is actioned, the responsibility for all unacknowledged I frames assigned to data link control reverts to a higher layer. Whether the content of the information field of such unacknowledged I frames is reassigned to data link control for transmission or not is decided at a higher level.

An information field may be present in the SARM command. The structure of the information field when present is as indicated in 5.5.3.2 and table 9.

5.5.3.3.3 Set asynchronous balanced mode (SABM) command

The SABM command shall be used to place the addressed combined station in the asynchronous balanced mode (ABM) where all control fields shall be one octet in length. The combined station shall confirm acceptance of the SABM command by transmission of a UA response at the first respond opportunity. Upon acceptance of this command, the combined station send and receive state variables shall be set to zero.

When this command is actioned, the responsibility for all unacknowledged I frames assigned to data link control reverts to a higher layer. Whether the content of the information field of such unacknowledged I frames is reassigned to data link control for transmission or not is decided at a higher layer.

An information field may be present in the SABM command. The structure of the information field when present is as indicated in 5.5.3.2 and table 9.

5.5.3.3.4 Disconnect (DISC) command

The DISC command shall be used to terminate an operational or initialization mode previously set by a command. In both switched and non-switched networks it shall be used to inform the addressed secondary/combined station(s) that the primary/combined station is suspending operation and that the secondary/combined station(s) should assume a logically disconnected mode. In switched networks, a logically disconnected function at the data link layer may also serve to initiate, at the physical layer interface, a physical disconnect operation of the physical layer; i.e., to have the addressed secondary/combined station go "on-hook". Prior to actioning the command, the secondary/combined station shall confirm the acceptance of the DISC command by the transmission of a UA response.

When this command is actioned, the responsibility for all unacknowledged I frames assigned to data link control reverts to a higher layer. Whether the content of the information field of such unacknowledged I frames is reassigned to data link control for transmission or not is decided at a higher layer.

An information field may be present in the DISC command. The structure of the information field when present is as indicated in 5.5.3.2 and table 9.

5.5.3.3.5 Set normal response mode extended (SNRME) command

The SNRME command shall be used to place the addressed secondary station in a normal response mode where numbered command/response control fields shall be two octets in length and unnumbered command/response control fields shall be one octet in length (see 5.3.1). The secondary station shall confirm acceptance of the SNRME command by transmission of a UA response at the first respond opportunity. Upon acceptance of this command, the secondary station send and receive state variables shall be set to zero.

When this command is actioned, the responsibility for all unacknowledged I frames assigned to data link control reverts to a higher layer. Whether the content of the information field of such unacknowledged I frames is reassigned to data link control for transmission or not is decided at a higher layer.

An information field may be present in the SNRME command. The structure of the information field when present is as indicated in 5.5.3.2 and table 9.

5.5.3.3.6 Set asynchronous response mode extended (SARME) command

The SARME command shall be used to place the addressed secondary station in an asynchronous response mode where numbered command/response control fields shall be two octets in length and unnumbered command/response control fields shall be one octet in length (see 5.3.1). The secondary station shall confirm acceptance of the SARME command by transmission of a UA response at the first respond opportunity. Upon acceptance of this command, the secondary station send and receive state variables shall be set to zero.

When this command is actioned, the responsibility for all unacknowledged I frames assigned to data link control reverts to a higher layer. Whether the content of the information field of such unacknowledged I frames is reassigned to data link control for transmission or not is decided at a higher layer.

An information field may be present in the SARME command. The structure of the information field when present is as indicated in 5.5.3.2 and table 9.

5.5.3.3.7 Set asynchronous balanced mode extended (SABME) command

The SABME command shall be used to place the addressed combined station in an asynchronous balanced mode where numbered command/response control fields shall be two octets in length and unnumbered command/response control fields shall be one octet in length (see 5.3.1). The combined station shall confirm acceptance of the SABME command by transmission of a UA response at the first respond opportunity. Upon acceptance of this command, the combined station send and receive state variables shall be set to zero.

When this command is actioned, the responsibility for all unacknowledged I frames assigned to data link control reverts to a higher layer. Whether the content of the information field of such unacknowledged I frames is reassigned to data link control for transmission or not is decided at a higher layer.

An information field may be present in the SABME command. The structure of the information field when present is as indicated in 5.5.3.2 and table 9.

5.5.3.3.8 Set initialization mode (SIM) command

The SIM command shall be used to cause the addressed secondary/combined station to initiate a station-specified procedure(s) to initialize its data link layer control functions. No information field shall be permitted with the SIM command. The secondary/combined station shall confirm acceptance of the SIM command by the transmission of a UA response at the first respond opportunity. Upon acceptance of this command, the secondary/combined station send and receive state variables shall be set to zero.

When this command is actioned, the responsibility for all unacknowledged I frames assigned to data link control reverts to a higher layer. Whether the content of the information field of such unacknowledged I frames is reassigned to data link control for transmission or not is decided at a higher layer.

5.5.3.3.9 Unnumbered poll (UP) command

The UP command shall be used to solicit response frames from a group of secondary stations (group poll), from all secondary stations (all-station poll) or from a single secondary/combined station (individual poll) by establishing a logical operational condition that exists at each addressed data station for one respond opportunity. In the case of a group poll or all-station poll, the mechanism employed to control response transmissions (to avoid simultaneous transmissions) is not defined in this International Standard. The UP command does not acknowledge receipt of any response frames that may have been previously transmitted by the secondary/combined station. No information field shall be permitted with the UP command.

The secondary/combined station(s) which receives the UP command with a group or all-station address shall respond in the same manner as when polled using an individual address. The response frame(s) shall contain the sending secondary/combined station's individual address, plus N(S) and N(R) numbers as required by the particular response(s). The continuity of each secondary/combined station's N(S) shall be maintained. If the UP command has the P bit set to "1", each addressed secondary/combined station shall respond with at least one frame, the last frame having the F bit set to "1". If the UP command has the P bit set to "0", each addressed secondary/combined station may or may not respond depending on the status of the secondary/combined station. Secondary/combined station responses sent in reply to a UP command with the P bit set to "0" shall have the F bit set to "0" in all frames of each secondary/combined station's response. A secondary/combined station which receives a UP command with the P bit set to "0" shall respond when:

a) it has an I/UI frame(s) to send;

b) it has an I frame to resend because it did not receive an acknowledgement;

c) it has received, but not acknowledged, an I frame(s);

d) it has received, but not responded to, a XID or TEST command;

e) it has experienced an exception condition or change of status that has not been reported; or

f) it has a status that has to be reported again (for example, a FRMR, RIM or RD, or, optionally, an appropriate frame to report a no-traffic condition, or a DM response to request a mode setting command).

If an idle data link channel state (15 "ones") exists following the receipt of a frame(s), or no response is received within a given period of time, it shall be assumed that the secondary/combined station has completed, or will not initiate, transmission.

5.5.3.3.10 Unnumbered information (UI) command

The UI command shall be used to send information (for example, status, application data, operation, interruption, data link layer programs, temporal data or parameters) to a secondary/combined station(s) without affecting the V(S) or V(R) variables at any station. Reception of the UI command is not sequence number verified by the data link procedures; therefore, the UI frame may be lost if a data link exception occurs during transmission of the command, or duplicated if an exception condition occurs during any reply to the command. There is no specified secondary/combined station response to the UI command. The UI command may be sent independently of the mode of the data link station.

5.5.3.3.11 Exchange identification (XID) command

The XID command shall be used to cause the addressed secondary/combined station to identify itself, and, optionally, to provide primary/combined station identification and/or characteristics to the addressed secondary/combined station. An information field is optional with the XID command. A secondary/combined station receiving a XID command shall, if capable, action the XID command in any mode unless a UA response to a mode setting command is awaiting transmission or a FRMR condition exists.

If an XID command contains an information field, the first octet of the information field shall be the format identifier for the remainder of the information field.

The encoding of the format identifier shall be as shown in figure 16.

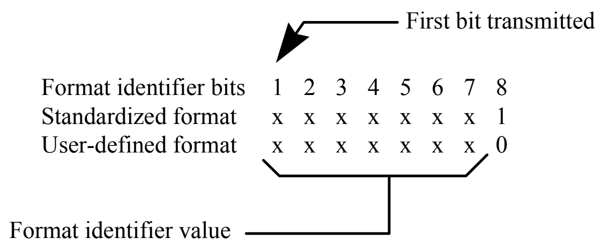


Figure 16 — XID format identifier

NOTE — The format identifier has a capability of designating 128 different standardized formats and 128 different user-defined formats.

In an operational mode (NRM, ARM or ABM), a FRMR condition may be established if the received XID command information field exceeds the maximum defined storage capability of the secondary/combined station.

5.5.3.3.12 Reset (RSET) command

The RSET command shall be used by a combined station in an operational mode to reset the receive state variable in the addressed combined station. No information field shall be permitted with the RSET command. The addressed combined station shall confirm acceptance of the RSET command by transmission of a UA response at the first respond opportunity. Upon acceptance of this command, the addressed combined station receive state variable shall be set to zero. If the UA response is received correctly, the initializing combined station shall reset its send state variable to zero.

The RSET command shall reset all frame rejection conditions in the addressed combined station, except for an invalid N(R) condition which the addressed combined station has reported by a FRMR frame. The RSET command may be sent by the combined station which detects an invalid N(R) to clear such a frame rejection condition in place of sending a FRMR frame. To clear an invalid N(R) frame rejection condition with a RSET command, the RSET command shall be transmitted by the combined station that detects the invalid N(R).

When this command is actioned, the responsibility for all unacknowledged I frames assigned to data link control reverts to a higher layer. Whether the content of the information field of such unacknowledged I frames is reassigned to data link control for transmission or not is decided at a higher layer.

5.5.3.3.13 Test (TEST) command

The TEST command shall be used to cause the addressed secondary/combined station to respond with the TEST response at the first respond opportunity, thus performing a basic test of the data link control. An information field is optional with the TEST command. If present, however, the received information field shall be returned, if possible, by the addressed secondary/combined station with the TEST response. The TEST command shall have no effect on the mode or sequence variables maintained by the secondary/combined station.

The primary/combined station shall consider the data link layer test terminated upon receipt of the TEST response or when a time-out period has run out. The results of the TEST command/response exchange may be made available for interrogation by a higher layer.

5.5.3.3.14 Set mode (SM) command

The SM command shall be used to place the addressed station (combined/secondary) in one of the operational modes where numbered command/response control fields are greater than two octets in length. The SM command may be used to place the addressed station (combined/secondary) in one of the operational modes where numbered command/response control fields are one or two octets in length.

The specific operational mode, in which the addressed station is placed using the SM command, may be determined by other means (see below). Furthermore, use of the SM frame may require these other means to set the number of octets to be used in I format and S format command/response control fields.

Various ways in which the mode and the modulus for operation can be selected are:

(a) with *a priori* knowledge;

(b) through XID exchange; or

(c) through the use of an information field in the SM command.

An information field may be present in the SM command. The structure of the information field when present is as indicated in 5.5.3.2 and table 9.

If the mode and modulus element or the HDLC optional functions element is present, the mode of operation and the modulus for operation shall be negotiated by setting the appropriate bits in the corresponding element; if not, then the mode of operation and modulus for operation shall be specified as in items (a) or (b). The combined/secondary station shall confirm the acceptance of the SM command by transmission of a UA response at the first respond opportunity. Upon acceptance of this command, the combined/secondary station's send and receive state variables shall be set to zero.

When this command is actioned, the responsibility for all unacknowledged I frames assigned to data link control reverts to a higher layer. Whether the content of the information field of such unacknowledged I frames is reassigned to data link control for transmission or not is decided at a higher layer.

5.5.3.3.15 Unnumbered information with header check (UIH) command

The UIH command shall be used to send information where the integrity of the information being transferred is of lesser importance than its delivery to the correct secondary/combined station(s) without affecting the V(S) or V(R) variables at either station. For the UIH command frame, the FCS shall be calculated over only a specified length of the beginning of the frame. The length of the protected portion shall be determined by parameter negotiation (XID exchange or mode-setting frame exchange), a priori knowledge or as a system definition.

Reception of the UIH command is not sequence number verified by the data link procedures; therefore, the UIH frame may be lost if a data link exception occurs during the transmission of the protected portion of the command, or duplicated if an exception condition occurs during any reply to the command. There is no specified secondary/combined station response to the UIH command. The UIH command may be sent independently of the mode of the data link station.

NOTE — Cases where the integrity of the information being transferred is of lesser importance than its delivery to the correct station include the timely transmission of packetized voice, video/graphic data, or periodically updated information.

5.5.3.4 Unnumbered responses

The unnumbered response encodings are shown in figure 17.

First bit transmitted (bit 1)

1	2	3	4	5	6	7	8	
1	1	0	0	F	1	1	0	UA response
1	1	1	0	F	0	0	1	FRMR response
1	1	1	1	F	0	0	0	DM response
1	1	0	0	F	0	1	0	RD response
1	1	1	0	F	0	0	0	RIM response
1	1	0	0	F	0	0	0	UI response
1	1	1	1	F	1	0	1	XID response
1	1	0	0	F	1	1	1	TEST response
1	1	1	1	F	1	1	1	UIH response

Figure 17 — Unnumbered response control field bit assignments

5.5.3.4.1 Unnumbered acknowledgement (UA) response

The UA response shall be used by the secondary/combined station to acknowledge the receipt and acceptance of SABM, SNRM, SARM, SNRME, SABME, SARME, SM, RSET, SIM and DISC commands. An information field may be present in the UA response. The structure of the information field when present is as defined in 5.5.3.2 and table 9.

When the UA response has an information field containing the mode and modulus element, at most one mode bit and one modulus bit can be set to “1”.

5.5.3.4.2 Frame reject (FRMR) response

The FRMR response shall be used by the secondary/combined station in an operational mode to report that one of the following conditions, that is not correctable by retransmission of the identical frame, resulted from the receipt of a frame without FCS error from the primary/combined station:

a) the receipt of a command or a response that is undefined or not implemented;

b) the receipt of an I/UI/UIH command or response, or, optionally, a TEST command, or, optionally, a XID command or response, with an information field which exceeded the maximum information field length which can be accommodated by the secondary/combined station;

c) the receipt of an invalid N(R) from the primary/combined station, i.e., an N(R) which identifies an I frame which has previously been transmitted and acknowledged or an I frame which has not been transmitted and is not the next sequential I frame awaiting transmission; or

d) The receipt of a frame containing an information field when no information field is permitted by the associated control field.

The secondary/combined station shall transmit the FRMR response at the first respond opportunity.

After sending a FRMR response, the secondary/combined station:

a) shall stop transmitting I frames if the frame reject exception condition was caused by an invalid N(R) since its direction of transmission is affected; or

b) may, because the opposite direction of transmission is affected, optionally continue sending I frames if the frame reject exception condition was caused by:

   1) a command or response that is undefined or not implemented, or

   2) an I frame with an information field which exceeded the maximum information field length which can be accommodated by the secondary/combined station.

(See 5.6.4 for a description of command-response rejection procedures.)

The primary/combined station receiving the FRMR response shall be responsible for initiating the appropriate mode setting or resetting corrective action by initializing one or both directions of transmission using the RSET, SNRM, SARM, SABM, SNRME, SARME, SABME, SM, or DISC command, as applicable.

An information field shall be returned with this response to provide the reason for the frame rejection. When modulo 8 is used, the information field shall contain the fields shown in figure 18a.

← First bit transmitted

1 2 3 4 5 6 7 8	9	10 11 12	13	14 15 16	17	18	19	20
Rejected frame control field	0	N(S)	C/R	N(R)	*w*	*x*	*y*	*z*

Figure 18a — Information field format for FRMR response in modulo 8 operation

The functions of these fields shall be as follows:

a) The rejected frame control field shall be the control field of the received frame which caused the frame reject exception condition.

b) N(S) shall be the current value of the send state variable at the secondary/combined station (bit 10 = low-order bit).

c) C/R set to "1" shall indicate that the frame which caused the frame reject exception condition was a response frame, and C/R set to "0" shall indicate that the frame which caused the frame reject exception condition was a command frame.

d) N(R) shall be the current value of the receive state variable at the secondary/combined station (bit 14 = low-order bit).

e) *w* set to "1" shall indicate that the control field received and returned in bits 1 to 8 inclusive was undefined or not implemented.

f) *x* set to "1" shall indicate that the control field received and returned in bits 1 to 8 inclusive was considered invalid because the frame contained an information field which is not permitted with this command or response. Bit *w* shall be set to "1" in conjunction with this bit.

g) *y* set to "1" shall indicate that the information field received exceeded the maximum information field length which can be accommodated by the secondary/combined station.

h) *z* set to "1" shall indicate that the control field received and returned in bits 1 to 8 inclusive contained an invalid N(R).

The *w, x, y* and *z* bits in the information field of the FRMR response may all be set to zero, indicating an unspecified rejection of the frame for one or more of the conditions cited above. If required, the information field contained within the FRMR response may be padded with zero bits so as to end on any convenient, mutually agreed upon character, byte, word or machine-dependent boundary. (See also 5.6.4.)

When the control field extension (see 5.3.1) is used for modulo 128, the format for the information field returned with the FRMR response shall be as shown in figure 18b.

First bit transmitted

1 ········ 16	17	18 ···· 24	25	26 ··· 32	33 ···· 36			
Rejected extended frame control field	0	N(S)	C/R	N(R)	*w*	*x*	*y*	*z*

Figure 18b — Information field format for FRMR response in modulo 128 operation

Bit 18 and bit 26 are the low-order bits of the current value of the send state and receive state variables, respectively, at the secondary/combined station.

In the extended FRMR response format in modulo 128 operation, the rejected frame control field is the control field of the received frame which caused the frame reject exception condition. When the rejected frame is an unnumbered frame, the control field of the rejected frame is positioned in bit positions 1 to 8, with bits 9 to 16 set to zero.

When the control field extension (see 5.3.1) is used for modulo 32 768, the format for the information field returned with the FRMR response shall be as shown in figure 18c.

First bit transmitted

1 ········ 32	33	34 ···· 48	49	50 ···· 64	65	66	67	68
Rejected extended frame control field	0	N(S)	C/R	N(R)	*w*	*x*	*y*	*z*

Figure 18c — Information field format for FRMR response in modulo 32 768 operation

Bit 34 and bit 50 are the low-order bits of the current value of the send state and receive state variables, respectively, at the secondary/combined station.

In the extended FRMR response format in modulo 32 768 operation, the rejected frame control field is the control field of the received frame which caused the frame reject exception condition. When the rejected frame is an unnumbered frame, the control field of the rejected frame is positioned in bit positions 1 to 8, with bits 9 to 32 set to zero.

When the control field extension (see 5.3.1) for modulo 2 147 483 648 is used, the format for the information field returned with the FRMR response shall be as shown in figure 18d.

First bit transmitted

1···············64	65	66····96	97	98····128	129	130	131	132
Rejected extended frame control field	0	N(S)	C/R	N(R)	*w*	*x*	*y*	*z*

Figure 18d — Information field format for FRMR response in modulo 2 147 483 648 operation

Bit 66 and bit 98 are the low-order bits of the current value of the send state and receive state variables, respectively, at the secondary/combined station.

In the extended FRMR response format in modulo 2 147 483 648 operation, the rejected frame control field is the control field of the received frame which caused the frame reject exception condition. When the rejected frame is an unnumbered frame, the control field of the rejected frame is positioned in bit positions 1 to 8, with bits 9 to 64 set to zero.

5.5.3.4.3 Disconnected mode (DM) response

The DM response shall be used to report a status where the secondary/combined station is logically disconnected from the data link, and is, by system definition, in NDM or ADM.

The DM response shall be sent by the secondary/combined station in NDM or ADM to request the primary/other combined station to issue a mode setting command, or if sent in response to the reception of a mode setting command, to inform the primary/other combined station that it is still in NDM/ADM and cannot action the mode setting command. An information field may be present in the DM response. The structure of the information field when present is as indicated in 5.5.3.2 and table 9.

A secondary/combined station in NDM or ADM shall monitor received commands to detect a respond opportunity in order to (re)transmit the DM response (or the RIM, XID, UI, TEST or RD responses, as appropriate); i.e., no commands (other than the XID, UI, and TEST commands) are accepted until the disconnected mode is terminated by the receipt of a mode setting command (SNRM, SARM, SABM, SNRME, SARME, SABME, SM, or SIM, as appropriate).

5.5.3.4.4 Request disconnect (RD) response

The RD response shall be used to indicate to the primary/combined station that the secondary/combined station wishes to be placed in the disconnected mode (NDM or ADM). No information field shall be permitted with the RD response.

A secondary/combined station which has sent an RD response and receives a command frame(s) other than the DISC command shall accept the command frame(s) if it is able to do so. If the secondary/combined station accepts the non-DISC command frame(s), it shall follow the normal procedures when responding to the primary/combined station. Secondary/combined station acceptance of a frame other than the DISC command after sending an RD response cancels the RD response. If the secondary/combined station still wishes to be placed in the disconnected mode (NDM or ADM), it shall re-issue the RD response. If the secondary/combined station cannot accept the non-DISC frames due to internal problems, it may again respond with an RD response to the non-DISC frames.

5.5.3.4.5 Request initialization mode (RIM) response

The RIM response shall be used in any mode to report a secondary/combined station's need for initialization. No information field shall be permitted with the RIM response.

Once a secondary/combined station has sent a RIM response, additional commands subsequently received (other than the SIM or DISC command, or, if capable, the XID or TEST command) shall be monitored to detect a respond opportunity to retransmit the RIM response, as an indication that the need for initialization persists.

5.5.3.4.6 Unnumbered information (UI) response

The UI response shall be used to send information (for example, status, application data, operation, interruption, or temporal data) to a primary/combined station without affecting the V(S) or V(R) variables at either station. Reception of the UI response is not sequence number verified by the data link procedures; therefore, the UI frame may be lost if a data link exception occurs during transmission of the UI response, or duplicated if an exception condition occurs during any reply to the UI response.

The UI response may be sent during any mode of the data link station.

5.5.3.4.7 Exchange identification (XID) response

The XID response shall be used to reply to an XID command, or to request an XID command/response exchange. An information field containing the secondary/combined station identification and/or characteristics may be optionally present with the XID response. A secondary/combined station in any mode receiving an XID command shall, if capable, send the XID response, unless a UA response is pending or a FRMR condition exists.

If an XID response contains an information field, the first octet of the information field shall be the format identifier for the remainder of that information field. See figure 19 for the encoding of the format identifier field.

A secondary/combined station may send an unsolicited XID response at any respond opportunity to request an XID exchange, including as a response to any received command, not just an XID command.

A combined station in ABM may establish a FRMR exception condition if the information field of a received XID response exceeds the maximum defined storage capability of the combined station.

5.5.3.4.8 Test (TEST) response

The TEST response shall be used to reply to the TEST command in any mode. A secondary/combined station, receiving a TEST command, shall, if capable, send the TEST response in accordance with the defined mode, unless a UA response is pending or a FRMR condition exists.

An information field, if present in the TEST command, shall be returned with the corresponding TEST response. If the secondary/combined station is busy and cannot accept an information field, a TEST response without an information field shall be returned. If the secondary/combined station is in an operational mode (NRM, ARM, ABM), a FRMR condition may be established if the received TEST command has an information field which exceeds the maximum established frame storage capability of the secondary/combined station. If a FRMR response is not returned for this condition, a TEST response without an information field shall be returned.

5.5.3.4.9 Unnumbered information with header check (UIH) response

The UIH response shall be used to send information where the integrity of the information being transferred is of lesser importance than its delivery to the correct primary/combined station(s) without affecting the V(S) or V(R) variables at either station. For the UIH response frame, the FCS shall be calculated over only a specified length of the beginning of the frame. The length of the protected portion shall be determined by parameter negotiation (XID exchange or mode-setting frame exchange), a priori knowledge or as a system definition.

Reception of the UIH response is not sequence number verified by the data link procedures; therefore, the UIH frame may be lost if a data link exception occurs during the transmission of the protected portion of the response, or duplicated if an exception condition occurs during any reply to the response. There is no specified primary/combined station response to the UIH response. The UIH response may be sent independently of the mode of the data link station.

NOTE — Cases where the integrity of the information being transferred is of lesser importance than its delivery to the correct station include the timely transmission of packetized voice, video/graphic data, or periodically updated information.

5.6 Exception condition reporting and recovery

The following procedures are available to effect recovery following the detection/occurrence of an exception condition at the data link layer. The exception conditions described are those situations which may occur as the result of transmission errors, data station malfunction or operational situations.

5.6.1 Busy

The busy condition shall result when a data station is temporarily unable to receive, or unable to continue to receive, I frames due to internal constraints; for example, receive buffering limitations. In this case, an RNR frame shall be transmitted with the N(R) number of the next I frame that is expected. Traffic awaiting transmission may be transmitted from the busy data station prior to, or following, the RNR frame. The continued existence of a busy condition shall be reported by retransmission of an RNR frame at each P/F frame exchange.

A data station receiving an RNR frame when in the process of transmitting (i.e., two-way simultaneous) shall stop transmitting I frames at the earliest possible time. It is suggested that a secondary station in NRM return a frame and the F bit set to "1" before suspending transmission. A secondary/combined station in ARM/ABM, respectively, shall perform a response/command time-out before resuming transmission.

Indication that a busy condition has cleared and that I frames will now be acceptable shall be reported by the transmission of an RR, REJ, SREJ, SNRM, SARM, SABM, SNRME, SARME, SABME, SM, or UA frame with or without the P/F bit set to "1". Clearance of a busy condition at a primary station shall also be indicated by the transmission of an I frame with the P bit set to "1". Clearance of a busy condition at a secondary/combined station shall also be indicated by the transmission of an I frame with the F bit set to "1".

5.6.2 N(S) sequence error

An N(S) sequence error exception condition shall occur in the receiver when an I frame received error free (no FCS error) contains an N(S) that is not equal to the receive state variable at the receiver. The receiver shall not acknowledge (i.e., not increment its receive state variable) the frame causing the sequence error or any I frames which may follow until an I frame with the correct N(S) is received. Unless the SREJ frame is to be used to recover from a given sequence error, the information field of all I frames received whose N(S) does not equal the receive state variable shall be discarded. (See 5.6.2.3 for SREJ recovery.)

A primary, secondary or combined station which receives one or more I frames having sequence errors, but which are otherwise error free, shall accept the control information contained in the N(R) field and the P/F bit to perform data link control functions; for example, to receive acknowledgement of previously transmitted I frames, to cause a secondary/combined station to respond (P bit set to "1"), and, in NRM, to detect that the secondary station is terminating transmission (F bit set to "1"). Therefore, the retransmitted I frame may contain an N(R) field and/or P/F bit information that are updated and different from those contained in the originally transmitted I frame.

Following the occurrence of a sequence error, the following means are available for initiating the retransmission of lost I frames or those with errors.

5.6.2.1 Poll/final (P/F) bit (checkpoint) recovery (see also 5.4.3.2)

When a data station receives a frame with the P/F bit set to "1", it shall initiate retransmission of unacknowledged I frames previously transmitted with sequence numbers that are less than the V(S), send state variable, value that was current at the time of transmission of the last frame with the F/P bit, respectively, set to "1". Retransmission shall start with the oldest numbered unacknowledged I frame. I frames shall be retransmitted sequentially. New I frames may be transmitted if they become available. Such retransmission of I frames as a result of an exchange of P/F bits set to "1" is known as checkpoint retransmission.

When using the multi-selective reject procedure, any I frames that were retransmitted subsequent to the transmission of the last frame with the P/F bit, respectively, set to "1", shall not be retransmitted. For a combined station, if any frames are retransmitted, then a poll shall be sent, either by transmitting an RR command (or RNR command if the station is in the busy condition) with the P bit set to "1" or by setting the P bit to "1" in the last retransmitted I frame.

Checkpoint retransmission shall not be initiated under the following conditions:

a) In the case of a secondary/primary station, if a REJ frame with the P/F bit set to "0" has been received and actioned, checkpoint retransmission shall be inhibited on the next P/F frame received, if it would cause retransmission of the same particular I frame; i.e., same N(R) in same numbering cycle.

b) In the case of a combined station, if a REJ command with the P bit set to "0" or "1", or a REJ response with the F bit set to "0", has been received and actioned while a P bit set to "1" was unanswered, checkpoint retransmission shall be inhibited on the next frame received with the F bit set to "1", if it would cause retransmission of the same particular I frame; i.e., same N(R) in same numbering cycle.

c) In the case of a secondary/primary station, if the multi-selective reject procedure is not used and if one or more SREJ frames with the P/F bit set to "0" have been received and actioned, checkpoint retransmission shall be inhibited on the next frame received with the P/F bit set to "1" when this frame is a SREJ frame and contains the same N(R) as the oldest unresolved SREJ frame, if it would cause retransmission of the same particular I frame; i.e., same N(R) in same numbering cycle.

d) In the case of a combined station, if the multi-selective reject procedure is not used and if a SREJ command with the P bit set to "0" or "1", or one or more SREJ responses with the F bits set to "0", have been received and actioned, checkpoint retransmission shall be inhibited on the next frame received with the F bit set to "1" when this frame is a SREJ frame and contains the same N(R) as the oldest unresolved SREJ frame, if it would cause retransmission of the same particular I frame; i.e., same N(R) in same numbering cycle.

e) If a P/F bit set to "1" is received in an unnumbered format frame, checkpoint retransmission shall be inhibited.

f) If, after sending a frame with the P/F bit set to "1", a data station receives an acknowledgement to that frame before receiving the corresponding frame with the F/P bit set to "1", checkpoint retransmission on the frame with the F/P bit set to "1" shall be inhibited.

g) If a SREJ frame with the P/F bit set to "1" is received, the SREJ recovery retransmission shall be used and not checkpoint retransmission.

h) In the case of a combined station, if any frame with the P bit set to "1" is received, checkpoint retransmission shall be inhibited.

i) In the case of a primary/secondary station, when the multi-selective reject procedure is used, checkpoint retransmission on receipt of an RR frame with the P/F bit set to "1" shall be inhibited if any new I frames were transmitted subsequent to the last frame with the P/F bit set to "1". In the case of a combined station, when the multi-selective reject procedure is used, checkpoint retransmission on receipt of an RR frame with the F bit set to "1" shall be inhibited if any new I frames were transmitted subsequent to the last frame with the P bit set to "1".

5.6.2.2 REJ recovery

The REJ command/response shall be used primarily to initiate an exception recovery (retransmission), following the detection of a sequence error, earlier than is possible by checkpoint (P/F bit) recovery; for example, in two-way simultaneous information transfer, if a REJ frame is immediately transmitted upon detection of a sequence error, then there is no requirement to wait for a frame with the P/F bit set to "1".

With respect to each direction of transmission on the data link, only one "sent REJ" exception condition from a given data station to another given data station shall be established at a time. A "sent REJ" exception condition shall be cleared when the requested I frame is received or when the response/command time-out function runs out. When the data station perceives by time-out that the requested I frame has not been received, because either the requested I frame or the REJ frame was in error or lost, the REJ frame may be repeated.

A data station receiving a REJ frame shall initiate sequential transmission (or retransmission) of I frames starting with the I frame indicated by the N(R) contained in the REJ frame. New I frames may be transmitted subsequently if they become available.

If

a) retransmission beginning with a particular frame occurs due to checkpointing (see 5.4.3.2.1, 5.4.3.2.2, 5.4.3.2.3, 5.4.3.2.4 and 5.6.2.1), and

b) a REJ frame is received which would also start retransmission with the same particular I frame [as identified by the N(R) in the REJ frame],

the retransmission resulting from the REJ frame shall be inhibited.

5.6.2.3 SREJ recovery

The SREJ command/response shall be used primarily to initiate more efficient error recovery by requesting the retransmission of one or more (not necessarily contiguous) I frame(s) following the detection of sequence errors rather than the retransmission of the earliest frame in need of retransmission plus all additional I frames which may have been transmitted subsequently.

5.6.2.3.1 Single SREJ recovery

Single SREJ recovery shall be used to request the retransmission of a single I frame following the detection of a sequence error.

When an I frame sequence error is detected, and it is determined that SREJ recovery is to be employed, the SREJ frame shall be transmitted at the earliest possible time. When a primary/secondary station sends one or more SREJ frames, each with the P/F bit set to "0", and these "sent SREJ" exception conditions are not cleared when the primary/secondary station is ready to issue the next frame with the P/F bit set to "1", the primary/secondary station shall send a SREJ frame with the P/F bit set to "1" with the same N(R) as the oldest unresolved SREJ frame. When a combined station sends one or more SREJ commands, each with the P bit set to "0", or one or more SREJ responses, each the F bit set to "0", or a SREJ command with the P bit set to "1", and these "sent SREJ" exception conditions are not cleared when the combined station is ready to issue the next response frame with the F bit set to "1", the combined station shall send a SREJ response with the F bit set to "1" with the same N(R) as the oldest unresolved SREJ frame.

In a primary/secondary station, since an I or S format frame sent with the P/F bit set to "1" has the potential of causing checkpoint retransmission, a primary/secondary station shall not send SREJ frames until it receives at least one in-sequence I frame or it perceives by time-out that the checkpoint retransmission will not be initiated by the remote station. In a combined station, since an I or S format frame sent with the F bit set to "1" has the potential of causing checkpoint retransmission, a combined station shall not send SREJ frames until it receives at least one in-sequence I frame or it perceives by time-out that the checkpoint retransmission will not be initiated by the remote station.

With respect to each direction of transmission on the data link, one or more "sent SREJ" exception conditions from a given data station to another given data station may be established at a time. A "sent SREJ" exception condition shall be cleared when the requested I frames have all been received.

When a data station perceives by time-out that the requested I frame will not be received, because either the requested I frame or the SREJ frame was in error or lost, the SREJ frame may be repeated.

A data station receiving one or more SREJ frames shall, when appropriate, initiate retransmission of the individual I frames indicated by the N(R) values contained in each SREJ frame. After having retransmitted these I frames, new I frames may be transmitted subsequently if they become available.

When a primary/secondary station receives and actions one or more SREJ frames, each with the F bit (primary station) or P bit (secondary station) set to "0", it shall disable actioning of the next SREJ frame received if that frame has the F bit (primary station) or P bit (secondary station) set to "1" and has the same N(R), (i.e., same value and same numbering cycle) as the previously actioned SREJ frame, and if the resultant retransmission was made following the retransmission of the P bit (primary station) or the F bit (secondary station). When a combined station receives and actions one or more SREJ commands, each with the P bit set to "0", or a SREJ command with the P bit set to "1", or one or more SREJ responses, each with the F bit set to "0", it shall disable actioning of the next SREJ response frame received if that SREJ frame has the F bit set to "1" and has the same N(R) (i.e., same value and same numbering cycle) as a previously actioned SREJ frame, and if the resultant retransmission was made following the retransmission of the P bit set to "1".

When the SREJ mechanism is used, the receiving station shall retain correctly received I frames and deliver them to the higher layer in sequence number order.

5.6.2.3.2 Multiple SREJ recovery

Multiple SREJ reject recovery shall be used when the multi-selective reject procedure is used to request the retransmission of one or more (not necessarily contiguous) I frame(s) following the detection of a sequence error.

When a primary/secondary or combined station receives an out-of-sequence I frame, the I frame shall be held for later delivery. The I frame shall be delivered to the upper layer only when all I frames numbered below N(S) are correctly received. If frame number N(S)-1 has not been received previously, then an SREJ frame with the P/F bit set to "0" shall be transmitted, at the earliest possible time, that contains the sequence numbers of the list of consecutive missing I frames ending at N(S)-1; the N(R) field in the control field shall be set to the first sequence number in the list; the information field shall contain the rest of the sequence numbers. If the list of sequence numbers is too large to fit in the information field of the SREJ frame, then the list shall be truncated by including only the earliest sequence numbers. The primary/secondary or combined station on receiving an SREJ frame with the P/F bit set to 0 shall retransmit all requested I frames. After having retransmitted these I frames, the primary/secondary or combined station may transmit new I frames, if they become available.

When a primary/secondary station is ready to issue the next frame with the P/F bit to "1" and if there are out-of-sequence I frames saved in the receive buffer, the primary/secondary station shall send a SREJ frame with the P/F bit set to "1" with N(R) equal to the oldest unacknowledged I frame and the information field containing the sequence numbers of the rest of the missing I frames. When a combined station is ready to issue the next response frame with the F bit to "1" and if there are out-of-sequence I frames saved in the receive buffer, the combined station shall send a SREJ response with the F bit set to "1" with N(R) equal to the oldest unacknowledged I frame and the information field containing the sequence numbers of the rest of the missing I frames. If the list of sequence numbers is too large to fit in the information field of the SREJ frame, then the list shall be truncated by including only the earliest sequence numbers. When a primary/secondary station receives an SREJ frame with the P/F bit set to "1", the primary/secondary station shall retransmit all requested I frames, except those that were transmitted subsequent to the last frame with the P/F bit set to "1". When a combined station receives an SREJ frame with the F bit set to "1", the combined station shall retransmit all requested I frames, except those that were transmitted subsequent to the last frame with the P bit set to "1". After having retransmitted these I frames, the primary/secondary or combined station may transmit new I frames, if they become available.

Annex B includes examples of the possible use of the multi-selective reject procedure and implementation guidelines.

5.6.2.4 Time-out recovery

In the event that the remote data station, as a result of a transmission error, does not receive (or receives and discards) a transmission consisting of a single I frame or the last I frame(s) in a sequence of I frames, it will not detect an out-of-sequence exception condition and therefore will not transmit a SREJ/REJ frame. The data station which transmitted the unacknowledged I frame(s) shall, following the completion of a system defined time-out period, take appropriate recovery action to determine the point at which retransmission shall begin.

A primary/combined station should inquire status with a supervisory frame. When

a) a secondary station has a respond opportunity, and

b) an optional time-out or equivalent function for unacknowledged I frames has run out, and

c) no new I frames are available,

then the secondary station should transmit only the last I frame and should wait until status is received from the primary station.

If the multi-selective reject procedure is used, then status inquiry should be done using a supervisory frame. For a primary/secondary station, I frame retransmissions shall be done only after a frame with the P/F bit set to "1" or an SREJ frame with the P/F bit set to "0" is received. For a combined station, I frame retransmissions shall be done only after a response with the F bit set to "1" or an SREJ response with the F bit set to "0" is received.

NOTE 1 If a data station retransmits one of the unacknowledged I frames (not the last I frame) after a time-out, the data station should keep record of the highest value of V(S) that had been sent so as to be able to identify an N(R) received as acknowledging or not acknowledging some or all of the I frames previously transmitted.

NOTE 2 If a data station does retransmit all unacknowledged I frames after a time-out, it should be prepared to receive a following REJ or SREJ frame with an N(R) greater than the send state variable at the data station which retransmits.

NOTE 3 When, as a result of a time-out, a secondary/combined station decides to retransmit a response frame, the retransmitted response frame should have the F bit set to "0" unless an unanswered P bit set to “1" has been received since the earlier transmission of the response frame.

NOTE 4 NOTE Care should be taken if a higher layer attempts to change an information field which is being retransmitted as part of time-out recovery, because the new information field is discarded if the receiving data station had correctly received an I frame with the same N(S).

NOTE 5 To account for possible retransmissions after time-out, a receiving data station should not set a SREJ exception condition when it receives an I frame with an N(S) one less than its receive state variable.

5.6.3 FCS or HCS error

Any frame received with a FCS or HCS error shall not be accepted by the receiver and shall be discarded. At a secondary/combined station, no action shall be taken as the result of that frame. At a primary/combined station, if the frame with the FCS or HCS error was a response frame with the F bit set to "1", a resulting time-out function shall occur in the primary/combined station prior to initiating recovery action.

5.6.4 Command/response frame rejection

A command/response rejection exception condition shall be established upon the receipt of an error-free frame which contains an undefined or not implemented command/response in the control field, an invalid frame format, an invalid N(R) or an information field which exceeds the maximum information field length which can be accommodated by the receiving data station.

At a primary station, this exception condition shall be subject to recovery/resolution at a higher layer. In the case of an invalid N(R), recovery shall include, at least, the issuance of a mode setting command.

At a secondary station, this exception condition shall be reported by a FRMR response for appropriate primary station action. Once a secondary station has established a FRMR exception condition, no additional I frames shall be accepted, except for examination of the state of the P bit and the value of the N(R) field, until the condition is cleared by the primary station issuing a mode setting command. The FRMR response shall be repeated at each respond opportunity until recovery is effected by the primary station.

At a combined station, this exception condition shall be dealt with in either of two ways:

a) The combined station may follow a course of action similar to that described for a primary station, where the exception condition is resolved as a higher layer function. The combined station shall issue a mode setting command or a RSET command, as appropriate, as a part of this recovery action.

b) The combined station may follow a course of action similar to that described for a secondary station and request that the other combined station resolve the exception condition and effect the required recovery.

   In the case of exception conditions that are not related to the I frame transmission from the reporting data station, the transmission of I frames may continue, with received I frames being examined only for the state of the P and F bits and the value of the N(R) field until the exception condition is cleared by the other combined station issuing a mode setting command or a RSET command, as appropriate. If recovery is not effected by the other combined station within a specified time-out interval, the reporting combined station may repeat the FRMR frame, or it may choose to assume control of the recovery function as described in a). If the other combined station that receives the FRMR frame is unable to effect an appropriate recovery action, it shall reply with a FRMR frame of its own, rejecting the received FRMR frame. The combined station that sent the original FRMR frame shall then initiate an appropriate recovery function as described in a).

5.6.5 Contention situations

Contention may occur in ARM (ABM) during a mode setting action in either TWA or TWS communications, or following an extended period of inactivity (idle data link channel state) in a TWA configuration. In the TWA case, the primary/one combined station and secondary/other combined station are contending for the use of the logical communication path for mode setting or data interchange purposes. In the TWS case, the primary/one combined station and secondary/other combined station are contending with regard to initiating a mode setting function.

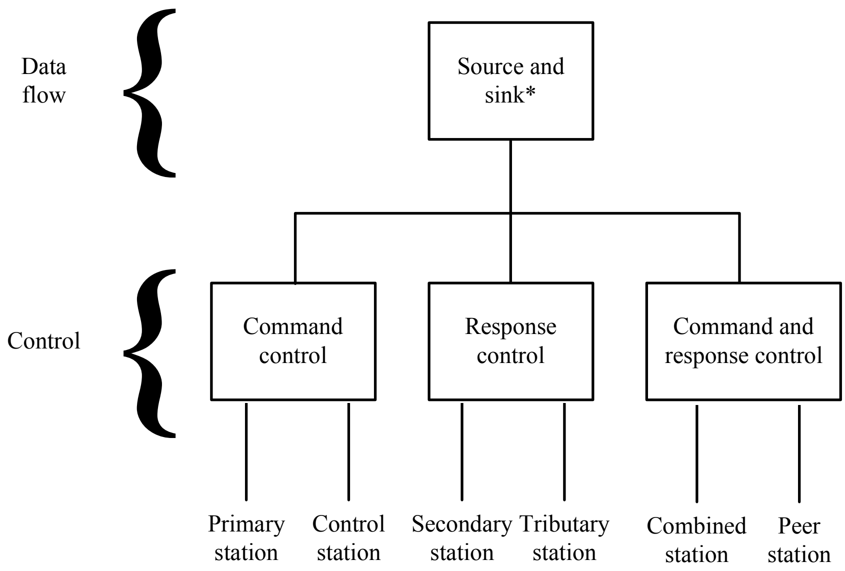
In all of the above cases, the contention situation shall be resolved through the use of different value time-out functions in each data station. The time-out function employed by secondary/one combined station shall be greater than that employed by the primary/other combined station so as to permit such contention situations to be resolved in favour of the primary/specified combined station.

6 HDLC classes of procedures

Five basic classes of procedures are defined in HDLC: two unbalanced classes of procedures, a balanced class of procedures, and two connectionless classes of procedures. (See 6.6.)

6.1 Types of data station

The types of data station that are defined in this International Standard utilize the building blocks illustrated in figure 19.



* For send-only I frame stations or receive-only I frame stations, remove source or sink capability, as appropriate.

Figure 19 — HDLC stations — Building blocks

Two types of data station are defined for the unbalanced classes of procedures (see figure 19):

a) primary station, which sends commands, receives responses and is ultimately responsible for data link layer error recovery;

b) secondary stations, which receive commands, send responses and may initiate data link layer error recovery.

One type of data station is defined for the balanced class of procedures (see figure 19), i.e., combined stations, which send both commands and responses, receive both commands and responses, and are responsible for data link layer error recovery.

Three types of data stations are defined for the connectionless classes of procedures (see figure 19):

a) control station in unbalanced connectionless class of procedure, which sends commands, receives responses, but does not support any form of data link layer connection establishment/termination, flow control, acknowledgement, or error recovery;

b) tributary stations in unbalanced connectionless class of procedure, which receives commands, sends responses, but does not support any form of data link layer connection establishment/termination, flow control, acknowledgement, or error recovery;

c) peer stations in balanced connectionless class of procedures, which send both commands and responses, receive both commands and responses, but are not responsible for any form of data link layer connection establishment/termination, flow control, acknowledgement, or error recovery.

NOTE - The above terms are introduced in order to avoid having to use compound terms such as "connectionless secondary station", etc., throughout the subclauses that deal with connectionless classes of procedures.

6.2 Configurations

For the two unbalanced classes of procedures, a single primary station plus one or more secondary station(s) shall be connected together over various types of transmission facilities to build point-to-point or multipoint, half-duplex or duplex, switched or non-switched configurations.

For the balanced class of procedures, two combined stations shall be connected together over various types of transmission facilities to build point-to-point, half-duplex or duplex, switched or non-switched configurations.

For the unbalanced connectionless class of procedures, a single control station plus one or more tributary station(s) shall be connected together over various types of transmission facilities to build point-to-point or multipoint, half-duplex or duplex, switched or non-switched configurations.

For the balanced connectionless class of procedures, two peer stations shall be connected together over various types of transmission facilities to build point-to-point, half-duplex or duplex, switched or non-switched configurations.

6.3 Operational modes

In an unbalanced class, any coupling of a primary station with secondary station(s) shall be operated in either the normal response mode (NRM) or the asynchronous response mode (ARM), two-way alternate or two-way simultaneous, in accordance with the capability of the configuration being employed. In the balanced class, two combined stations shall be operated in the asynchronous balanced mode (ABM), two-way alternate or two-way simultaneous, in accordance with the capability of the configuration being employed.

In the unbalanced connectionless class, any coupling of a control station with tributary station(s) shall be operated in the unbalanced connectionless mode (UCM), two-way alternate or two-way simultaneous, in accordance with the capability of the configuration being employed.

In the balanced connectionless class, two peer stations shall be operated in the balanced connectionless mode (BCM), two-way alternate or two-way simultaneous, in accordance with the capability of the configuration being employed.

6.4 Addressing scheme

In all classes (unbalanced, balanced, and connectionless), commands shall always be sent containing a destination data station address, and responses shall always be sent containing the assigned transmitting data station address.

The "all-station" address or a "group" address may be used to transmit a command frame simultaneously to all the secondary stations on a multipoint configuration or to the defined group of secondary stations. The addressing convention is specified in 4.7. The mechanism to avoid overlapping responses to multiple station addressing is system dependent and is not specified in this International Standard.

6.5 Send and receive state variables

For each primary-to-secondary or combined-to-combined pairing, a separate pair of send and receive state variables shall be used for each direction of transmission of information (I) frames. Upon receipt and acceptance of a mode setting command, both the send and receive state variables of the receiving station shall be set to zero. Upon receipt and acceptance of an acknowledgement response to a mode setting command, both the send and receive state variables of the originating station shall be set to zero.

For each control-to-tributary or peer-to-peer pairing, there are no send and receive state variables used for each direction of transmission of data.

6.6 Fundamental classes of procedures

6.6.1 Designations

Five fundamental classes of procedures are defined. They are designated:

UNC - Unbalanced operation Normal response mode Class;

UAC - Unbalanced operation Asynchronous response mode Class;

BAC - Balanced operation Asynchronous balanced mode Class;

UCC - Unbalanced operation Connectionless mode Class; and

BCC - Balanced operation Connectionless mode Class.

In these designations

— the first letter, U or B, indicates unbalanced or balanced operation;

— the second letter, A, N, or C, indicates asynchronous, normal, or connectionless response mode; and

— the third letter, C, stands for class.

6.6.2 Basic repertoires

The following basic repertoires utilize single octet addressing, unextended control field format, a 16-bit FCS, and synchronous transmission.

6.6.2.1 UNC

The basic repertoire of commands and responses for UNC shall be as follows:

Commands	Responses
I	I
RR	RR
RNR	RNR
SNRM	UA
DISC	DM
	FRMR

6.6.2.2 UAC

The basic repertoire of commands and responses for UAC shall be as follows:

Commands	Responses
I	I
RR	RR
RNR	RNR
SARM	UA
DISC	DM
	FRMR

6.6.2.3 BAC

The basic repertoire of commands and responses for BAC shall be as follows:

Commands	Responses
I	I
RR	RR
RNR	RNR
SABM	UA
DISC	DM
	FRMR

6.6.2.4 UCC

The basic repertoire of commands and responses for UCC shall be as follows:

Commands	Responses
UI	UI

6.6.2.5 BCC

The basic repertoire of commands and responses for BCC shall be as follows:

Commands	Responses
UI	

6.7 Optional functions

Table 13 lists the optional functions that are available to modify the fundamental classes of procedures defined in 6.6. These optional functions involve the additions or deletions of commands and responses to or from the basic repertoires, or the use of alternate address or control field formats or alternate frame checking sequences or alternate form of transmission (see table 13).

6.8 Consistency of classes of procedures

The consistency in the five classes of procedures, obtained through the use of the concepts of modes of operation, basic command/response repertoires, and hierarchical structuring, is illustrated in 6.6.2. This consistency in repertoire facilitates the inclusion of multiple versions of the classes of procedures in a data station that is configurable.

6.9 Conformance to the HDLC classes of procedures

A data station shall be described as conforming to a given class of procedures, with optional functions, if it implements all commands and responses in the basic repertoire for the class of procedures as modified by the selected optional functions, i.e.,

a) a primary station shall have the ability to receive all of the responses in the basic repertoire for the unbalanced class of procedures as modified by the selected optional functions;

b) a secondary station shall have the ability to receive all of the commands in the basic repertoire for the unbalanced class of procedures as modified by the selected optional functions;

c) a combined station shall have the ability to receive all of the commands and responses in the basic repertoire for the balanced class of procedures as modified by the selected optional functions.

d) a control station shall have the ability to receive all of the responses in the basic repertoire for the unbalanced connectionless class of procedures as modified by the selected optional functions;

e) a tributary station shall have the ability to receive all of the commands in the basic repertoire for the unbalanced connectionless class of procedures as modified by the selected optional functions;

f) a peer station shall have the ability to receive all of the commands and responses in the basic repertoire for the balanced connectionless class of procedures as modified by the selected optional functions.

6.10 Method of indicating classes and optional functions

The classes of procedures and the optional functions shall be indicated by specifying the designation of the class (see 6.6.1) plus the number(s) of the accompanying optional functions (see 6.7).

Example 1: Class UNC1,2,6,9 indicates the unbalanced operation normal response mode class of procedures with the optional functions for identification (XID), REJ recovery (REJ), unnumbered polling (UP), and one-way data flow from the secondary station(s) to the primary station.

Example 2: Class UAC1,5,10.1,13 indicates the unbalanced operation asynchronous response mode class of procedures with the optional functions for identification (XID), initialization (SIM, RIM), extended sequence numbering (modulo 128), and request disconnect (RD).

Example 3: Class BAC2,8 indicates the balanced operation asynchronous balanced mode class of procedures with the optional functions for REJ recovery (REJ) and the ability to send I frames as commands only.

Example 4: Class UCC1,12 indicates the unbalanced connectionless operation connectionless-mode class of procedures with the optional functions for identification (XID) and data link test (TEST).

Example 5: Class BCC1,14 indicates the balanced connectionless operation connectionless-mode class of procedures with the optional functions for identification (XID) and 32-bit FCS.

Table 13 — Optional functions

Option	Functional description	Required change	UNC	UAC	BAC	UCC	BCC
1	Provides the ability to exchange identification and/or characteristics of data stations	Add command: XID Add response: XID	X	X	X	X	X
2	Provides the ability for more timely reporting of I frame sequence errors	Add command: REJ Add response: REJ	X	X	X		
3.1	Provides the ability for more efficient recovery from I frame sequence errors by requesting retransmission of a single frame	Add command: SREJ Add response: SREJ	X	X	X		
3.2	Provides the ability for more efficient recovery from I frame sequence errors by requesting retransmission of one or more individual I frames with a single request consisting of individual I-frame indicators only	Add command: SREJ Add response: SREJ Support multi-selective reject procedure using individual I-frame indicators only	X	X	X		
3.3	Provides the ability for more efficient recovery from I frame sequence errors by requesting retransmission of one or more individual I frames with a single request consisting of individual I-frame indicators and span list indicators, as appropriate	Add command: SREJ Add response: SREJ Support multi-selective reject procedure using individual I-frame indicators and span list indicators	X	X	X		
4	Provides the ability to exchange information fields independent of the mode (operational or non-operational) without impacting the I frame sequence numbers	Add command: UI Add response: UI	X	X	X		
5	Provides the ability to initialize a remote data station, and the ability to request initialization	Add command: SIM Add response: RIM	X	X	X	X	X
6	Provides the ability to perform unnumbered group and all-station polling as well as unnumbered individual polling	Add command: UP	X	X	X	X	X
7	Provides for greater than single octet addressing	Use extended addressing format instead of basic addressing format	X	X	X	X	X
8	Limits the procedures to allow I frames to be commands only	Delete response: I	X	X	X		
9	Limits the procedures to allow I frames to be responses only	Delete command: I	X	X	X		
10.1	Provides the ability to use extended sequence numbering (modulo 128)	Use extended control field format instead of basic control field format; use the SXXME command instead of the SXXM command	X	X	X		
10.2	Provides the ability to use extended sequence numbering (modulo 32 768)	Use extended control field format instead of basic control field format; use the SM command instead of the SXXM command	X	X	X		
10.3	Provides the ability to use extended sequence numbering (modulo 2 147 483 648)	Use extended control field format instead of basic control field format; use the SM command instead of the SXXM command	X	X	X		
11	Provides the ability to reset the state variables associated with only one direction of information flow	Add command: RSET			X		
12	Provides the ability to perform a basic data link test	Add command: TEST Add response: TEST	X	X	X	X	X
13	Provides the ability to request logical disconnection	Add response: RD	X	X	X		
14.1	Provides for 32-bit frame checking sequence (FCS)	Use the 32-bit FCS instead of the 16-bit FCS	X	X	X	X	X
14.2	Provides for 8-bit frame checking sequence (FCS)	Use the 8-bit FCS instead of the 16-bit FCS	X	X	X	X	X

Table 13 — Optional functions (*continued*)

Option	Functional description	Required change	UNC	UAC	BAC	UCC	BCC
15.1	Provides for start/stop transmission with basic transparency	Use start/stop transmission with basic transparency instead of synchronous transmission	X	X	X	X	X
15.2	Provides for start/stop transmission with basic transparency and flow-control transparency	Use start/stop transmission with basic transparency and flow-control transparency instead of synchronous transmission	X	X	X	X	X
15.3	Provides for start/stop transmission with basic transparency and control-character octet transparency	Use start/stop transmission with basic transparency and control-character octet transparency instead of synchronous transmission	X	X	X	X	X
16	Provides for operation in a start/stop transmission environment that only permits transfer of seven data bits per character	Use the seven-bit data path transparency function, in conjunction with one of the Option 15 functions	X	X	X		
17	Provides the ability to set up a link	Use the Set Mode command in place of the corresponding frame from the basic repertoire (SXXM) or the associated extended frame (SXXME) to set up the link	X	X	X		
18	Provides the ability to have an optional information field in the UA and DM response frames and the DISC command frame	Use the UA and DM responses and the DISC command with an optional information field	X	X	X		
19	Provides the ability to have an optional information field in different mode setting commands from the basic repertoire (i.e., SABM, SARM, SNRM) or the alternative frame per optional function 10.1 (i.e., SABME, SARME and SNRME)	Use the corresponding mode setting command with an optional information field	X	X	X		
20	Provides the ability to exchange information fields that are not fully protected by a check sequence, independent of the mode (operational or non operational) without impacting the I frame sequence numbers	Add command: UIH Add response: UIH	X	X	X	X	X
21	Provides the ability to have more than one address field in a consecutive manner following the opening flag	Use more than one address field after the opening flag and before the control field.	X	X	X	X	X
22	Provides the frame format field immediately following the opening flag sequence and before any address fields	Include the frame format field after the opening frame sequence	X	X	X	X	X
23	Use of segmentation	The segmentation subfield is present in the frame format field	X	X	X	X	X
24	Inhibits bit or octet insertion as a transparency mechanism	Do not perform bit or octet insertion	X	X	X	X	X
25	Start/stop mode intra-frame timeout	Set the timer upon receipt of a stop bit and disable upon receipt of a start bit or upon the timer running out	X	X	X	X	X
26	Provides a check sequence over the header	A HCS is inserted after the control field	X	X	X	X	X

6.11 Unbalanced operation (point-to-point and multipoint)

6.11.1 General

The following requirements apply to the procedure for unbalanced operation of synchronous or start/stop data transmission over point-to-point or multipoint data links with two-way alternate or two-way simultaneous data transfer. The procedure uses the HDLC frame structure defined in clause 4 and the HDLC elements of procedures described in clause 5. It uses the basic command/response repertoire designated UNC or UAC (see 6.6.2.1 or 6.6.2.2, respectively). Although only the basic commands and responses are described, there are several optional functions available for enhanced operation. These are listed in 6.7 and shown in table 13.

NOTE — The HDLC unbalanced classes of procedures operate as illustrated in the examples given in Annex B.

6.11.2 Description of the data link

6.11.2.1 Configuration (see figure D, Introduction)

The unbalanced operation data link configuration shall consist of one primary station and one or more secondary stations interconnected by physical layer transmission facilities.

6.11.2.2 Physical layer transmission facilities

The physical layer transmission facilities may provide either half-duplex or duplex transmission over switched or non-switched data circuits.

NOTE — In the case of a switched data circuit, the procedures described assume that the switched data circuit has been established.

The data link layer shall not initiate data transmission until an indication of circuit availability is provided by the physical layer. (In some systems providing two-way alternate data exchange on physical layer data circuits using half-duplex transmission, this indication of physical layer circuit availability is indicated by an idle data link channel state.)

6.11.3 Description of the procedures

6.11.3.1 General

Unbalanced control procedures shall operate on a data link with one primary station and one or more secondary station(s) in either normal or asynchronous response mode. Only one secondary station at a time shall be put in asynchronous response mode. The primary station shall be ultimately responsible for overall data link error recovery.

Each data station shall check for the correct receipt of the I frames it has sent to the remote data station by checking the N(R) of each received I frame and supervisory frame.

6.11.3.2 Data station characteristics

The primary station shall be responsible for:

a) setting up the data link and disconnecting the data link;

b) sending information transfer, supervisory and unnumbered commands; and

c) checking received responses.

Each secondary station shall be responsible for:

a) checking received commands; and

b) sending information transfer, supervisory and unnumbered responses as required by the received commands.

6.11.4 Detailed definition of the procedures

The procedures for a permanently connected data link or an established switched connection are defined in 6.11.4.1 to 6.11.4.6.

The protocol for establishing and disconnecting a switched data circuit is not within the scope of this International Standard. However, the ability to exchange identification and/or characteristics after the switched connection is established is available as an optional function.

6.11.4.1 Setting up and disconnecting the data link

6.11.4.1.1 Setting up the data link

The primary station shall initialize the data link with a secondary station by sending a SNRM (or SARM) command and shall start a response time-out function (or equivalent). The addressed secondary station, upon receiving the SNRM (or SARM) command correctly, shall send the UA response at its first opportunity and shall set its send and receive state variables to zero. If the UA response is received correctly, the data link set up to the addressed secondary station is complete, and the primary station shall set its send and receive state variables relative to that secondary station to zero and shall stop the response time-out function (or equivalent). If, upon receipt of the SNRM (or SARM) command, the secondary station determines that it cannot enter the indicated mode, it shall send the DM response. If the DM response is received correctly, the primary station shall stop the response time-out function (or equivalent).

If the SNRM (or SARM) command, UA response or DM response is not received correctly, it shall be ignored. The result will be that the primary station's response time-out function (or equivalent) will run out, and the primary station may resend the SNRM (or SARM) command and restart the response time-out function (or equivalent) (see 6.11.4.3).

This action may continue until a UA response has been received correctly or until recovery action takes place at a higher layer.

6.11.4.1.2 Disconnecting the data link

The primary station shall disconnect the data link(s) with secondary station(s) by sending a DISC command and shall start a response time-out function (or equivalent). The addressed secondary station(s), upon receiving the DISC command correctly, shall send a UA response at its first opportunity and shall enter the normal disconnect mode (NDM), or the asynchronous disconnected mode (ADM), as predefined for that secondary station. If, upon receipt of the DISC command, the addressed secondary station is already in the disconnected mode, it shall send the DM response. The primary station, upon receiving a UA or DM response to a sent DISC command, shall stop the response time-out function (or equivalent).

When it is a multipoint configuration, the UA response from secondary stations shall not interfere with one another. The mechanism used to avoid overlapping responses to the disconnect (DISC) command using a group address or the all-station address is system-defined.

If the DISC command, UA response or DM response is not received correctly, it shall be ignored by the receiving station. This will result in the expiry of the primary station's response time-out function (or equivalent), and the primary station may resend the DISC command and restart the response time-out function (or equivalent) (see 6.11.4.3).

This action may continue until either the UA response or a DM response has been received correctly or until recovery action takes place at a higher layer.

6.11.4.1.3 Procedure in a disconnected mode

A secondary station in NDM (or ADM) shall monitor commands, shall react, at the earliest respond opportunity, to a SNRM (or SARM) command as outlined in 6.11.4.1.1, and shall respond with a DM response to a received DISC command. The secondary station shall respond to other commands received with the P bit set to "1" with a disconnected mode (DM) response with the F bit set to "1". Other commands received with the P bit set to "0" shall be ignored. The DM response shall be used to report the secondary station status asynchronously in ADM.

6.11.4.2 Exchange of information (I) frames

6.11.4.2.1 Sending I frames

The control field format shall be as defined in 5.5.1 for an I frame with N(S) set to the value of the send state variable V(S) and with N(R) set to the value of the receive state variable V(R). Following data link set-up, both V(S) and V(R) shall be set to zero. The maximum length of the information field in I frames shall be a system-defined parameter.

If the data station is ready to send an I frame numbered N(S), where N(S) is equal to the last received acknowledgement plus the modulo - 1, the data station shall not send the I frame but shall follow the procedures described in 6.11.4.3.

6.11.4.2.2 Receiving I frames

After a data station receives correctly an in-sequence I frame [i.e., N(S) equals the value of the receive state variable V(R)] that it can accept, it shall increment its receive state variable V(R), and, at its next opportunity to send, take one of the following actions:

a) If information is available for transmission and the remote data station is ready to receive, it shall act as described in 6.11.4.2.1 and acknowledge the received I frame(s) by setting N(R) in the control field of the next transmitted I frame to the value of V(R).

b) If information is not available for transmission but the data station is ready to receive I frames, the data station shall send an RR frame and acknowledge the received I frame(s) by setting N(R) to the value of V(R).

c) If the data station is not ready to receive further I frames, the data station may send an RNR frame and acknowledge the received I frame(s) by setting the N(R) to the value of V(R).

If the data station is unable to accept the correctly received I frame(s), V(R) shall not be incremented. The data station may send an RNR frame with the N(R) set to the value of V(R).

6.11.4.2.3 Reception of incorrect frames

If a frame is received with an incorrect FCS, it shall be discarded.

If an I frame is received with a correct FCS but with an incorrect N(S), the receiving data station shall ignore the N(S) field and discard the information field in that frame. This shall continue until the expected I frame is received correctly. The data station shall, however, use the P/F and N(R) indications in the discarded I frames. The data station shall then acknowledge the expected I frame, when received correctly, as described in 6.11.4.2.2.

NOTE — Ignoring the N(S) field and discarding the information field of an I frame applies to the basic repertoire. When using any variant of optional function 3 for individual frame retransmission, the N(S) field is not ignored and the information field is retained.

The P/F recovery (checkpointing) shall cause retransmission of the I frames received incorrectly, as described in 5.4.3.2.

6.11.4.2.4 Data station receiving acknowledgements

A data station receiving an I, RR or RNR frame with a valid N(R) = *x* shall treat as acknowledged all previously transmitted I frames up to and including the I frame transmitted with N(S) equal to *x - 1*.

6.11.4.3 Time-out considerations

In order to detect a no-reply or lost-reply condition, each primary station shall provide a response time-out function (or equivalent). Also, in ARM, each secondary station shall provide a command time-out function (or equivalent). In each case, the expiry of the time-out function (or equivalent) shall be used to initiate appropriate error recovery procedures. In NRM, a secondary station shall depend on the primary station to initiate time-out recovery.

The duration of time-out functions (or equivalent) shall be system-dependent. To resolve possible contention situations in ARM, the duration of the secondary station's time-out function shall be different from that of the primary station.

6.11.4.4 P/F bit usage

P/F bit usage in the unbalanced classes of procedures, UNC and UAC, shall be as described in 5.4.3.

6.11.4.5 Two-way alternate considerations

In the case of normal respond opportunity, two-way alternate, data link operation

a) transmission from the primary station shall not be allowed until either:

   1) receipt of a frame with the F bit set to "1", or

   2) expiry of a no-response time-out function; and

b) transmission from the secondary station shall not be allowed until receipt of a frame with the P bit set to "1".

NOTE 1 — In multipoint configurations of normal respond opportunity, two-way alternate, data link operation over duplex physical facilities, the primary station may transmit frames with the P bit set to "0" to non-polled secondary stations in the above mentioned period.

In the case of normal respond opportunity, two-way alternate, data link operation, a data station shall not accept further frames after a frame with the P/F bit set to "1" was accepted and before it sends a frame with the F/P bit, respectively, set to "1".

In the case of asynchronous respond opportunity, two-way alternate, data link operation, transmission from a data station shall not be allowed until either

a) detection of an idle data link channel state after receipt of a frame or a flag; or

b) the end of an extended period of inactivity (idle data link channel state).

NOTE 2 — In the case of half-duplex data circuit facilities, appropriate accommodation has to be made to control the direction of data transmission. The direction of transmission is controlled by the data link layer, and may be signalled by the physical layer.

If no frames are transmitted from either data station while in ARM and information is waiting for transmission, it is advisable that the data station transmits at first a supervisory frame only in order to avoid long time recovery action, which would occur in the case of I frame contention.

If a data station has transmitted frames and no further frames are pending for transmission, it shall give the right to transmit to the remote data station.

6.11.4.6 Two-way simultaneous considerations

For each unbalanced class of procedures, two-way simultaneous communication protocols may be used independent of physical data circuit capability (i.e., half-duplex transmission). However, in the case of half-duplex data circuit facilities, appropriate accommodation has to be made to control the direction of data transmission. The direction of transmission is controlled by the data link layer. In addition, in the case of normal respond opportunity, data transmission from the secondary station shall not be allowed until receipt of a frame with the P bit set to "1".

6.12 Balanced operation (point-to-point)

6.12.1 General

The following requirements apply to the procedure for balanced operation of synchronous or start/stop data transmission over point-to-point data links with two-way alternate or two-way simultaneous data transfer. The procedure uses the HDLC frame structure defined in clause 4 and the HDLC elements of procedures described in clause 5. It uses the basic command/response repertoire designated BAC (see 6.6.2.3). Although only the basic commands and responses are described, there are several optional functions available for enhanced operation. These are listed in 6.7 and shown in table 13.

NOTE — The HDLC balanced class of procedures operates as illustrated in the examples given in Annex B.

6.12.2 Description of the data link

6.12.2.1 Configuration (see figure E, Introduction)

The balanced operation data link configuration shall consist of two combined stations interconnected by physical layer transmission facilities.

6.12.2.2 Physical layer transmission facilities

The physical layer transmission facilities may provide either half-duplex or duplex transmission over switched or non-switched data circuits.

NOTE — In the case of a switched data circuit, the procedures described assume that the switched data circuit has been established.

The data link layer shall not initiate data transmission until an indication of circuit availability is provided by the physical layer. (In some systems providing two-way alternate data exchange on physical layer data circuits using half-duplex transmission, this indication of physical layer circuit availability is indicated by an idle data link channel state.)

6.12.3 Description of the procedures

6.12.3.1 General

Balanced control procedures shall operate on a data link where the data station at each end of the data link is a combined station. The procedures shall use the asynchronous balanced mode. Each combined station shall be equally responsible for data link layer error recovery.

Each combined station shall check for the correct receipt of the I frames it has sent to the remote combined station by checking the N(R) of each received I frame or supervisory frame.

6.12.3.2 Combined station characteristics

Each station shall be a combined station, i.e., it shall be able to set up the data link, disconnect the data link, and both send and receive commands and responses.

6.12.4 Detailed definition of the procedures

The procedures for a point-to-point data link using a permanently connected or an established switched connection are defined in 6.12.4.1 to 6.12.4.6.

The protocol for establishing and disconnecting a switched data circuit is not within the scope of this International Standard. However, the ability to exchange identification and/or characteristics after the switched connection is established is available as an optional function.

6.12.4.1 Setting up and disconnecting the data link

6.12.4.1.1 Setting up the data link

Either combined station may take the initiative to initialize the data link. It shall send the SABM command and start a response time-out function (or equivalent). The other combined station, upon receiving the SABM command correctly, shall send a UA response and reset both its send and receive state variables to zero. If the UA response is received correctly, the data link set-up shall be complete, and the initiating combined station shall set both its state variables to zero, stop the response time-out function (or equivalent), and enter the indicated mode. If, upon receipt of the SABM command, a combined station determines that it can not enter the indicated mode, it shall send the DM response. If the DM response is received correctly, the initiating combined station shall stop the response time-out function (or equivalent).

If an SABM command, UA response or DM response is not received correctly, it shall be ignored. The result will be that the response time-out function (or equivalent) will run out in the combined station which originally sent the SABM command and that combined station may resend the SABM command and restart the response time-out function (or equivalent) (see 6.12.4.3).

This action may continue until a UA response has been received correctly or until recovery action takes place at a higher layer.

6.12.4.1.2 Disconnecting the data link

Either combined station may take the initiative to disconnect the data link. It shall send the DISC command and start a response time-out function (or equivalent). The other combined station, in an operational mode, upon receiving the DISC command correctly, shall send a UA response and enter the asynchronous disconnected mode (ADM). If, upon receipt of the DISC command, the other combined station is already in the disconnected mode, it shall send the DM response. The initiating combined station, on receiving a UA or DM response to a sent DISC command, shall stop its response time-out function (or equivalent).

If a DISC command, UA response or DM response is not received correctly, it shall be ignored. The result will be that the response time-out function (or equivalent) will run out in the combined station which originally sent the DISC command unless a separate mode setting command is received, in which case the response time-out function (or equivalent) may be stopped. This combined station may resend the DISC command and restart its response time-out function (or equivalent).

This action may continue until a UA or DM response has been received correctly, a DISC command has been received correctly, or until recovery action takes place at a higher layer.

6.12.4.1.3 Procedure in a disconnected mode

A combined station in ADM shall monitor received commands, shall react to a SABM command as outlined in 6.12.4.1.1, and shall respond with a DM response to a received DISC command. It shall respond to other commands received with the P bit set to "1" with a disconnected mode (DM) response with the F bit set to "1". Other commands received with the P bit set to "0" shall be ignored. The DM response shall be used to report the combined station status asynchronously in ADM.

6.12.4.1.4 Simultaneous attempts to set mode (contention)

When a combined station issues a mode setting command and, before receiving an appropriate response, receives a mode setting command from the remote combined station, a contention situation has developed. Contention situations shall be resolved in the following manner.

When the sent and received mode setting commands are the same, each combined station shall send a UA response at the earliest respond opportunity. Each combined station shall either enter the indicated mode immediately or defer entering the indicated mode until receiving a UA response. In the latter case, if the UA response is not received, the combined station may enter the mode when the response time-out function (or equivalent) expires, or the combined station may reissue the mode setting command.

When the mode setting commands are different, each combined station shall enter ADM and issue a DM response at the earliest respond opportunity. In the case of a DISC command contention with a different mode setting command, no further action is required. In the case of contention between a SABM and a SABME or SM command, the combined station sending the SABME or SM command shall have priority over the combined station sending the SABM command in re-attempting data link establishment.

6.12.4.2 Exchange of information (I) frames

6.12.4.2.1 Sending I frames

The control field format shall be as defined in 5.5.1 for an I frame, with N(S) set to the value of the send state variable V(S) and with N(R) set to the value of the receive state variable V(R). Following data link set-up, both V(S) and V(R) shall be set to zero. The maximum length of the information field in I frames shall be a system-defined parameter.

If the combined station is ready to send an I frame numbered N(S), where N(S) is equal to the last received acknowledgement plus the modulo - 1, the combined station shall not send the I frame but shall follow the procedures described in 6.12.4.3.

The decision whether to send an I frame as a command or as a response, i.e., to use the remote or the local address to indicate a P or an F bit, respectively, shall depend on the need to acknowledge a received P bit set to "1" by transmitting a response with the F bit set to "1".

6.12.4.2.2 Receiving I frames

After a combined station receives correctly an in-sequence I frame [i.e., N(S) equals the value of the receive state variable V(R)] that it can accept, the combined station shall increment its receive state variable V(R), and, at its next opportunity to send, take one of the following actions:

a) if information is available for transmission and the remote combined station is ready to receive, it shall act as described in 6.12.4.2.1 and acknowledge the received I frame(s) by setting N(R) in the control field of the next transmitted I frame to the value of V(R);

b) if information is not available for transmission, but the combined station is ready to receive I frames, the combined station shall send an RR frame and acknowledge the received I frame(s) by setting N(R) to the value of V(R); or

c) if the combined station is not ready to receive further I frames, the combined station may send an RNR frame and acknowledge the received I frame(s) by setting the N(R) to the value of V(R).

If the combined station is unable to accept the correctly received I frame(s), V(R) shall not be incremented. The combined station may send an RNR frame with the N(R) set to the value of V(R).

The I or supervisory frame transmitted will be either a command or a response depending on whether a P bit set to "1" or an F bit set to "1" transmission, respectively, is required. If the transmission of a P bit or F bit set to "1" is not required, the acknowledgement frames may be either commands or responses.

6.12.4.2.3 Reception of incorrect frames

If a frame is received with an incorrect FCS, it shall be discarded.

If an I frame is received with a correct FCS but with an incorrect N(S), the receiving combined station shall ignore the N(S) field and discard the information field in that frame. This shall continue until the expected I frame is received correctly. The combined station shall, however, use the P/F and N(R) indications in the discarded I frames. The combined station shall then acknowledge the expected I frame, when received correctly, as described in 6.12.4.2.2.

NOTE — Ignoring the N(S) field and discarding the information field of an I frame applies to the basic repertoire. When using any variant of optional function 3 for individual frame retransmission, the N(S) field is not ignored and the information field is retained.

The P/F recovery (checkpointing) shall cause the retransmission of the I frames received incorrectly, as described in 5.4.3.2.

6.12.4.2.4 Combined station receiving acknowledgements

A combined station receiving an I, RR, or RNR frame with a valid N(R) = x shall treat as acknowledged all previously transmitted I frames up to and including the I frame transmitted with N(S) equal to x - 1.

6.12.4.3 Time-out considerations

In order to detect a no-reply or lost-reply condition, each combined station shall provide a response time-out function (or equivalent). The expiry of the time-out function (or equivalent) shall be used to initiate appropriate error recovery procedures.

The duration of time-out functions (or equivalent) shall be system-dependent. The duration of the time-out function (or equivalent) in the two combined stations shall be unequal in order to resolve contention situations, especially in two-way alternate operation.

The time-out function (or equivalent) shall be started whenever the combined station has transmitted a frame for which a reply is required. When the expected reply is received, the time-out function (or equivalent) shall be stopped. If, during the interval that the time-out function (or equivalent) is running, other frames are sent for which acknowledgements are required, the time-out function (or equivalent) may have to be restarted.

If the response time-out function (or equivalent) runs out, a command with the P bit set to "1" may be (re)transmitted, and the response time-out function (or equivalent) restarted.

6.12.4.4 P/F bit usage

P/F bit usage in the balanced class of procedure, BAC, shall be as described in 5.4.3.

6.12.4.5 Two-way alternate considerations

In two-way alternate, data link operation, transmission from a combined station shall not be allowed until either

a) detection of an idle data link channel state after receipt of a frame or a flag; or

b) the end of an extended period of inactivity (idle data link channel state).

NOTE — In the case of half-duplex data circuit facilities, appropriate accommodation has to be made to control the direction of data transmission. The direction of transmission is controlled by the data link layer, and may be signalled by the physical layer.

If no frames were transmitted from either combined station while in ABM and information is waiting for transmission, it is advisable that the combined station transmits at first a supervisory frame only in order to avoid long time recovery action, which would occur in the case of I frame contention.

If a combined station has transmitted frames and no further frames are pending for transmission, it shall give the right to transmit to the remote combined station.

6.12.4.6 Two-way simultaneous consideration

For a balanced class of procedures, two-way simultaneous communication protocols may be used independent of physical data circuit capability (i.e., half-duplex or duplex transmission). However, in the case of half-duplex data circuit facilities, appropriate accommodation has to be made to control the direction of data transmission. The direction of transmission is controlled by the data link layer.

6.13 Unbalanced connectionless operation (point-to-point and multipoint)

6.13.1 General

The following requirements apply to the procedure for unbalanced connectionless operation of synchronous or start/stop data transmission over point-to-point or multipoint data links with two-way alternate or two-way simultaneous data transfer. The procedure uses the HDLC frame structure defined in clause 4 and the HDLC elements of procedures described in clause 5. It uses the basic command/response repertoire designated UCC (see 6.6.2.4). Although only the basic command and response are described, there are several optional functions available for enhanced operation. These are listed in 6.7 and shown in table 13.

6.13.2 Description of the data link

6.13.2.1 Configuration

The unbalanced connectionless operation data link configuration shall consist of one control station plus one or more tributary stations interconnected by physical layer transmission facilities.

6.13.2.2 Physical layer transmission facilities

The physical layer transmission facilities may provide either half-duplex or duplex transmission over switched or non-switched data circuits.

NOTE — In the case of a switched data circuit, the procedures described assume that the switched data circuit has been established.

The data link layer shall not initiate data transmission until an indication of circuit availability is provided by the physical layer. (In some systems providing two-way alternate data exchange on physical layer data circuits using half-duplex transmission, the indication of physical layer circuit availability is indicated by an idle data link channel state.)

6.13.3 Description of the procedures

6.13.3.1 General

Unbalanced connectionless control procedures shall operate on a data link with one control station and one or more tributary station(s). The procedures shall use the connectionless-mode of operation. The control station shall be responsible for sending unnumbered command frames and receiving unnumbered response frames. The tributary station(s) shall be responsible for receiving unnumbered command frames and sending unnumbered response frames. Neither shall be responsible for connection establishment/termination, flow control, acknowledgements, or error recovery.

Both the control station and the tributary station(s) shall check incoming frames for correct frame check sequence and correct frame format. Incorrect frames shall be discarded without notification to the other station.

6.13.3.2 Unbalanced connectionless station characteristics

The control station shall be responsible for:

a) sending unnumbered command frames;

b) receiving unnumbered response frames; and

c) determining when each tributary station shall send.

The tributary station shall be responsible for:

a) receiving unnumbered command frames; and

b) sending unnumbered response frames when given the right to transmit.

6.13.4 Detailed definition of the procedures

The procedures for a permanently connected (dedicated) data link or an established switched connection are defined in 6.13.4.1 to 6.13.4.6. The protocol for establishing and disconnecting a switched data circuit is not within the scope of this International Standard. However, the ability to exchange identification and/or characteristics after the switched connection is established is available as an optional function.

6.13.4.1 Setting up and disconnecting the data link

[There are no data link set-up procedures or data link disconnect procedures in the unbalanced connectionless class of procedures.]

6.13.4.2 Exchange of unnumbered information (UI) frames

6.13.4.2.1 Sending UI frames

The control field format shall be as defined in 5.5.3 for a UI frame. The maximum length of the information field in UI frames shall be a system-defined parameter.

Whenever the control station is ready to send a UI command frame, it shall send it immediately since there is no flow control in connectionless class service. The tributary station(s) shall only send UI response frames when given permission to do so.

6.13.4.2.2 Receiving UI frames

When a control or tributary station receives correctly a UI frame that it can accept, the information field contents are passed up to the higher layer. If the control or tributary connectionless station is unable to accept the correctly received UI frame, the information field contents are discarded.

If a tributary station correctly receives a UI command frame with the P bit set to "1", the tributary station shall send whatever UI response frames it has to send and then will send a UI response frame with the F bit set to "1". The UI response frame with the F bit set to "1" shall contain a zero length information field (in order to minimize its exposure to transmission errors).

6.13.4.2.3 Reception of incorrect frames

If a frame is received with an incorrect FCS, it shall be discarded. If a frame is received with incorrect format, it shall be discarded.

6.13.4.2.4 Unbalanced connectionless station receiving acknowledgements

Unbalanced connectionless stations do not operate with acknowledgements per se. A tributary station reacts to the receipt of a UI command frame with the P bit set to "1" by sending a UI response frame with the F bit set to "1" as part of the polling process. A control station reacts to the receipt of a UI response frame with the F bit set to "1" as a result of a previously sent UI command frame with the P bit set to "1" as an indication that the secondary is through sending UI frames.

6.13.4.3 Time-out considerations

In order to detect a no-reply or lost-reply condition relative to P/F bit exchange (i.e., polling), each control station shall provide a response time-out function (or equivalent). The expiry of the time-out function (or equivalent) shall be available for use to initiate transmission of another P bit set to "1" UI command frame, to the same or a different tributary station.

The duration of the time-out function (or equivalent) shall be system-dependent.

The time-out function (or equivalent) shall be started whenever the control station has transmitted a UI command frame with the P bit set to "1". When a UI response frame with the F bit set to "1" is received from the tributary station, the time-out function (or equivalent) shall be stopped.

If the response time-out function (or equivalent) runs out, a UI command frame with the P bit set to "1" may be transmitted, and the response time-out function (or equivalent) restarted.

6.13.4.4 P/F bit usage

P/F bit usage in the unbalanced connectionless class of procedure, UCC, serves to indicate which tributary station is being allowed to transmit. The issuance of a UI response frame with F bit set to "1" indicates that the tributary station has no more information to send.

6.13.4.5 Two-way alternate considerations

In two-way alternate data link operation

a) transmission from the control station shall not be allowed until either:

   1) receipt of a UI response frame with the F bit set to "1", or

   2) expiry of a no-response time-out function (or equivalent); and

b) transmission from a tributary station shall not be allowed until receipt of a UI command frame with the P bit set to "1".

NOTE 1 — In multipoint configuration, two-way alternate data link operation over duplex physical facilities, the control station may transmit UI command frames with the P bit set to "0" to non-polled tributary stations in the above mentioned period.

NOTE 2 — In the case of half-duplex data circuit facilities, appropriate accommodation has to be made to control the direction of data transmission. The direction of transmission is controlled by the data link layer, and may be signalled by the physical layer.

6.13.4.6 Two-way simultaneous consideration

For the unbalanced connectionless class of procedures, two-way simultaneous operation may be used independent of physical data circuit capability (i.e., half-duplex or duplex transmission). However, in the case of half-duplex data circuit facilities, appropriate accommodation has to be made to control the direction of data transmission. The direction of transmission is controlled by the data link layer. In addition, data transmission from the tributary station shall not be allowed until receipt of a frame with the P bit set to "1".

6.14 Balanced connectionless operation (point-to-point)

6.14.1 General

The following requirements apply to the procedure for balanced connectionless operation of synchronous or start/stop data transmission over point-to-point data links with two-way alternate or two-way simultaneous data transfer. The procedure uses the HDLC frame structure defined in clause 4 and the HDLC elements of procedures described in clause 5. It uses the basic command/response repertoire designated BCC (see 6.6.2.5) Although only the basic command defined is described, there are several optional functions available for enhanced operation. These are listed in 6.7 and shown in table 13.

6.14.2 Description of the data link

6.14.2.1 Configuration

The balanced connectionless operation data link configuration shall consist of two peer stations interconnected by physical layer transmission facilities.

6.14.2.2 Physical layer transmission facilities

The physical layer transmission facilities may provide either half-duplex or duplex transmission over switched or non-switched data circuits.

NOTE — In the case of a switched data circuit, the procedures described assume that the switched data circuit has been established.

The data link layer shall not initiate data transmission until an indication of circuit availability is provided by the physical layer. (In some systems providing two-way alternate data exchange on physical layer data circuits using half-duplex transmission, the indication of physical layer circuit availability is indicated by an idle data link channel state.)

6.14.3 Description of the procedures

6.14.3.1 General

Balanced connectionless control procedures shall operate on a data link where the data station at each end of the data link is a peer station. The procedures shall use the connectionless-mode of operation. Each peer station shall be responsible for sending UI command frames and receiving UI command frames, but shall not be responsible for connection establishment/termination, flow control, acknowledgements, or error recovery.

Each peer station shall check incoming frames for correct frame check sequence and correct frame format. Incorrect frames shall be discarded without notification to the other peer station.

6.14.3.2 Balanced connectionless station characteristics

Each station shall be a peer station. It shall be able to both send and receive UI command frames without the need for a data link connection to be established.

6.14.4 Detailed definition of the procedures

The procedures for a point-to-point data link using a permanently connected (dedicated) or an established switched connection are defined in 6.14.4.1 to 6.14.4.6. The protocol for establishing and disconnecting a switched data circuit is not within the scope of this International Standard. However, the ability to exchange identification and/or characteristics after the switched connection is established is available as an optional function.

6.14.4.1 Setting up and disconnecting the data link

[There are no data link set-up procedures or data link disconnect procedures in the balanced connectionless class of procedures.]

6.14.4.2 Exchange of unnumbered information (UI) frames

6.14.4.2.1 Sending UI frames

The control field format shall be as defined in 5.5.3 for a UI frame. The maximum length of the information field in UI frames shall be a system-defined parameter.

Whenever a peer station is ready to send a UI command frame, it shall send it immediately since there is no flow control in connectionless class service.

6.14.4.2.2 Receiving UI frames

When a peer station receives correctly a UI command frame that it can accept, the information field contents are passed up to the higher layer. If the peer station is unable to accept the correctly received UI command frame, the information field contents are discarded.

6.14.4.2.3 Reception of incorrect frames

If a frame is received with an incorrect FCS, it shall be discarded. If a frame is received with incorrect format, it shall be discarded.

6.14.4.2.4 Balanced connectionless station receiving acknowledgements

Peer stations do not operate with acknowledgements.

6.14.4.3 Time-out considerations

In order to detect a no-activity condition in two-way alternate configurations, each peer station shall provide a no-activity time-out function (or equivalent) - idle data link channel state detector. The expiry of this time-out function (or equivalent) shall be available for use to initiate transmission of UI command frames.

The duration of this time-out function (or equivalent) shall be system-dependent. The duration of the time-out function (or equivalent) in the two peer stations shall be unequal in two-way alternate operation in order to resolve contention situations. This time-out function (or equivalent) shall be started whenever the peer station observes a steady idle state condition. When a UI command frame is received the time-out function (or equivalent) shall be stopped. If the no-activity time-out function (or equivalent) runs out, a UI command frame may be transmitted.

6.14.4.4 P/F bit usage

There is no P/F bit usage in the balanced connectionless class of procedure, BCC.

6.14.4.5 Two-way alternate considerations

In two-way alternate data link operation, transmission from a peer station shall not be allowed until either:

a) detection of an idle data link channel state after receipt of a frame or a flag; or

b) the end of an extended period of inactivity (idle data link channel state).

NOTE — In the case of half-duplex data circuit facilities, appropriate accommodation has to be made to control the direction of data transmission. The direction of transmission is controlled by the data link layer, and may be signalled by the physical layer.

If no frames were transmitted from either peer station for quite some time and information becomes available for transmission, it is advisable that the peer station transmits at first a UI command frame with a zero length information field in order to avoid long timer recovery action, which would occur in the case of contention of UI frames with information.

If a peer station has transmitted frames and no further frames are pending for transmission, it shall give the right to transmit to the remote peer station.

6.14.4.6 Two-way simultaneous consideration

For the balanced connectionless class of procedures, two-way simultaneous operation may be used independent of physical data circuit capability (i.e., half-duplex or duplex transmission). However, in the case of half-duplex data circuit facilities, appropriate accommodation has to be made to control the direction of data transmission. The direction of transmission is controlled by the data link layer.

6.15 Uses of the optional functions

Some uses of the optional functions defined in 6.7 are described in this clause. The optional functions provide additional capabilities beyond the basic operations described in 6.11, 6.12, 6.13 and 6.14. The commands and responses identified are, in general, defined in 5.5.

6.15.1 Option 1 — identification

The identification optional function provides the means for data link layer entities to exchange data link layer parameters and characteristics of operation before or during normal operation. The function utilizes the Exchange Identification (XID) command and response frames.

A prime application of Option 1 is in conjunction with a switched network connection. Following the indication of a working physical path from the physical layer, and prior to establishing a logical data link connection over which higher layer information can be exchanged, the data link layer entities can exchange details concerning the data link layer addresses (individual and group) that they are responsive to, the capabilities that they support (for example options, class(es) of procedure, etc.), and the parameter values employed (for example, value of reply timer, receive window size, maximum information field length, etc.). The manner in which these details are encoded in the information field of the XID frames exchanged is the subject of clause 7.

Included in the identification function is an option for accommodating a limited amount of higher layer information in the XID frame information field. This may be useful in applications where security and/or authentication check routines must be invoked prior to the establishment of a logical data link connection between higher layer entities. Such information is transported transparently by the data link layer entities.

In addition to its applicability before data link connection establishment, the identification function also provides a mechanism for indicating a change in data link layer parameter value(s) while in the information transfer phase. Examples of such parameters are the receive window size and the maximum frame length. Local conditions at one end of a data link connection (for example, long term congestion or non-temporary reduction in buffering capacity) may dictate a change in operation of the remote station in order to maintain efficient utilization of the physical facilities. The identification function allows a local-to-remote transfer of local parameter values at any time, with a remote-to-local confirmation in return.

6.15.2 Option 2 — REJ recovery

The REJ recovery optional function provides a mechanism for reporting an observed out-of-sequence exception condition of received I frames, and thereby requesting the retransmission of I frames starting with the first missing I frame. The mechanism is the reject (REJ) command/response frame.

This function has its greatest utility in systems that support two-way simultaneous operation, so that an observed gap in received sequence numbers can be reported immediately, during incoming information transfer. In two-way alternate operation, the REJ function offers a somewhat lesser utility, but does separate the sequence error reporting from the P/F bit exchange checkpointing function that in some modes of operation is required to be associated with the last frame transmitted in each transmit opportunity.

In two-way simultaneous operation, the improvement in performance gained by using the REJ function is measured by the number of I frames that would be sent after the point in time where the gap is reported, versus when the transmitter's transmit window is exhausted or acknowledgement timer times-out, and the status enquiry process performed. In cases of large transmit windows or long acknowledgement timers, this could be a substantial amount of time.

6.15.3 Option 3 — SREJ recovery

This optional function is equally adaptable to both two-way simultaneous operation and two-way alternate operation. In two-way simultaneous operation, the retransmitted I frames are interspersed in the ongoing sequential transmission of new I frames. In two-way alternate operation, the requested I frames alone are retransmitted, followed by new I frames as appropriate. Although this optional function imposes greater buffering requirements in the receiver data link layer to hold out-of-sequence, higher-numbered good frames received until the required lower-numbered frames are received, it yields a better utility of the information transfer capacity of the data link.

6.15.3.1 Option 3.1 — single individual I frame retransmission request

The single individual I frame retransmission optional function provides a mechanism for a receiver to request retransmission of a single I frame out of a series of I frames. Any number of requests for different I frames may be outstanding at a time. The mechanism is the selective reject (SREJ) command/response frame.

The SREJ frame does not incorporate an acknowledgement function for I frames received when the P/F bit is set to "0"; it does when the P/F bit is set to "1". For example, to report frames numbered X, X+3, and X+5 missing, a SREJ(X) frame could be sent with its P/F set to "1", when appropriate for the mode of operation, to acknowledge receipt of I frames numbered up through X-1. SREJ(X+3) and SREJ(X+5) frames could be sent immediately with their P/F bits set to "0", not acknowledging any I frames received. Acknowledging receipt of a retransmitted I frame is usually accomplished by an I, RR or RNR frame transmission with an N(R) value that identifies the correct receipt of the requested I frame.

Another request for retransmission can take place when it is perceived that the desired action has not taken place. This perception comes about either as the result of a SREJ timer timeout, or by the receipt of requested I frame X before requested I frame $X - n$ (the request for I frame $X - n$ precedes the request for I frame X).

6.15.3.2 Option 3.2 — multiple individual I frame(s) retransmission request consisting of individual I-frame indicators only

The multiple individual I frame(s) retransmission optional function that uses only individual I-frame indicators provides a mechanism for a receiver to request retransmission of one or more individual I frame(s) out of a series of I frames with a single request by incorporating an information field in the SREJ frame. Any number of requests for different I frames may be outstanding at a time. The mechanism is the selective reject (SREJ) command/response frame with the multi-selective reject procedure using only individual I-frame indicators.

The multi-selective reject procedure SREJ frame using only individual I-frame indicators does not incorporate an acknowledgement function of I frames received when the P/F bit is set to “0”; it does when the P/F bit is set to “1”, as in the case of 6.15.3.1 above. With this multi-selective reject procedure, to report I frames numbered X, X+3 and X+5 missing, a single SREJ frame would be sent with "X" encoded in the control field N(R) subfield and with "X+3" and "X+5" encoded as individual I-frame indicators in the information field of the SREJ frame. Acknowledging receipt of retransmitted I frames is accomplished in the normal manner by an I, RR or RNR frame transmission with an N(R) value that identifies the correct in-sequence receipt of the requested I frame(s).

Another request for retransmission can take place when it is perceived that the desired action has not been accomplished. This perception comes about either as the result of a SREJ timer time-out, or by the receipt of a requested I frame X before requested I frame X-n (the request for I frame X-n precedes the request for I frame X, either in an earlier SREJ frame or the same multi-selective reject procedure SREJ frame that uses only individual I-frame indicators).

6.15.3.3 Option 3.3 — multiple individual I frame(s) retransmission request consisting of individual I-frame indicators and span list indicators, as appropriate

The multiple individual I frame(s) retransmission optional function that uses both individual I-frame indicators and span list indicators, as appropriate, provides a mechanism for a receiver to request retransmission of one or more individual I frame(s) out of a series of I frames with a single request by incorporating an information field in the SREJ frame. Any number of requests for different I frames may be outstanding at a time. The mechanism is the selective reject (SREJ) command/response frame with the multi-selective reject procedure using both individual I-frame indicators and span list indicators, as appropriate.

The multi-selective reject procedure SREJ frame using both individual I-frame indicators and span list indicators, as appropriate, does not incorporate an acknowledgement function of I frames received when the P/F bit is to “0”; it does when the P/F bit is set to “1”, as in the case of 6.15.3.1 above. With the multi-selective reject procedure, to report I frames numbered, X, X+3, X+5, X+6, X+7, and X+8 missing, a single SREJ frame would be sent with “X” encoded in the control field N(R) subfield, and with “X+3” encoded as an individual I-frame indicator, and “X+5, X+6, X+7 and X+8” encoded in a span list indicator in the information field of the SREJ frame. Acknowledging receipt of retransmitted I frames is accomplished in the normal manner by an I, RR or RNR frame transmission with an N(R) value that identifies the correct in-sequence receipt of the requested I frames.

Another request for retransmission can take place when it is perceived that the desired action has not been accomplished. This perception comes about either as the result of a SREJ timer time-out, or by the receipt of a requested I frame X before requested I frame X-n (the request for I frame X-n precedes the request for I frame X, either in an earlier SREJ frame or the same multi-selective reject procedure SREJ frame that uses individual I-frame indicators and span list indicators, as appropriate.

6.15.4 Option 4 — unnumbered information

The unnumbered information optional function provides a mechanism for the sending of higher layer information at any time without any impact on whatever mode of operation may be in use. The mechanism is the unnumbered information (UI) command/response frame.

There are no flow control procedures and no acknowledgement procedures associated with UI frame operation. There are no data link establishment and no error recovery procedures required with UI frame operation. Error control procedures cover only those matters concerned with frame structure and the frame check sequence, leading to the frame being discarded and no action taken. The only data link layer parameter that is involved is the maximum established information field size at the receiver. Violation of maximum information field size may lead to a frame rejection (FRMR) exception condition when received during an operational mode (see 5.2.1).

UI frames can be transmitted to one or more or all multiple stations without concern for sequence number alignment at the stations involved. Depending on the application, UI frames can be transmitted repeatedly with the same contents to improve the likelihood that a good copy of the transmittal is received correctly at all intended receivers.

UI frame-only operation may be a logical choice of operation in highly reliable, error-free data link layer environments. Higher layer provision of error recovery procedures and flow control procedures may result in an acceptable information transport mechanism for the users of such configurations.

6.15.5 Option 5 — initialization

The initialization optional function provides the mechanisms for requesting and initiating an initialization mode of operation wherein system-defined initialization procedures are utilized. The mechanisms are the set initialization mode (SIM) command and the request initialization mode (RIM) response frames.

This function can be employed at any time, whenever it is deemed necessary by the station involved. A RIM response would result in an SIM command being sent. The SIM command shall be responded to using the UA response frame. The nature and make-up of the exchange or exchanges involved to realize a successful initialization are system defined. The conclusion of the initialization mode is identified by the exchange of an appropriate mode-setting command frame and the UA response frame. When a primary/combined station initiates the initialization procedures, a SIM command frame is sent without there being a requesting RIM response frame.

6.15.6 Option 6 — unnumbered polling

The unnumbered polling optional function provides the mechanism for a primary/combined station to poll one or more or all of the associated secondary/combined stations with a single frame transmission. The mechanism is the unnumbered poll (UP) command frame.

The UP command frame contains no sequence numbers, acknowledges no frames received and is addressable to one or more or all of the stations on the data link. The order of response and ensuring non-overlap of responses is not the subject of this International Standard. Responses are optional or mandatory depending on whether the UP command frame had its P bit set to "0" or "1", respectively. Unless the underlying response-ordering-mechanism provides an indicator of "last responder", it is suggested that a specified "last" station respond to every UP command frame received, with an F bit set to the value of the P bit in the UP command frame, so that the station which sent the UP command does not have to rely on time-out.

6.15.7 Option 7 — multi-octet addressing

The multi-octet addressing optional function defines the means for having an address field of N octets in length. The mechanism employs one bit per octet to act as an end-of-address-field indicator. This bit set to "0" means that another address field octet follows. This bit set to "1" means that this octet is the final octet in the address field. The sum of the 7N bits in the identified N-octet address field constitutes a single address. This address can be an individual or group address. The all-station address is always an address octet of "1" bits. An N-octet address field can be considered to have an address that is expressed as a bit stream of 7N bits, or as an N-character series, for instance, using the ISO 646 character set.

This optional function may be employed in situations where it is considered desirable for each data link location within a system (even a system that spans independent data links) to have a unique data link layer identifier. System management and station administration may benefit as a result. Station portability from data link to data link within the system could be enhanced. This optional function may also be employed in situations where one octet of addressing (i.e., 256 total addresses, including the null and the all-station addresses) is insufficient.

6.15.8 Option 8 — command I frames only

The command I frames only optional function restricts I frames to being I command frames only.

In balanced operation, each combined station's ability to send I frames is only impeded to the extent that an I response frame cannot be utilized to return an F bit set to "1" when an F bit set to "1" must be sent. A non-I response frame must be utilized. If a series of I command frames is in the process of transmission when an F bit set to "1" must be sent, a non-I response frame must be inserted into the stream of I frames, between I frames, in order to convey the F bit set to "1" to the remote station.

In unbalanced operation, applying the optional function results in a quite different overall service, one that yields an information send-only service at the primary station and an information receive-only service at the secondary station(s).

6.15.9 Option 9 — response I frames only

The response I frames only optional function restricts I frames to being I response frames only. This function was defined to be the procedural complement of the command I frames only optional function (see 6.15.8).

In balanced operation, each combined station's ability to send I frames is only impeded to the extent that I frames cannot carry P bits. Hence, a non-I command frame must be sent if a P bit set to "1" is required. If a series of I response frames is in the process of transmission when a P bit set to "1" must be sent, a non-I command frame must be inserted into the stream of I frames, between I frames, in order to convey the P bit set to "1" to the remote station.

In unbalanced operation, applying the optional function results in a quite different overall service, one that yields an information receive-only service at the primary station and an information send-only service at the secondary station(s).

6.15.10 Option 10 — extended sequence numbering

Typical applications for modulus values greater than 8 are: satellite operations, long propagation delay environments and very high speed/heavy traffic load situations. The greater modulo value allows for larger send and receive windows to be defined so that information transfer performance can be improved in such applications. The choice of higher modulus value depends on the actual delay and other parameters of the specific environment.

6.15.10.1 Option 10.1 — extended sequence numbering — modulo 128

The extended sequence numbering modulo 128 optional function provides the mechanism for defining the sequence numbering for I frame transfer to be modulo 128. The mechanism is in the form of separate mode-setting commands and different frame formats for extended sequence numbering for the normal response mode (NRM) operation, the asynchronous response mode (ARM) operation, and the asynchronous balanced mode (ABM) operation.

The send and receive sequence numbers in I frames are modulo 128. The receive sequence number in supervisory frames is modulo 128. The control field in I frames and supervisory frames is extended to two octets in length. The control field in unnumbered frames remains one octet in length.

6.15.10.2 Option 10.2 — extended sequence numbering — modulo 32 768

The extended sequence numbering modulo 32 768 optional function provides the mechanism for defining the sequence numbering for I frame transfer to be modulo 32 768. The mechanism is in the form of an SM command with an optional information field to indicate the modulo and the mode of the operation (i.e., the normal response mode (NRM) operation, the asynchronous response mode (ARM) operation, or the asynchronous balanced mode (ABM) operation).

The send and receive sequence numbers in I frames are modulo 32 768. The receive sequence number in supervisory frames is modulo 32 768. The control field in I frames and supervisory frames is extended to four octets in length. The control field in unnumbered frames remains one octet in length.

6.15.10.3 Option 10.3 — extended sequence numbering — modulo 2 147 483 648

The extended sequence numbering modulo 2 147 483 648 optional function provides the mechanism for defining the sequence numbering for I frame transfer to be modulo 2 147 483 648. The mechanism is in the form of an SM command with an optional information field to indicate the modulo and the mode of the operation (i.e., the normal response mode (NRM) operation, the asynchronous response mode (ARM) operation, or the asynchronous balanced mode (ABM) operation).

The send and receive sequence numbers in I frames are modulo 2 147 483 648. The receive sequence number in supervisory frames is modulo 2 147 483 648. The control field in I frames and supervisory frames is extended to eight octets in length. The control field in unnumbered frames remains one octet in length.

6.15.11 Option 11 — one-way reset

The one-way reset optional function provides a mechanism for initiating the resetting of the logical data link for one direction of information transfer in the balanced mode of operation without affecting the logical data link for the other direction of information transfer. The mechanism is the reset (RSET) command frame.

A combined station initiates a reset of the logical data link relative to its I frame transmission by sending the RSET command frame. The remote station acknowledges the RSET command frame by returning a UA response frame.

Resetting one direction of the logical data link results in the following events taking place at the RSET sender and the UA sender. The send state variable is reset at the RSET sender, and the receive state variable is reset at the UA sender. The retransmission counter is reset at the RSET sender. The UA response indicates that any busy condition that existed at the UA sender has been cleared. Also, any frame reject (FRMR) condition that existed at the UA sender has been cleared.

6.15.12 Option 12 — data link test

The data link test optional function provides a mechanism for testing the basic data link layer function at a remote station, at any time, independent of the mode of operation or the phase of the procedures. The mechanism is the test (TEST) command and response frames. It is not intended as a conclusive test of remote station operation.

The test function checks the following capabilities at the remote station:

a) detect an opening flag;

b) remove zero bits that have been inserted for transparency from the received bit stream following the opening flag;

c) detect a closing flag;

d) calculate an FCS for the received bit stream;

e) check that the unique FCS remainder was obtained;

f) decode its address as being the contents of the address field;

g) decode the control field as the TEST command;

h) accommodate the length of the information field;

i) generate a bit stream consisting of its own address in the address field, the TEST response encoding in the control field with the F bit set to the same value as the P bit in the received TEST command control field, and the information received in the information field;

j) send an opening flag;

k) insert zero bits into the transmitted bit stream following the opening flag so that a flag sequence is not simulated before the closing flag is sent;

l) calculate an FCS on the transmitted bit stream (consisting of the address, control and information fields) and append it to the transmitted bit stream for zero bit insertion; and

m) end the transmission with a closing flag.

6.15.13 Option 13 — request disconnect

The request disconnect optional function provides a mechanism for a secondary/combined station to request that a data link disconnect be initiated by a primary/combined station. The mechanism is the request disconnect (RD) response frame.

At an appropriate respond opportunity, a secondary/combined station may send a RD response frame to indicate to the primary/combined station that the secondary/combined station wishes to be placed in the disconnected mode (NDM or ADM). Upon receipt of the RD response frame, the primary/combined station may

a) ignore the RD response frame and continue with the normal procedures; or

b) accept the RD response and issue a DISC command frame.

6.15.14 Option 14 — Alternate frame check sequences

Use of an alternate frame check sequence is determined by prior agreement or by use of a FCS negotiation mechanism (for example, see Annex E when both stations are capable of supporting both the 16-bit FCS and the 32-bit FCS).

6.15.14.1 Option 14.1 — alternate frame checking sequence — 32-bit FCS

The 32-bit FCS optional function provides a higher degree of transmission error detection capability than that available with the normal 16-bit FCS capability. The generator polynomial and the FCS generation and checking process are described in 4.2.5.3.

6.15.14.2 Option 14.2 — alternate frame checking sequence — 8-bit FCS

The 8-bit FCS optional function can be used by those applications with short frames (e.g., such as on the order of 10 octets for digitized voice) where overhead is a concern and/or where the protection afforded is adequate. The generator polynomial and the FCS generation and checking process are described in 4.2.5.4.

6.15.15 Option 15 — start/stop transmission

The start/stop transmission optional function permits HDLC frames and procedures to be used in start/stop transmission environments. The mechanism for start/stop transmission is described in 4.3.2. The three levels of transparency available are as indicated below. Use of this optional function is determined by prior agreement.

6.15.15.1 Option 15.1 — start/stop transmission with basic transparency

The basic transparency option provides transparency processing for the flags and the control escape octets.

6.15.15.2 Option 15.2 — start/stop transmission with basic transparency and flow-control transparency

In addition to the basic transparency, the flow-control transparency option provides transparency processing for the DC1/XON and DC3/XOFF control characters defined in ISO/IEC 646. 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.

6.15.15.3 Option 15.3 — tart/stop transmission with basic transparency and control-character octet transparency

In addition to the basic transparency, the control-character octet transparency option provides transparency processing for all octets in which both the 6th and 7th bits are "0" as well as for the DELETE character octet. 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.

6.15.16 Option 16 — even-bit data path transparency

The seven-bit data path transparency option, for use in conjunction with any of the functions of Option 15, permits HDLC frames and procedures to be used in start/stop transmission environments where only seven data bits per start/stop character can be transferred (e.g., where bit 8 is used for parity). The mechanism for seven-bit data path transparency is described in 4.3.2.1. Use of this optional function is always in conjunction with one of the transparency functions of Option 15; selection of the particular Option 15 transparency function is independent from the use of Option 16. Use of optional function 16 is determined by prior agreement.

6.15.17 Option 17 — set mode command (SM) with optional information field used in place of SXXM or SXXME command

The optional function provides an alternate mechanism for data link set-up in place of the use of SXXM (modulo 8) or SXXME (modulo 128) commands. The mechanism is the set mode (SM) mode setting command.

The SM frame may contain an information field, in which the mode of operation and the modulus to use may be identified. Also includable in the information field can be items such as the operational parameters (both standard and user-defined) and higher layer user data. This function thereby allows the use of a single mode setting command, SM, in place of up to six set mode commands (SABM, SARM, SNRM, SABME, SARME and SNRME) in those environments where one or more modes of operation, or one or more moduli, are supported by a single data link layer entity.

6.15.18 Option 18 — presence of an information field in UA and DM responses, and in DISC commands

This optional function allows for information to be conveyed in mode setting response frames (UA and DM) and in the mode setting disconnect command frame (DISC). The mechanism is the incorporation of an information field in these frames.

The type of information conveyed in UA and DM response frames can include mode of operation and modulus data, parameter selection matters, and user data information. The type of information that can be conveyed in a DISC command frame is restricted to user data only. The existence of this optional function complements the selection of optional functions 10.2, 10.3, 17 or 19.

6.15.19 Option 19 — presence of an information field in SABM, SARM, SNRM, SABME, SARME, SNRME commands

This optional function provides for the ability to convey control and/or user data information in the transmission of an SABM, SARM, SNRM, SABME, SARME or SNRME mode-setting command frame. The mechanism is the incorporation of an information field in these commands.

The information field can convey information relative to the operational parameters (both standard and user-defined) being supported, and user data for passage up to the higher layer.

6.15.20 Option 20 — unnumbered information with header check

The unnumbered information with header check optional function provides the ability to exchange information fields that may not be entirely protected by a frame check sequence, independent of the mode (operational or non-operational), without impacting the I frame sequence numbers. This option can be used when the integrity of the information being transferred is of lesser importance than its delivery to the correct station(s). Cases where the integrity of the information being transferred is of lesser importance than its delivery to the correct station include the timely transmission of packetized voice, video/graphic data, or periodically updated information.

6.15.21 Option 21 — multiple address fields

The multiple address fields optional function allows frames to 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 immediately following the opening flag, or the frame format field (see 4.9), when present. Each address field may be chosen independently to use either the single-octet format or the extended format (see 4.7.1).

6.15.22 Option 22 — frame format field

The frame format field optional function allows a frame to have a frame format field immediately following after the opening flag sequence and before any address fields. The frame format field includes the format type, frame length and optional segmentation subfields. The frame format field is defined in 4.9 and frame formats are defined in Annex H. The XID parameter supported frame format types contains a bit mask of the frame format types supported by this station.

6.15.23 Option 23 — segmentation

The segmentation optional function indicates that the segmentation subfield exists in the frame format field. This option can only be used when Option 22 is also used. The segmentation subfield is defined in 4.9.3.

6.15.24 Option 24 — no bit or octet insertion

This optional function indicates that the normal transparency mechanisms are inhibited. This option can only be used with Option 22, since the length subfield defined by Option 22 makes it possible to inhibit bit or octet insertion as a transparency mechanism.

6.15.25 Option 25 — start/stop mode intra-frame timeout

This optional function indicates that an intra-frame timeout is being used in start/stop mode. See 4.6.3 for a description of the intra-frame timeout.

6.15.26 Option 26 — header check sequence

The header check sequence (HCS) optional function indicates that there is a HCS following the control field and before the information field. The HCS can only be used with Option 22. If present, the HCS is the same length as the FCS and uses the same polynomial.

7 General purpose Exchange Identification (XID) frame

A general purpose XID frame is defined for use by two correspondents wishing to communicate with one another in an HDLC environment.

7.1 General purpose XID frame information field structure

The general purpose XID frame information field structure is the same as that described in 5.5.3.1 for mode-setting commands and responses.

7.1.1 Format identifier subfield

The format identifier (FI) subfield is defined in 5.5.3.3.11. The list of standard XID format identifiers that are registered is given in ISO/IEC TR 10171.

7.2 General purpose XID frame information field encoding

The general purpose XID format identifier subfield is the first octet of the general purpose XID information field. The data link layer subfields, if present, follow in ascending order according to their GI values. Except where noted, specific data link layer subfields may appear only once in the general purpose XID information field. The absence of a particular data link layer subfield should be interpreted to mean that parameters within this subfield shall maintain their present values. The user data subfield, if present, is always the last subfield of the XID information field.

7.2.1 Format identifier subfield encoding

The format identifier (FI) subfield is encoded as illustrated in figure 20.

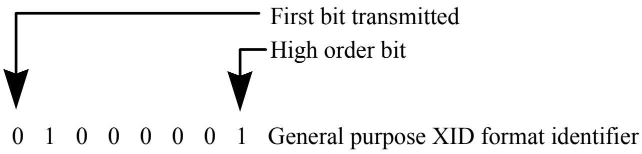


Figure 20 — General purpose XID format identifier subfield encoding

7.2.2 Data link layer subfield encoding

Figure 21 indicates the GI encodings for the data link layer subfields that are useable with the general purpose XID frame.

The GI encoding of all ones (1111 1111) is not used as a data link layer subfield encoding.

All GI encodings not assigned in this International Standard (here and in 5.5.3.2.2) are reserved for future use.

NOTE 1 The HDLC parameters data link layer subfield and the user-defined parameters data link layer subfield may each appear more than once in an XID information field. This allows a station to convey multiple menus of supportable parameters through a single XID frame exchange.

NOTE 2 The user-defined parameters identifier is for use to identify parameters outside the scope of the HDLC parameters identifier, while making use of those parameters that are explicitly identified by the HDLC parameters identifier — thus allowing parameter negotiation with a single XID exchange.

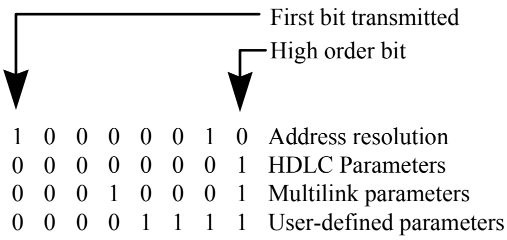


Figure 21 — General purpose XID data link layer subfield identifier encodings

The group length is expressed as a two-octet binary number representing the length of the associated parameter field in octets.

The following is a list of parameter field elements that are defined for the address resolution, HDLC parameters, multilink parameters, and user-defined parameters data link layer subfields.

The following legend explains the symbols used in tables 14, 15, 16, 17 and 18.

PI : Parameter Identifier, expressed as a decimal value.

PL : Parameter Length in octets, expressed as a decimal value.

E : Indicates the field is bit encoded. When this bit position is "1", the feature is present or supported by the sender. When the bit position is "0", the feature is absent or not supported by the sender.

B : Indicates this field is binary encoded.

N : Number of octets.

NA : Not applicable.

SD : System defined.

Bit No. : Numerical order of bits transmitted.

TBD : To be determined.

Table 14 — Data link layer subfield parameter field elements
Address resolution (GI = 10000010)

PI	Parameter field element
1	Unique identifier
2	Local data link layer address

HDLC parameters (GI = 00000001)

PI	Parameter field element
1	Unique identifier
2	Class of procedures
3	HDLC optional functions
4	Group address(es)
5	Maximum information field length - transmit
6	Maximum information field length - receive
7	Window size (k) - transmit
8	Window size (k) - receive
9	Acknowledgement timer
10	Retransmission attempts
11	Reply delay timer
12	Port number
13	Number of protected bits in a UIH frame

Multilink parameters (GI = 00010001)

PI	Parameter field element
1	Lost frame timer (MT1)
2	Group busy timer (MT2)
3	Reset confirmation timer (MT3)
4	Multilink window size (MW) - transmit
5	Multilink window size (MW) - receive
6	Guard region window size (MX)
7	Multilink group size
8	Multilink group member(s)

User-defined parameters (GI = 00001111)

PI	Parameter field element
0	Parameter set identification

Table 15 — Address resolution data link layer subfield parameter field elements

Name	PI	PL	Parameter field element	Code type	Bit No.	Value
Identifier	1	TBD	Unique identifier	B	TBD	B (see the note)
Address	2	N	Local data link layer address	NA	NA	SD

NOTE The value of this PV is a subject for further study.

Table 16 — HDLC parameters elements

Name	PI	PL	Parameter field element	Code type	Bit No.	Value
Identifier	1	TBD	Unique identifier	B	TBD	B[1)]
Classes of procedures[2)]	2	2	Balanced ABM	E	1	0/1
			Unbalanced NRM-Primary	E	2	0/1
			Unbalanced NRM-Secondary	E	3	0/1
			Unbalanced ARM-Primary	E	4	0/1
			Unbalanced ARM-Secondary	E	5	0/1
			Balanced BCC	E	8	0/1
			Unbalanced UCC-Control	E	9	0/1
			Unbalanced UCC-Tributary	E	10	0/1
			Two-way alternate	E	6	0/1
			Two-way simultaneous	E	7	0/1
			Reserved		11 to 16	0
HDLC optional functions[2)]	3	5	1 Reserved		1	0
			2 REJ cmd/resp	E	2	0/1
			3.1 SREJ cmd/resp single frame	E	3	0/1
			3.2 SREJ cmd/resp multiple frames-individual I-frame indications only	E	22	0/1
			3.3 SREJ cmd/resp multiple frames-individual I-frame indications and span list indicators	E	24	0/1
			4 UI cmd/resp	E	4	0/1
			5 SIM cmd/RIM resp	E	5	0/1
			6 UP cmd	E	6	0/1
			7 Basic address (basic capability)	E	7	0/1
			7.1 Extended address	E	8	0/1
			8 Delete resp I	E	9	0/1
			9 Delete cmd I	E	10	0/1
			10 Modulo 8 (basic capability)	E	11	0/1
			10.1 Modulo 128	E	12	0/1
			10.2 Modulo 32 768	E	25	0/1
			10.3 Modulo 2 147 483 648	E	26	0/1
			11 RSET cmd	E	13	0/1
			12 TEST cmd/resp	E	14	0/1
			13 RD resp	E	15	0/1
			14 16-bit FCS (basic capability)	E	16	0/1
			14.1 32-bit FCS	E	17	0/1
			14.2 8-bit FCS	E	32	0/1
			15 Synchronous transmission (basic capability)	E	18	0/1
			15.1 Start/stop transmission with basic transparency	E	19	0/1
			15.2 Start/stop transmission with basic and flow control transparency	E	20	0/1

Table 16 — HDLC parameters elements (*continued*)

Name	PI	PL	Parameter field element	Code type	Bit No.	Value
			15.3 Start/stop transmission with basic and control-character octet transparency	E	21	0/1
			16 Transfer of seven data bits/character in start/stop transmission environments	E	30	0/1
			17 Set Mode command with an optional information field to be used in place of SXXM or SXXME	E	27	0/1
			18 UA and DM responses, and the DISC command with an optional information field	E	28	0/1
			19 SABM, SNRM, SARM, SABME, SNRME, SARME command with an optional information field	E	29	0/1
			20 UIH cmd/resp	E	23	0/1
			21 Support for multiple address fields	E	31	0/1
			22 Support of frame format field	E	33	0/1
			23 Support of segmentation	E	34	0/1
			24 Inhibit bit or octet insertion	E	35	0/1
			25 Start/stop mode intra-frame timeout	E	36	0/1
			26 Header check sequence	E	37	0/1
			Reserved		381 to 40	0
Group address(es)[3)]	4	N	Data link group address	NA	NA	SD
Maximum information field length (transmit)	5	N	Maximum information field length transmit (bits)	B	NA	B
Maximum information field length (receive)	6	N	Maximum information field length receive (bits)	B	NA	B
Window size k (transmit)	7	N	Window size k-transmit (frames)	B	NA	0 to modulus -1
Window size k (receive)	8	N	Window size k-receive (frames)	B	NA	0 to modulus -1
Acknowledgement timer	9	N	Wait for acknowledgement timer (msec)	B	NA	B
Retransmission attempts	10	N	Maximum number of retransmission attempts	B	NA	B
Reply delay timer	11	N	Maximum delay in generation of reply (msec)	B	NA	B
Port number	12	2	Local port identifier (for multilink use)	B	NA	B
Number of protected bits	13	N	Number of protected bits in a UIH frame	B	NA	B
Address-field count	14	N	Count of address fields	B	NA	B (see note 4)
Supported frame format types	15	N	Frame format types supported	B	NA	B (see note 5)
Intra-frame time-out	16	2	Maximum time between octets (msec)	B	NA	B

NOTE 1 The value of this PV is beyond the scope of this International Standard.

NOTE 2 This parameter field element may be repeated to specify multiple operational configurations.

NOTE 3 This parameter field element may be repeated for multiple group addresses.

NOTE 4 The count is not meant to restrict protocols to a specific interpretation of this field. For example, this field may be used as a count of the actual number of address fields or of the maximum number of address fields allowed to be present in frames.

NOTE 5 The MSB of the first octet of the bit mask represents type 0; the second MSB, type 1; and so. The initiating station may use the bit mask to indicate the type it wants, the recipient can use it to indicate the types it can support.

Table 17 — Multilink parameters elements

Name	PI	PL	Parameter field element	Code type	Bit No.	Value
Lost frame timer	1	N	MT1 - lost frame timer (msec)	B	NA	B
Group busy timer	2	N	MT2 - Group busy timer (msec)	B	NA	B
Reset confirmation timer	3	N	MT3 - Reset confirmation timer (msec)	B	NA	B
Multilink window size (transmit)	4	2	Multilink window size (MW) - transmit (frames)	B	1-12	0 through 4095-MX
			Reserved	B	13-16	0
Multilink window size (receive)	5	2	Multilink window size (MW) - receive (frames)	B	1-12	0 through 4095-MX
			Reserved	B	13-16	0
Guard region window size	6	2	Guard region window size (MX) (frames)	B	1-12	B
			Reserved	B	13-16	0
Multilink group size	7	1	Number of data links in multilink group	B	NA	B
Multilink group member (see note)	8	4	Local port number - remote port number, for the data link connection	B	NA	B

NOTE This parameter field element is repeated for each member of the multilink group.

Table 18 — User-defined parameters elements

Name	PI	PL	Parameter field element	Code type	Bit No.	Value
Identifier	0	N	Parameter set identification	NA	NA	(See Note 1)
(Implementor-defined) (See Note 2)	1 to 255	N	(Implementor-defined)	NA	NA	NA

NOTE 1 Parameter set identification may be from 1 to 255 octets in length. Certain values are listed in ISO/IEC TR 10171.

NOTE 2 The use of PI/PL/PV encoding in this subfield for PI values other than PI=0 is not required. Such usage is at the discretion of the organization associated with the parameter set identified by PI=0.

7.2.3 User data subfield encoding

7.2.3.1 User data identifier encoding

The user data identifier identifies the subfield as the user data subfield. Figure 22 provides its encoding.

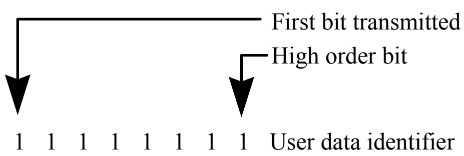


Figure 22 — User data subfield encoding

7.2.3.2 User data subfield encoding

The user data subfield is transported transparently by the data link and passed on to the user of the data link. The encoding of the user data subfield is the responsibility of the data link user, and may be any format that is mutually agreed upon by the data link users involved.

7.3 Single-frame exchange negotiation process

This subclause defines a single-frame exchange negotiation process using the XID command/response frame exchange with a general purpose XID information field to identify and profile the correspondents desiring to communicate over either switched or private data links.

The primary/combined station desiring to, or having been requested to, initiate the XID frame exchange transmits an XID command frame with the P bit set to "1" with an information field containing an offered profile of supportable parameters.

The responding station initiates an XID response frame with an information field that indicates the parameter selection from the profile.

7.3.1 Address resolution

See clause 8.

7.3.2 Parameter negotiation

7.3.2.1 Specifying supportable parameters

The XID command frame shall specify the modes which are supported by the local station. Encoding of these modes shall be as follows:

— In situations where XID frame collisions are possible during parameter negotiation, the local unique identifier shall be placed in the Parameter field.

— Pairs of classes of procedures and the HDLC optional functions parameter value are used to specify multiple modes of operation. Each pair shall be encoded such that all HDLC optional functions specified in the HDLC optional functions parameter value are supported in association with all classes of procedure specified in the classes of procedures value.

— All other parameter values are encoded as necessary.

7.3.2.2 Specifying parameter values selected

The XID response frame shall designate the mode in which the local station will operate. Acceptance criteria or method of selection of parameter values by the responding station from those offered by the initiating station is as follow:

— For the "E" bit encoded parameters, only options supported by both stations may be selected.

— For the window size parameters and the maximum information field length parameters, the minimum values are chosen.

— Parameter fields not supported by the receiver are ignored and omitted from the XID response frame.

— In the case of HDLC optional function parameters 3, 7, 10 and 15 (see table 16), one alternative must be chosen. The method of changing from one version to another version, in these cases, is not the subject of this International Standard.

— In the case of HDLC optional function parameter 14 (see table 16), one or both versions may be identified as supported. The method of selection is in accordance with the single-frame exchange negotiation process. The operation of a system that supports the 16-bit FCS and the 32-bit FCSboth versions is described in 7.4.

7.3.2.3 Collision of XID command frames

Which station has control of parameter selection during collision situations shall be resolved in the following way. The local unique identifier is compared with the remote unique identifier received in the XID command frame. If the local unique identifier is greater than the remote unique identifier, then the local station shall select the operating parameters from the offered profile of supportable parameters supplied by the remote station in the XID command frame. Selection of these operating parameters and transmission of the XID response frame is described in 7.3.2.2. If the local unique identifier is less than the remote unique identifier, then the local station yields control of operating parameter selection to the remote station. If an XID response frame does not contain an HDLC parameters subfield, this is interpreted to mean that parameters within this subfield shall maintain their present values (see 7.2).

7.3.2.4 User-defined parameters negotiation

Every user-defined parameters subfield must contain one and only one parameter set identification parameter, and it must be the first parameter within the subfield.

Parameter set identification values (PV of PI=0) are by prior agreement between data link layer entities, and are not a subject of this International Standard. (See ISO/IEC TR 10171 Table 4 for specific values.) It is the responsibility of the stations selecting parameter set identification values to insure that the values are unique within the scope of the intended application.

A station decoding a user-defined parameters subfield containing an unrecognized parameter set identification value shall ignore that entire subfield. Likewise if a station does not support user-defined parameters at all, subfields with group identifiers of 00001111 shall be ignored.

Multiple user-defined parameters subfields with different parameter set identification values are permitted and are to be treated independently of one another by the station. Handling of multiple user-defined parameters subfields with identical parameter set identification values is to be determined by the stations agreeing to use the given parameter set identification value. For example, it may be designated that only one of those user-defined parameters subfields with identical parameter set identification values may be returned in an XID response (selection from a menu).

The interpretation of parameter set identifier values other than PI=0 is determined by prior agreement between the stations. However, user-defined parameters are not to be used for conveyance of parameters or information for the use of higher layer entities (the user data subfield should be used for this purpose). Neither may user-defined parameters negotiation be used to negotiate parameters which are defined in the basic HDLC standards (the standard mechanisms defined elsewhere in this International Standard should be used for this purpose).

7.4 Frame check sequence negotiation rules

For negotiation between the 16-bit FCS and the 32-bit FCS, tTwo cases are covered: the general case and a constrained case. The constrained case allows for some simplification in the operating procedures (by virtue of the known roles of initiating and responding station) and in the capabilities that the stations involved must support (because collision situations do not exist). The differences in the basic principles (rules) that are used in the FCS negotiation process are noted by parenthetical explanations below and in the second example given in Annex E.

The following basic principles (rules) apply to stations that support both 16-bit FCS and 32-bit FCS as far as frame check sequence negotiation is concerned.

— FCS negotiation or re-negotiation is only performed in the logical data link disconnected phase.

— The initiating station will start the negotiation process from the 16-bit FCS mode as far as transmitted XID frames are concerned.

— During the FCS negotiation process, and until the mode-setting command and response have been exchanged, the stations will receive and process frames in both the 16-bit FCS mode and the 32-bit FCS mode simultaneously. (In the constrained case, it is not necessary for the initiating station to process received frames in both 16-bit FCS and 32-bit FCS modes simultaneously since the responding station does not send frames with 32-bit FCS until after it has indicated selection of the 32-bit FCS mode and has received a set mode command with a 32-bit FCS from the initiating station.)

— The responding station will select the value of FCS to be used from that which both stations are indicating they support, and will indicate the selected value in the XID response HDLC parameters data link layer subfield.

— The stations will disable the unusable FCS mode upon the sending of or the receipt of the mode-setting command that confirms the other station's concurrence as far as the value of FCS to be used for information transfer is concerned.

— The stations will reactivate the disabled FCS mode upon the sending of or the receipt of a mode-setting disconnect mode command, thereby returning to a condition where all frames are received and processed in both the 16-bit FCS mode and the 32-bit FCS mode simultaneously.

Illustrative examples of the application of these FCS negotiation rules are given in Annex E.

7.5 Rules for negotiation use of the frame format field in non-basic frame format mode

Two cases are covered: the general case and a constrained case. The constrained case allows for some simplification in the operating procedures (by virtue of the known roles of initiating and responding station) and in the capabilities that the stations involved must support (because collision situations do not exist). The differences in the basic principles (rules) that are used in the negotiation process are noted by parenthetical explanations.

The following basic principles (rules) apply to stations that support both basic-mode and Option 22 (frame format field) as far as negotiation of the frame format field is concerned. (In the following paragraph, we will assume for brevity that “non-basic mode” means “non-basic mode with the frame format field Option 22.”)

— Negotiation or re-negotiation is only performed in the logical data link disconnected phase.

— The initiating station will start the negotiation process from the basic mode as far as transmitted XID frames are concerned.

— During the negotiation process, and until the mode-setting command and response have been exchanged, the stations will receive and process frames in both the basic mode and the non-basic mode simultaneously. (In the constrained case, it is not necessary for the initiating station to process received frames in both basic mode and non-basic modes simultaneously since the responding station does not send frames with non-basic mode until after it has indicated selection of the non-basic mode and has received a set mode command with a non-basic mode from the initiating station.)

— The responding station will select non-basic mode options to be used from that which both stations are indicating they support, and will indicate the selected options in the basic-mode XID response HDLC parameters data link layer subfield.

— The stations will disable the basic mode upon the sending of or the receipt of the mode-setting command that confirms the other station’s concurrence as far as the options to be used for information transfer is concerned.

— The stations will reactivate the basic mode upon the sending of or the receipt of a mode-setting disconnect mode command, thereby returning to a condition where all frames are received and processed in both the basic mode and the non-basic mode simultaneously.

8 Resolution/negotiation of data link layer address in switched environments

8.1 Operational requirements

1. XID Command/Response Frame Support: All stations shall support the XID frame optional function defined as optional function 1 (see 6.15.1).

2. All-Stations Address Support: All stations shall support the "all-stations" address capability.

3. Station Address Support: All stations shall be capable of supporting the complete range of assignable addresses within the constraints of HDLC procedures.

8.2 Address resolution

In cases where the operational data link layer addresses are not known on an a priori basis (e.g., on switched circuit data links), the stations involved that initially are assuming an initiating combined station status shall start the address resolution procedure in order to establish the data link layer addresses to be employed in subsequent frame exchanges.

Upon receipt of an indication from the physical layer that a physical connection exists, the initiating combined station shall transmit as soon as possible an XID command frame as indicated in 8.2.1 below. The non-initiating combined station, upon receipt of an indication from the physical layer that a physical connection exists, shall await the receipt of an XID command frame in order to transmit an XID response frame as described in 8.2.2 below.

In order to prevent stations from assuming the "all-stations" or "no-stations" data link layer address, as a result of address resolution, stations sending XID command frames shall choose data link layer addresses in the range from 2 to 253.

8.2.1 Generating XID command frames

An address resolution XID command frame shall be sent that contains, within the information field, both the Local Data Link Layer Address parameter and the Unique Identifier parameter, in accordance with clause 7. The XID command frame shall be sent with the "all-stations" address in the address field and with the P-bit set to “1”.

If a valid XID response frame is not received within a predefined time, another XID command frame shall be sent, containing the then current value of that station's Local Data Link Layer Address parameter as well as the station's Unique Identifier parameter. This procedure may be repeated "n" times (where the value of "n" is implementation dependent).

For the non-initiating combined station, if a valid XID command frame is not received within a predefined time, the non-initiating combined station shall assume the role of an initiating combined station.

Whenever a station initiates address resolution (i.e., has sent an XID command frame with the "all-stations" address), it shall remain in the disconnected phase until it has successfully completed an XID frame exchange.

8.2.2 Generating XID response frames

Upon reception of an XID command frame, the received data link layer address parameter field is compared with the local data link layer address.

— If the two addresses are different, no address modification is necessary. An XID response frame shall be transmitted with the local data link layer address contained in the address field of the frame as well as in the local data link layer address parameter field.

— If the two addresses are identical, the local data link layer address must be modified before transmitting the XID response frame. If the local Unique Identifier parameter value is greater than the Unique Identifier parameter value contained in the information field of the received XID command frame, then the local station shall increment its data link layer address by one.

— If the local Unique Identifier parameter value is less than the Unique Identifier parameter value contained in the received XID command frame, then the local station shall decrement its data link layer address by one.

Once the address has been modified, an XID response frame shall be sent with the new local data link layer address contained in the address field of the frame as well as in the local data link layer address parameter field.

NOTE 1 The Unique Identifier parameter values are considered as pure binary numbers for performing the comparison.

NOTE 2 In the case of multiple octet addressing, the incrementation/decrementation operation shall be done such that the bits reserved for address extension, low order bit “b1”, are not changed.

Annex A
(informative)

Explanatory notes on the implementation of the frame checking sequence

In order to permit the use of existing devices that are arranged to use a zero preset register, the following implementation may be used. (This example is given in terms of the 16-bit frame checking sequence, and assumes that all bits of the frame are checked.)

At the transmitter, generate the FCS sequence in the following manner while transmitting the elements of the frame unaltered onto the line:

a) preset the FCS register to zeros;

b) invert the first 16 bits (following the opening flag) before shifting them into the FCS register;

c) shift the remaining fields of the frame into the FCS register uninverted;

d) invert the contents of the FCS register (remainder) and shift onto the line as the FCS sequence.

At the receiver, operate the FCS checking register in the following manner while receiving (and storing) unaltered the elements of the frame as received from the line:

a) preset the FCS register to zeros;

b) invert the first 16 bits (following the opening flag) before shifting them into the FCS checking register;

c) shift the remaining elements of the frame, up to the beginning of the FCS, into the checking register uninverted;

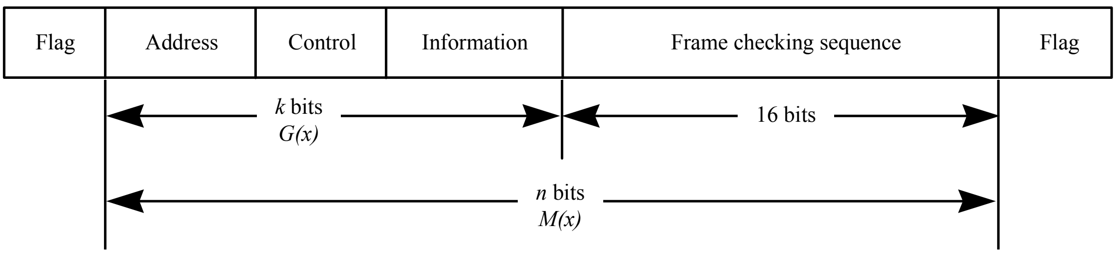
d) invert the FCS sequence before shifting into the checking register.

In the absence of errors, the FCS register will contain all zeros after the FCS is shifted in.

In the above, inversion of the first 16 bits is equivalent to a ones preset, and inversion of the FCS at the receiver causes the registers to go to the all zeros state.

The transmitter or the receiver can independently use the ones preset or the first 16-bit inversion. Also, the receiver can choose not to invert the FCS in which case it has to check for the unique nonzero remainder specified in 4.2.5.

It shall be realized that inversion of the FCS by the receiver requires a 16-bit storage delay before shifting received bits into the register. The receiver cannot anticipate the beginning of the FCS. Such storage, however, will normally take place naturally as the FCS checking function will need to differentiate the FCS from the data, and it will thus withhold 16 bits from the next function at all times.



The procedure for using the FCS is based on the assumptions that:

a) the k bits of data which are being checked by the FCS can be represented by a polynomial $G(x)$.

Example: $G(x) = x^5 + x^3 + 1$ represents 101001.

b) The address field, control field and information field (if it exists in the frame) are represented by the polynomial $G(x)$.

c) For the purpose of generating the FCS, the first bit following the opening flag is the most significant bit of $G(x)$ regardless of the actual representation of the address, control and information fields.

d) There exists a generator polynomial $P(x)$ of degree 16, having the form $P(x) = x^{16} + x^{12} + x^{5} + 1$.

The FCS is defined as the ones complement of a remainder $R(x)$ obtained from the modulo 2 division of

$x^{16}G(x) + x^{k}(x^{15} + x^{14} + x^{13} + x^{12} + x^{11} + x^{10} + x^{9} + x^{8} + x^{7} + x^{6} + x^{5} + x^{4} + x^{3} + x^{2} + x + 1)$
by the generator polynomial $P(x)$.

$$\frac{x^{16}G(x) + x^{k}(x^{15} + x^{14} + \cdots x + 1)}{P(x)} = Q(x) + \frac{R(x)}{P(x)}^{\overline{PCS}}$$

The multiplication of $G(x)$ by x^{16} corresponds to shifting $G(x)$ by 16 places and thus providing the space of 16 bits for the FCS. The addition of $x^{k}(x^{15} + x^{14} + \cdots + x + 1)$ to $x^{16}G(x)$ [equivalent to inverting the first 16 bits of $x^{16}G(x)$] corresponds to initializing the initial remainder to a value of all "ones". This addition is provided for the purpose of protection against the obliteration of leading flags, which may be non-detectable if the initial remainder is zero. The complementing of $R(x)$, by the transmitter, at the completion of the division ensures that the received, error-free message will result in a unique, non-zero remainder at the receiver. The non-zero remainder provides protection against potential non-detectability of the obliteration of trailing flags.

At the transmitter, the FCS is added to the $x^{16}G(x)$, resulting in an $M(x)$ of length n, where $M(x) = x^{16}G(x) + FCS$.

At the receiver, the incoming $M(x)$ is multiplied by x^{16}, added to $x^{n}(x^{15} + x^{14} + \cdots + x + 1)$ and divided by $P(x)$.

$$\frac{x^{16}[x^{16}G(x) + FCS] + x^{n}(x^{15} + x^{14} + \cdots + x + 1)}{P(x)} = Qr(x) + \frac{P\,r(x)}{P(x)}$$

If the transmission is error free, the remainder $Rr(x)$ will be "0001 1101 0000 1111" (x^{15} through x^{0}, respectively).

$Rr(x)$ is the remainder of the division $\frac{x^{16}L(x)}{P(x)}$ where $L(x) = x^{15} + x^{14} + \cdots + x + 1$. This can be shown by establishing that all other terms of the numerator of the receiver division are divisible by $P(x)$.

Note that $FCS = \overline{R(x)} = L(x) + R(x)$. [Adding $L(x)$ without carry to a polynomial of its same length is equivalent to a bit-by-bit inversion of the polynomial.]

The equation above, for the FCS receiver residual, is used in the following to show that inverting the FCS at the receiver returns the checking register to zero. This equation is $\frac{x^{16}L(x)}{P(x)} = Q(x) + \frac{Rr(x)}{P(x)}$ where $L(x)$ is as defined above and $Rr(x)$ is the residual contents of the FCS register. $x^{16}L(x)$

If is added to the numerator, the rabove esult is $\frac{x^{16}L(x) + x^{16}L(x)}{P(x)} = 0$.

Physically, the addition of $x^{16}L(x)$ is achieved by inverting the FCS.

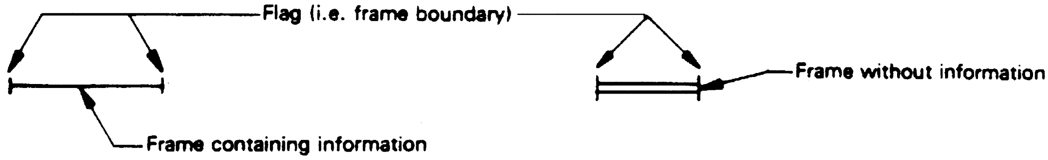
Annex B
(informative)

Example of the use of commands and responses

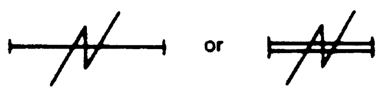
B.1 Introduction

B.1.1 General notation

The notation used in the diagrams in this annex is illustrated below.



Frame with error :



B.1.2 Notation for primary and secondary stations

Information format
Send sequence number

Information frame : I N(S), N(R) P/F ← Poll or final bit ON

Receive sequence number (next expected frame)

Example : Pri xmits : I2,6 P. This denotes a primary information frame with send sequence number 2, the next expected I frame from the secondary is receive sequence number 6 (frames numbered 5 and below are therefore acknowledged) and the poll bit is set to "1" (i.e. the secondary is to initiate transmission with I frames if available).

Supervisory command/response

Supervisory frame : XXX N(R), P/F ← Poll or final bit ON

Receive sequence number

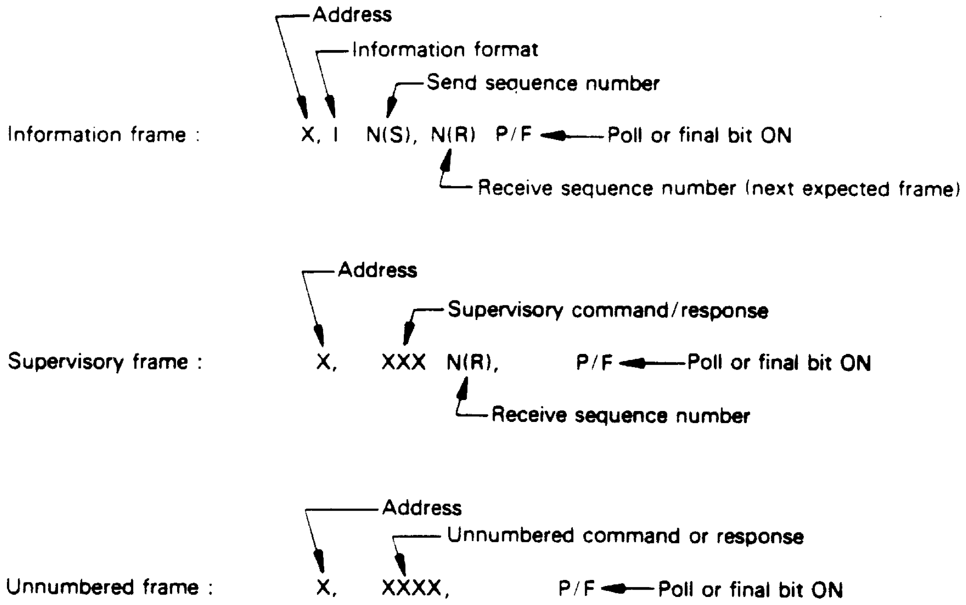
Example : Pri xmits : RR2 P. This denotes a receive ready (RR) command, N(R) = 2 (i.e. the next expected I frame from the secondary is receive sequence number 2); and the poll bit is set to "1".

Unnumbered command or response

Unnumbered frame : XXXX, P/F ← Poll or final bit ON

Example : Pri xmits : SNRM, P. This denotes the normal response mode (NRM) mode-setting command with the P bit set to "1".

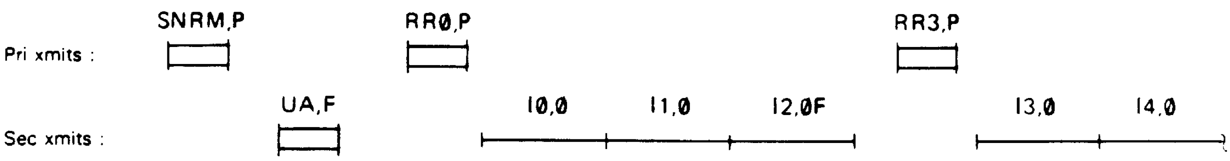
B.1.3 Notation for combined stations



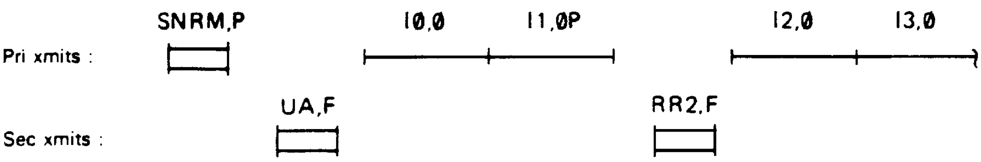
B.2 Examples of normal response mode (NRM) two-way alternate (TWA) transmission

B.2.1 Normal response mode (NRM) TWA without transmission errors

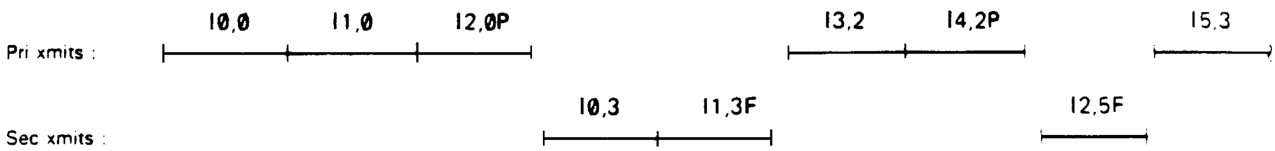
B.2.1.1 NRM start-up procedure and secondary only information transfer



B.2.1.2 NRM start-up procedure and primary only information transfer

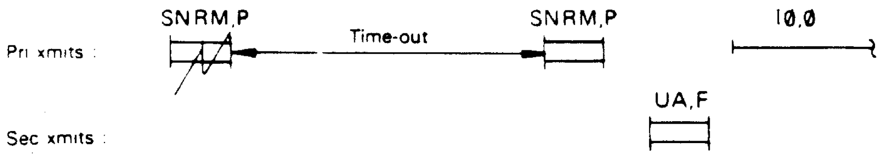


B.2.1.3 NRM information transfer by primary and secondary

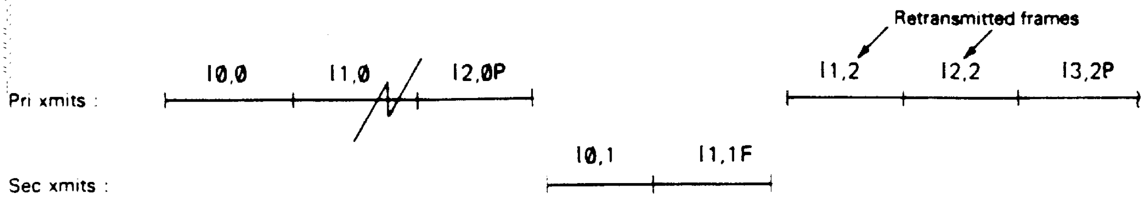


B.2.2 Normal response mode (NRM) TWA with transmission errors in command frames

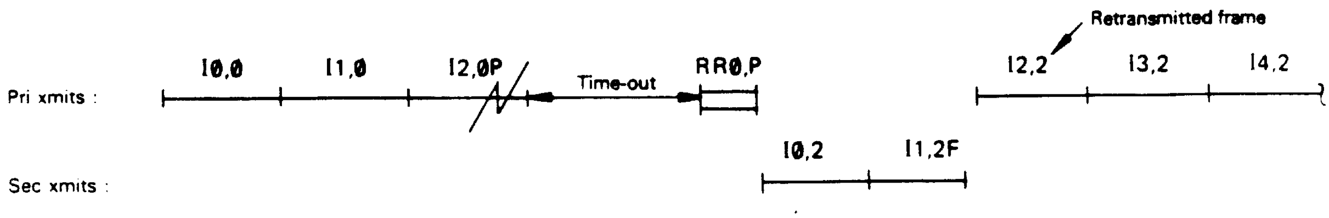
B.2.2.1 NRM start-up command error



B.2.2.2 NRM primary information frame error

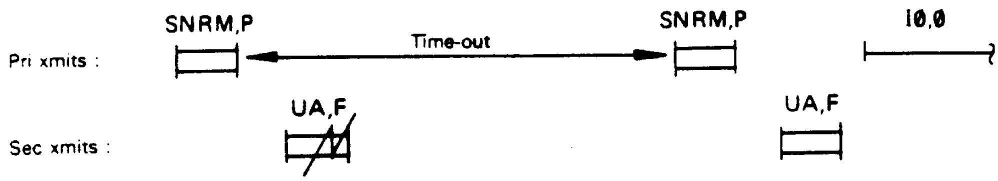


B.2.2.3 NRM primary poll frame error

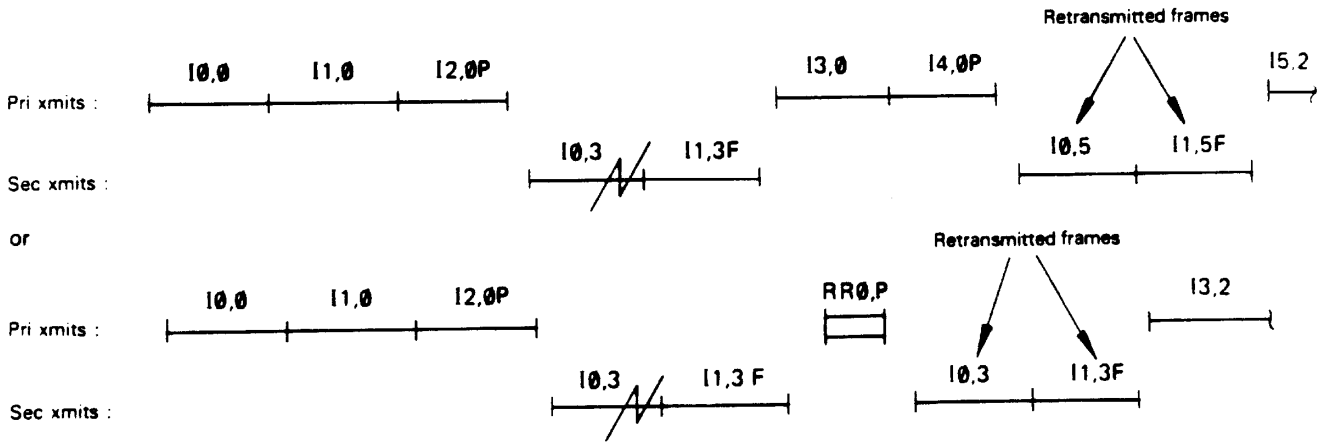


B.2.3 Normal response mode (TWA) HDX with transmission errors in response frames

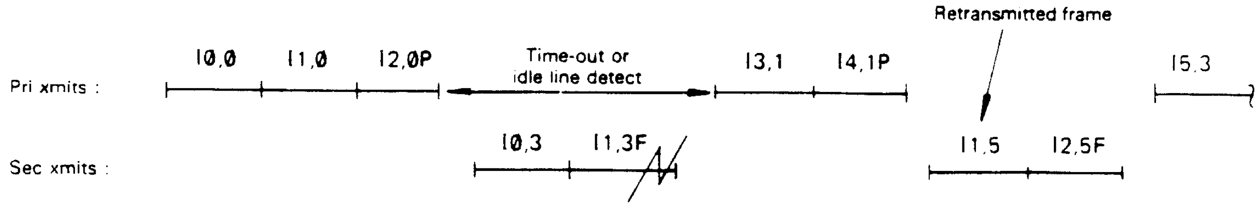
B.2.3.1 NRM start-up response error



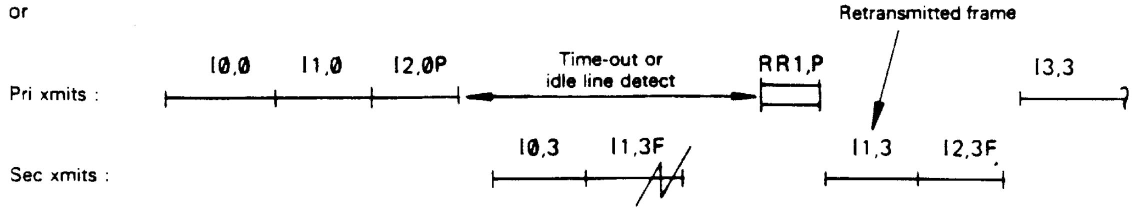
B.2.3.2 NRM secondary information frame error



B.2.3.3 NRM secondary "final" frame error



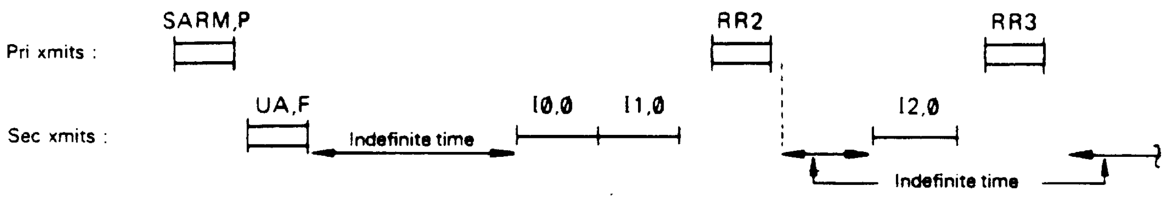
or



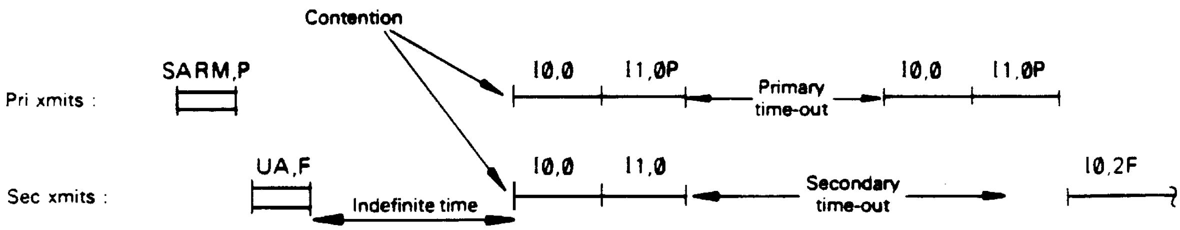
B.3 Examples of asynchronous response mode (ARM) two-way alternate (TWA) transmission

B.3.1 Asynchronous response mode (ARM) TWA without transmission errors

B.3.1.1 ARM start-up procedure and secondary only information transfer

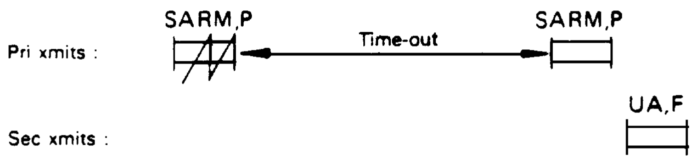


B.3.1.2 ARM primary and secondary information transfer with contention situation



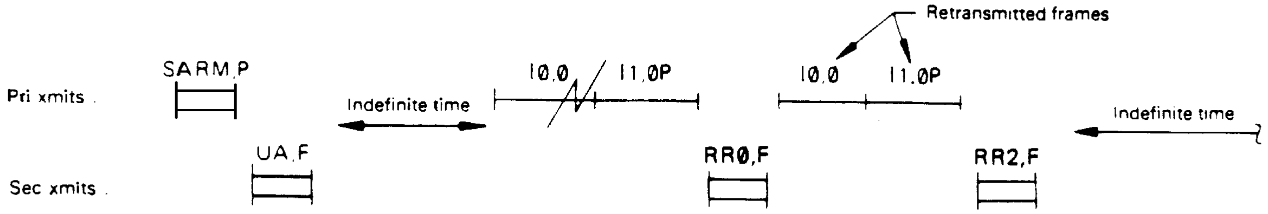
B.3.2 Asynchronous response mode (ARM) TWA with transmission errors in command frames

B.3.2.1 ARM start-up command error



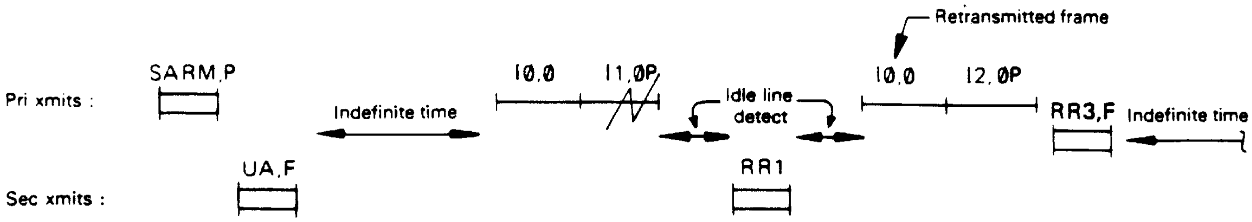
B.3.2.2 ARM primary information frame error

NOTE — Recovery procedure is identical to NRM operation.



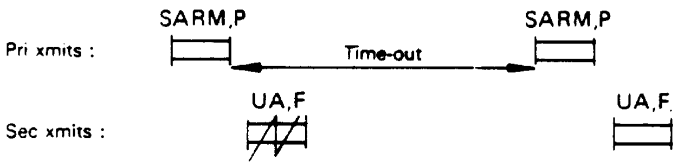
B.3.2.3 ARM primary "poll" information frame error

NOTE — Recovery procedure is identical to NRM operation.

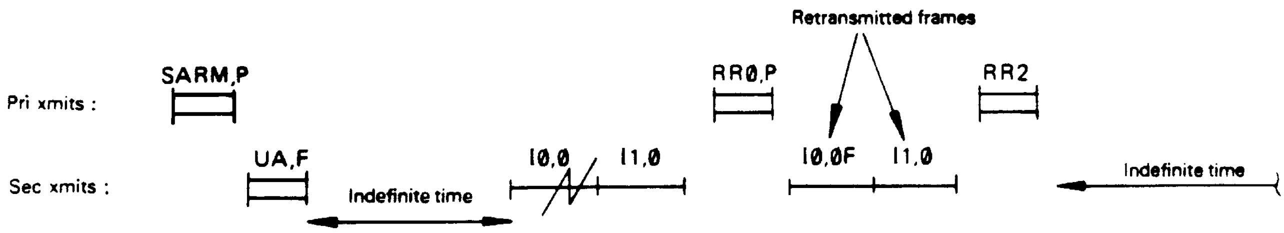


B.3.3 Asynchronous response mode (ARM) TWA with transmission errors in response frames

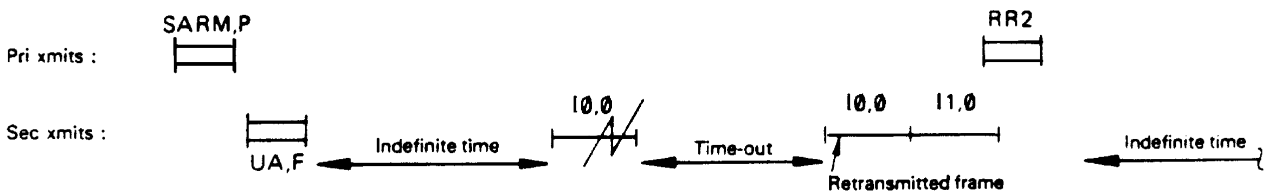
B.3.3.1 ARM start-up



B.3.3.2 ARM secondary information frame error



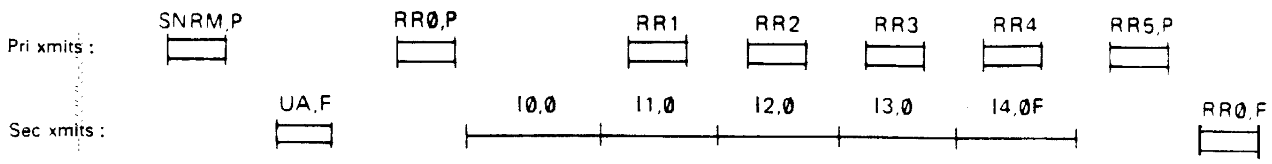
B.3.3.3 ARM secondary "final" information frame error



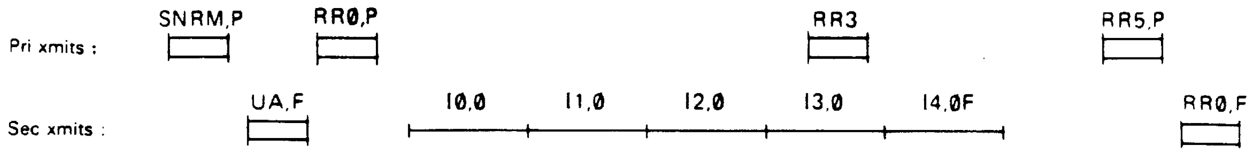
B.4 Examples of normal response mode (NRM) two-way simultaneous (TWS) transmission

B.4.1 Normal response mode (NRM) TWS without transmission errors

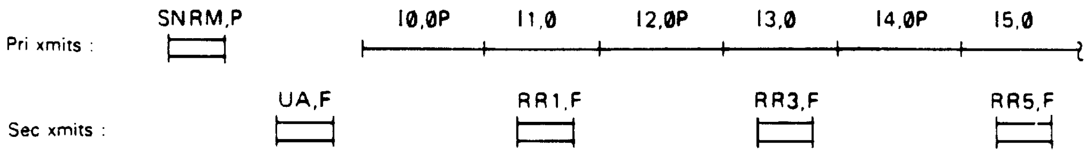
B.4.1.1 NRM start-up procedure and secondary only information transfer



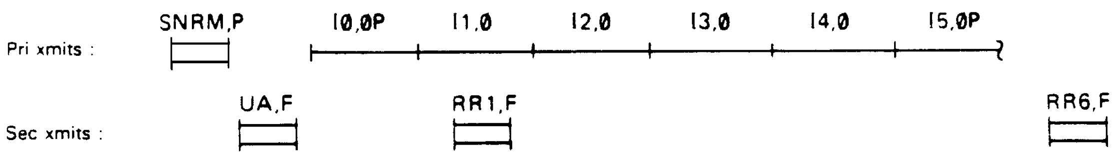
or (where primary acknowledgments are returned for several response frames)



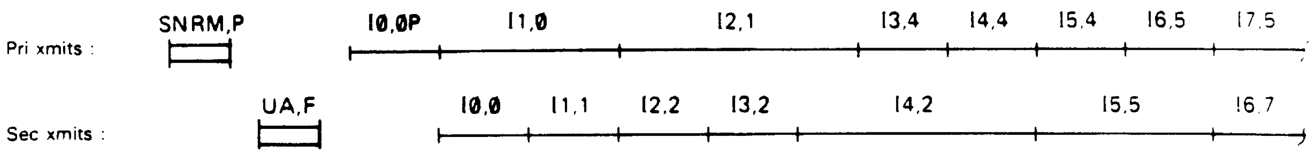
B.4.1.2 NRM start-up procedure and primary only information transfer



or (where primary sets poll bit to "1" to solicit acknowledgment for several frames)

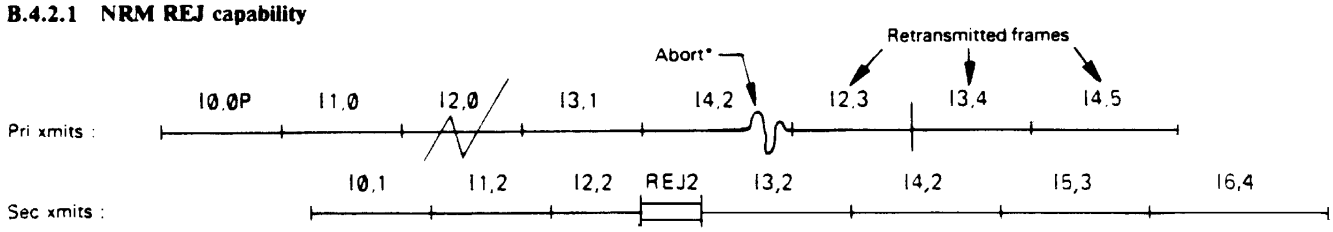


B.4.1.3 NRM start-up procedure and primary/secondary information transfer



B.4.2 Normal response mode (NRM) TWS with transmission errors in command frames

B.4.2.1 NRM REJ capability



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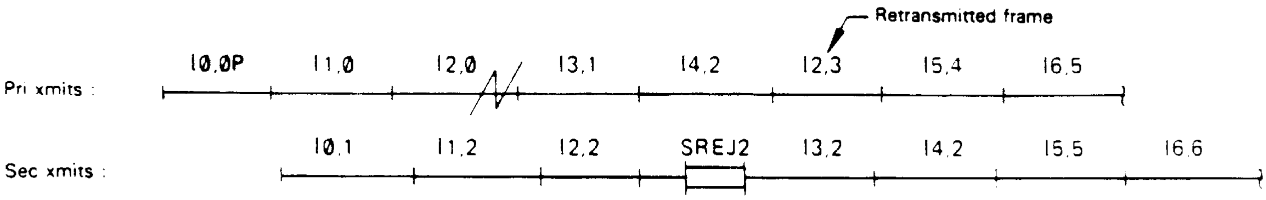
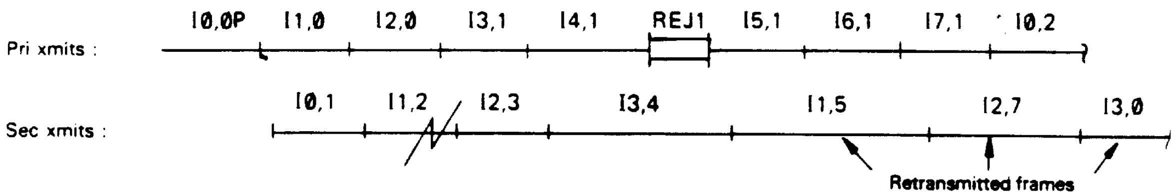
* Optional : Frame may be completed or aborted.

B.4.2.2 NRM SREJ capability

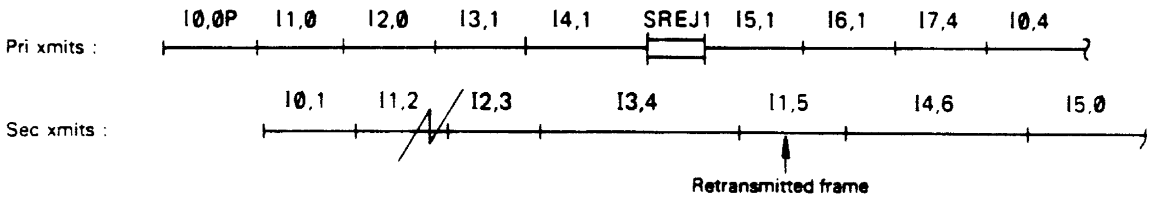


B.4.3 Normal response mode (NRM) TWS with transmission errors in response frames

B.4.3.1 NRM REJ capability



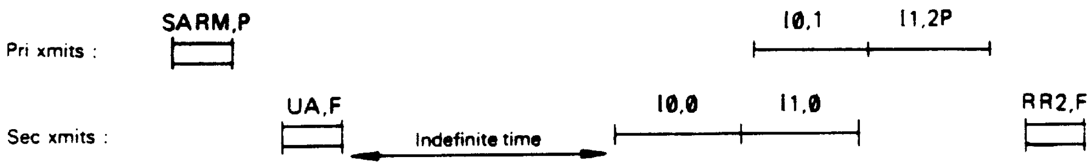
B.4.3.2 NRM SREJ capability



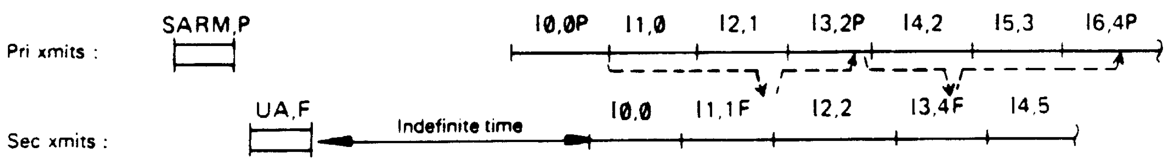
B.5 Examples of asynchronous response mode (ARM) two-way simultaneous (TWS) transmission

B.5.1 Asynchronous response mode (ARM) TWS without transmission errors

B.5.1.1 ARM start-up procedure and intermittent secondary or primary information transfer

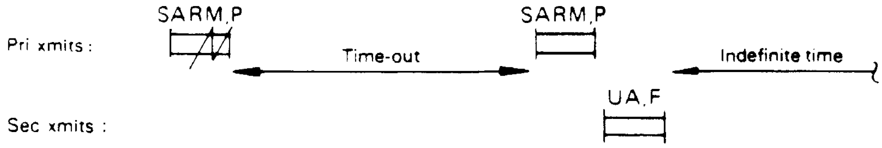


B.5.1.2 ARM start-up procedure and continuous primary/secondary information transfer

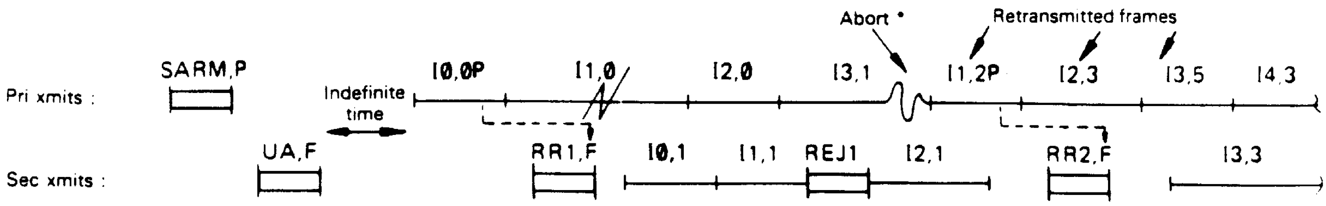


B.5.2 Asynchronous response mode (ARM) TWS with transmission errors in command frames

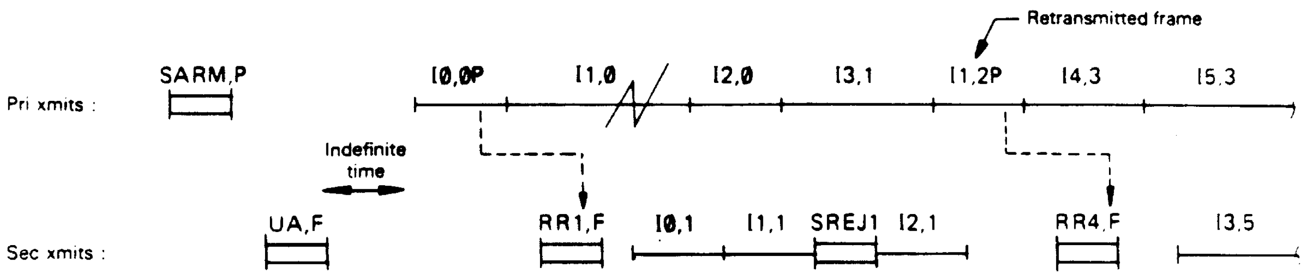
B.5.2.1 ARM start-up command error



B.5.2.2 ARM REJ capability

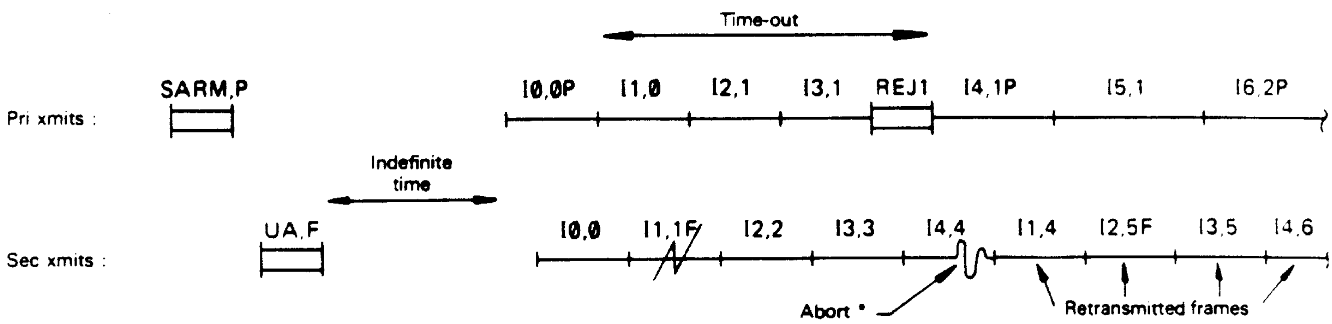


B.5.2.3 ARM SREJ capability



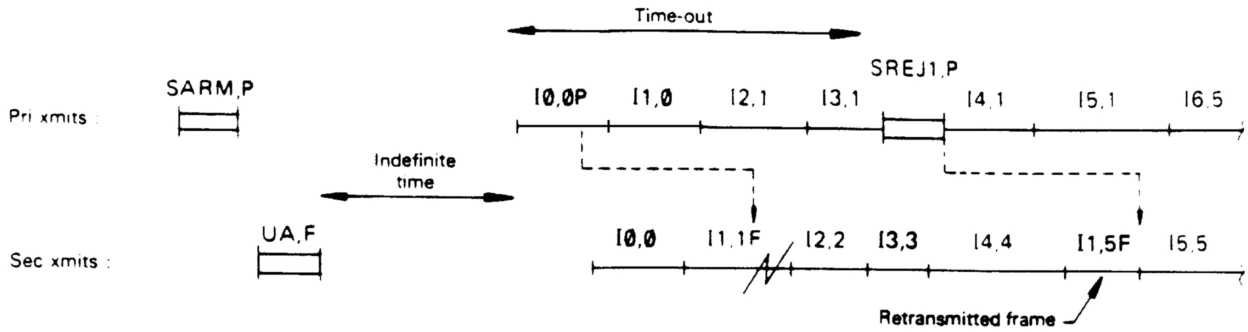
B.5.3 Asynchronous response mode (ARM) TWS with transmission errors in response frames

B.5.3.1 ARM REJ capability

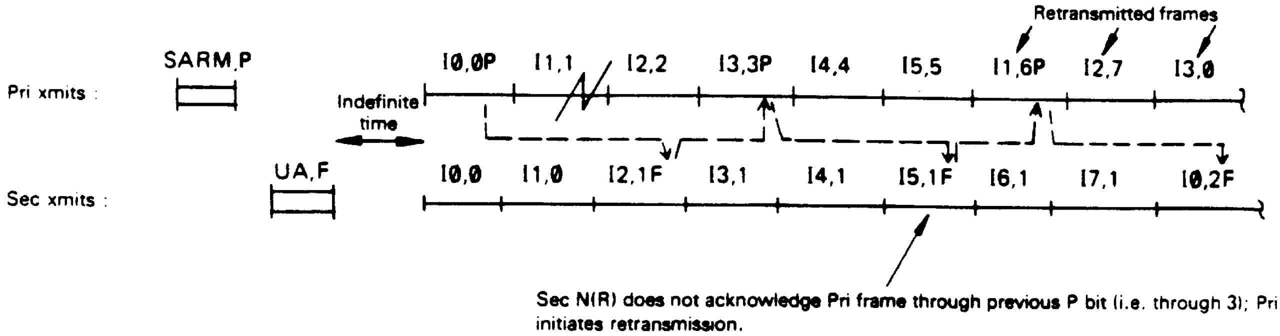


* Optional : Frame may be completed or aborted.

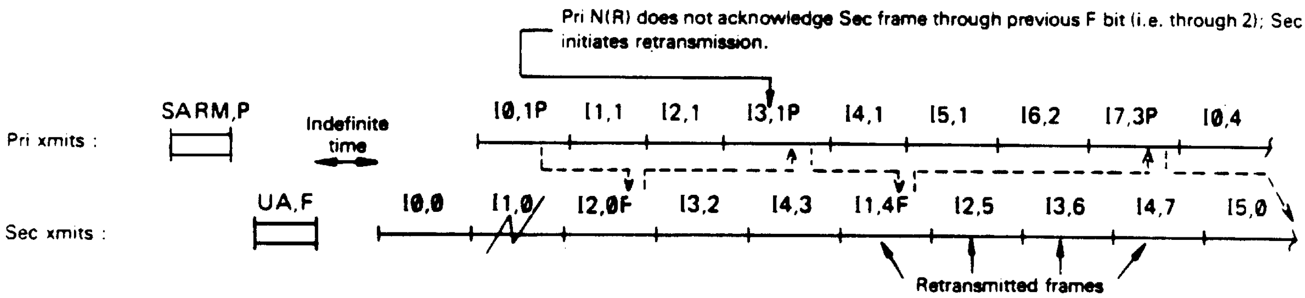
B.5.3.2 ARM SREJ capability



B.5.3.3 ARM P/F bit recovery with transmission errors in command frames



B.5.3.4 ARM P/F bit recovery with transmission errors in response frames

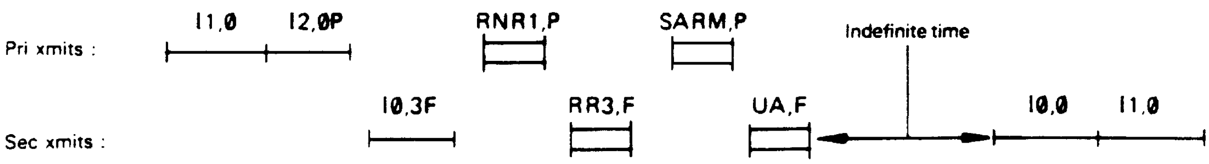


B.6 Examples of changing control mode

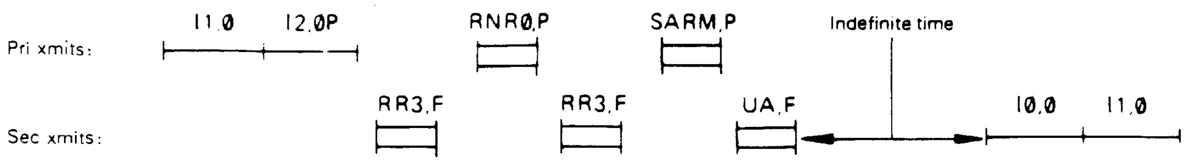
B.6.1 Normal response mode (NRM) to asynchronous response mode (ARM) change

B.6.1.1 Two-way alternate (TWA) transmission NRM to ARM code change

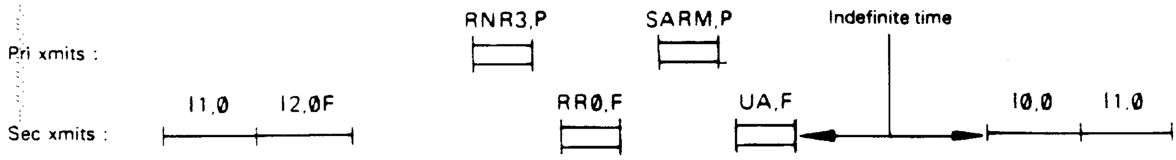
Example A



Example B

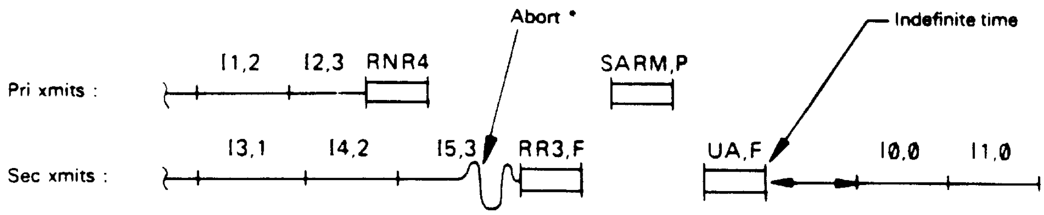


Example C

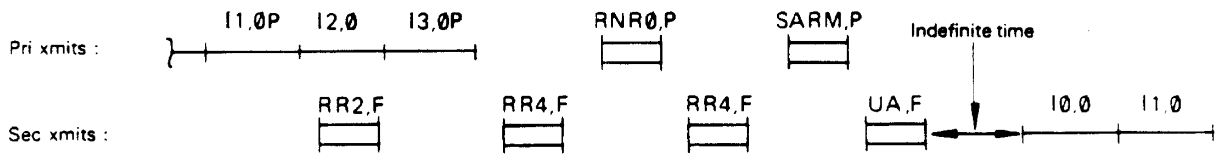


B.6.1.2 Two-way simultaneous (TWS) transmission NRM to ARM mode change

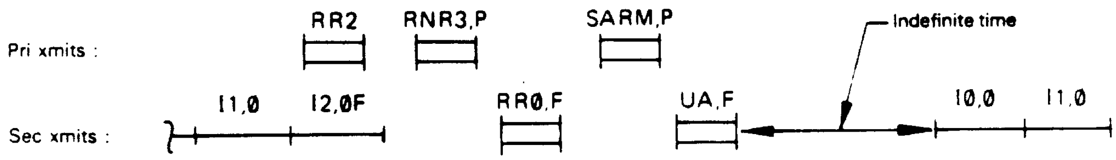
Example A



Example B



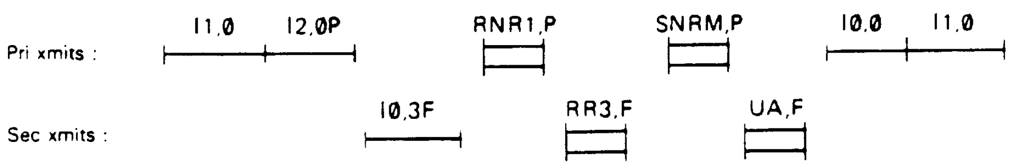
Example C



B.6.2 Asynchronous response mode (ARM) to normal response mode (NRM) change

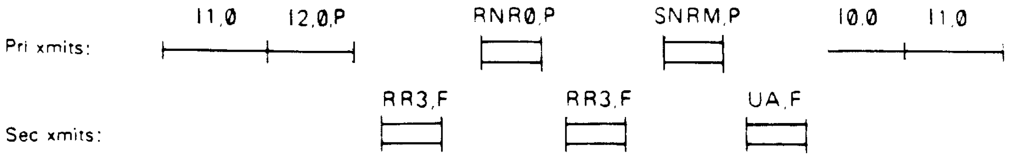
B.6.2.1 Two-way alternate (TWA) transmission ARM to NRM mode change

Example A

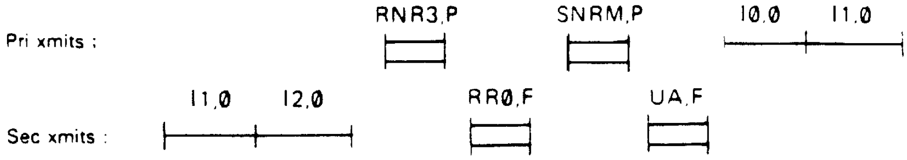


* Optional : Frame may be completed or aborted.

Example B

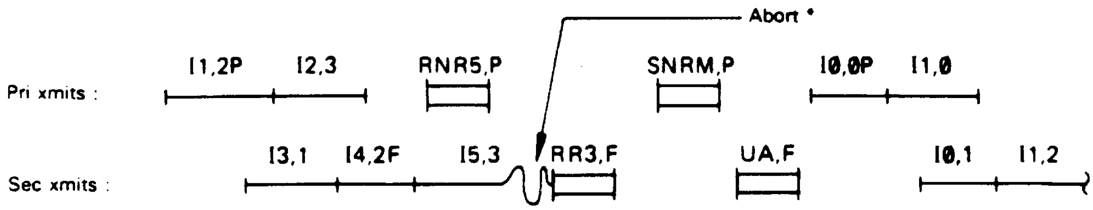


Example C

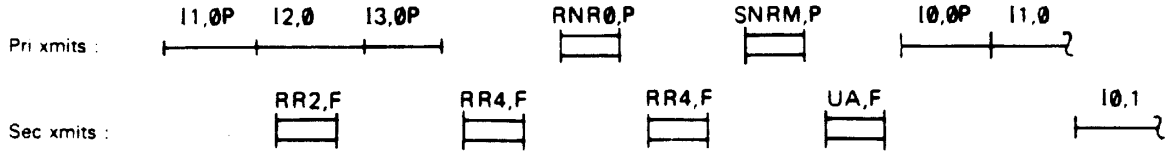


B.6.2.2 Two-way simultaneous (TWS) transmission ARM to NRM mode change

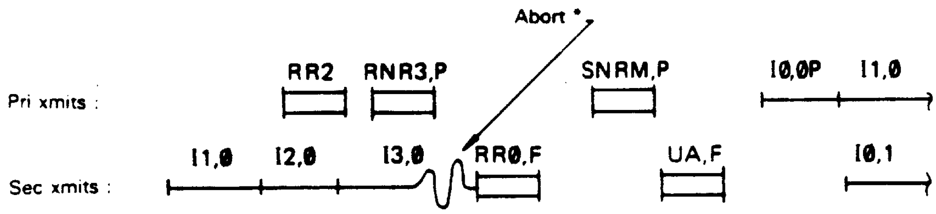
Example A



Example B

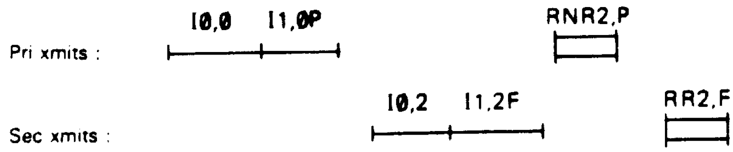


Example C



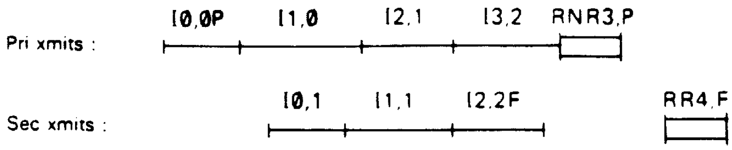
B.7 Examples of end of operation (general closing procedure)

B.7.1 Normal response mode (NRM), two-way alternate (TWA) transmission

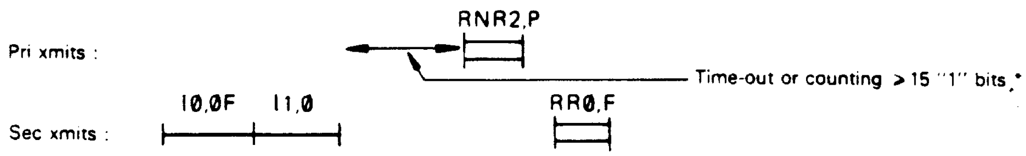


* Optional : Frame may be completed or aborted.

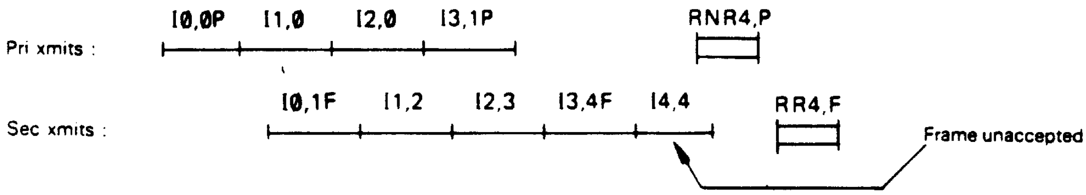
B.7.2 Normal response mode (NRM), two-way simultaneous (TWS) transmission



B.7.3 Asynchronous response mode (ARM) two-way alternate (TWA) transmission



B.7.4 Asynchronous response mode (ARM), two-way simultaneous (TWS) transmission

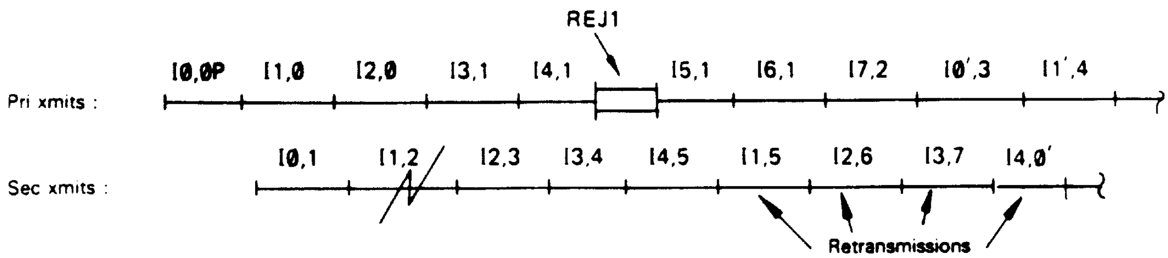


B.8 Examples of exception recovery procedures

B.8.1 REJ and poll/final bit exception recovery for TWS operation

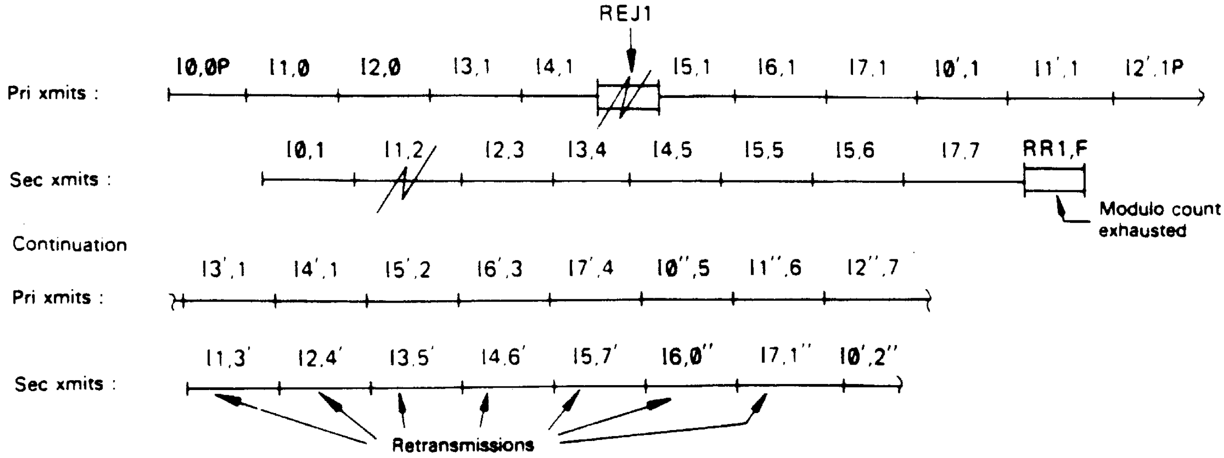
B.8.1.1 NRM — TWS with information frame exception

B.8.1.1.1 REJ received correctly



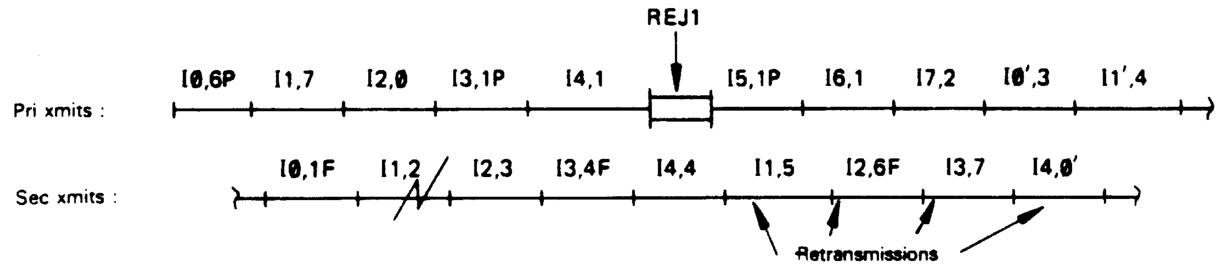
* The method of counting 15 binary "1" bits is still subject to further study with respect to possible impact on ISO 3309.

B.8.1.1.2 REJ not received correctly

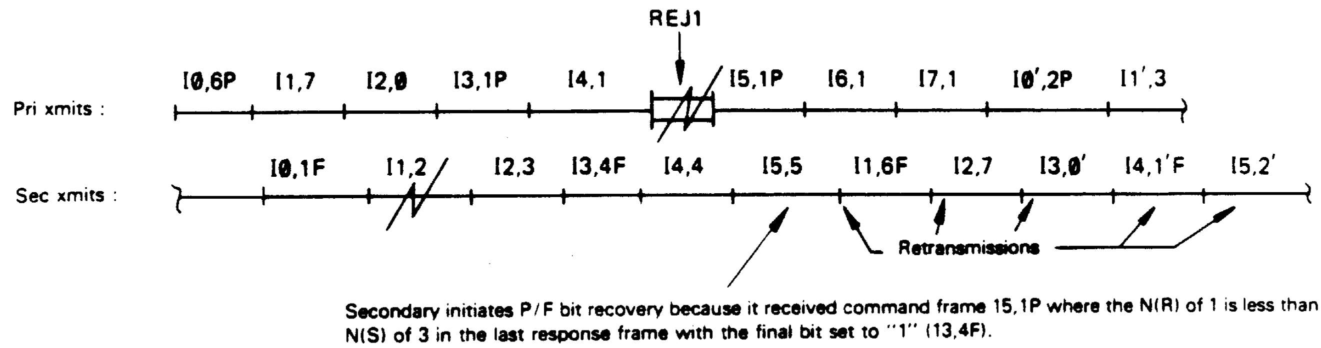


B.8.1.2 ARM — TWS information frame exception

B.8.1.2.1 REJ received correctly



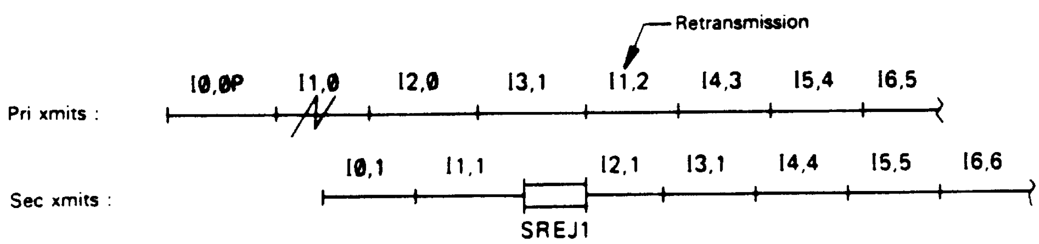
B.8.1.2.2 REJ not received correctly



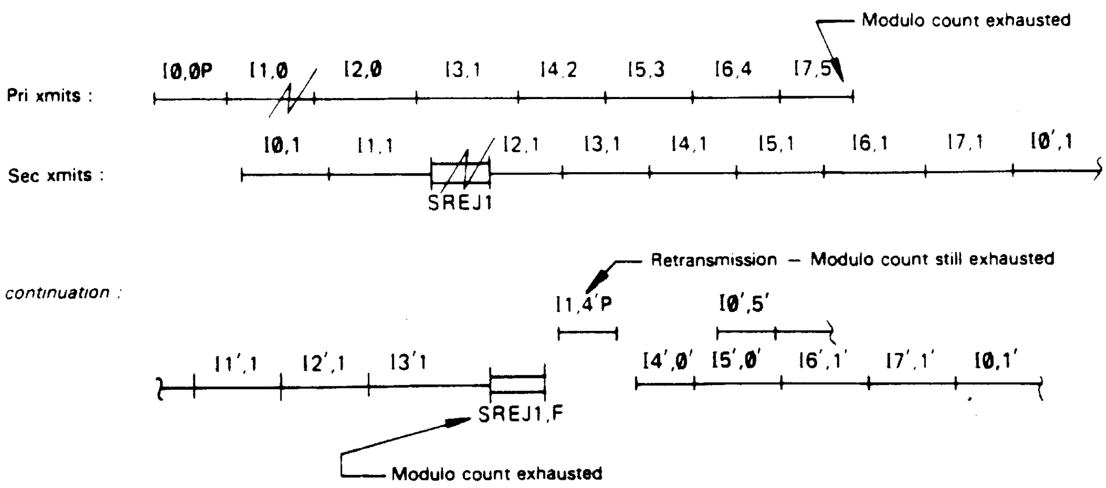
B.8.2 SREJ/REJ exception recovery for TWS operation

B.8.2.1 NRM — TWS with information frame exception

B.8.2.1.1 SREJ received correctly

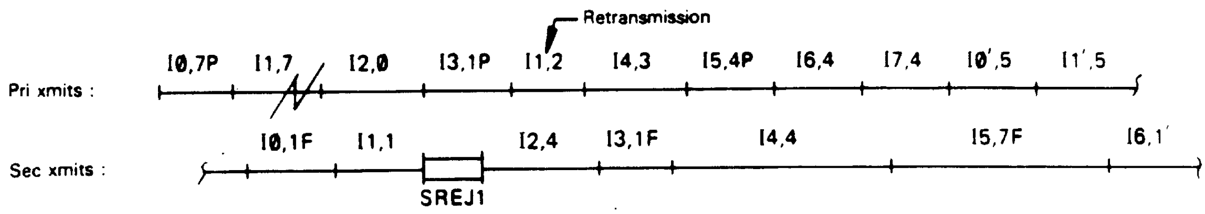


B.8.2.1.2 SREJ not received correctly

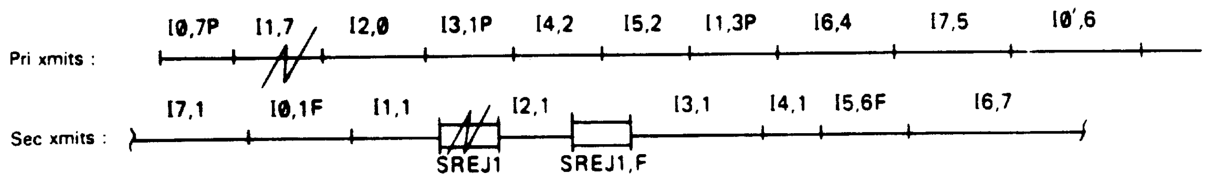


B.8.2.2 ARM — TWS with I frame exception condition

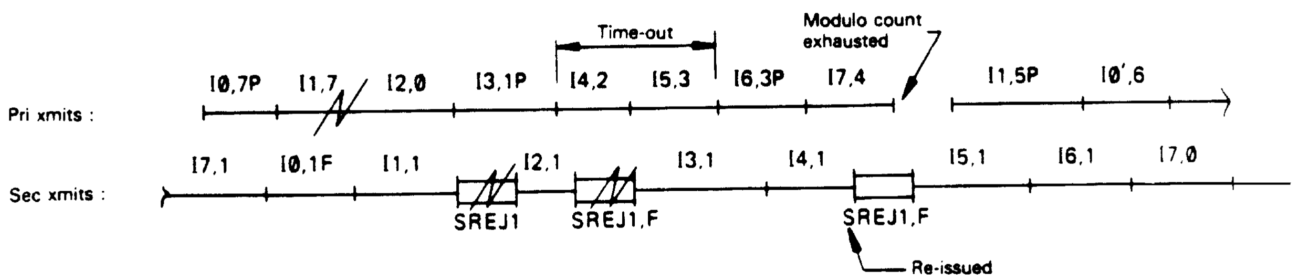
B.8.2.2.1 SREJ received correctly



B.8.2.2.2 SREJ not received correctly



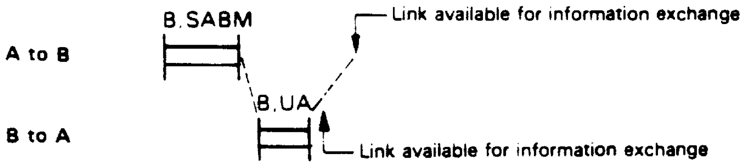
B.8.2.2.3 Second SREJ not received correctly



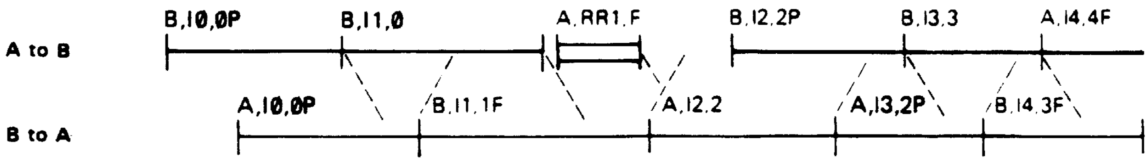
B.9 Examples of asynchronous balanced mode (ABM)

B.9.1 Asynchronous balanced mode (ABM) without transmission errors

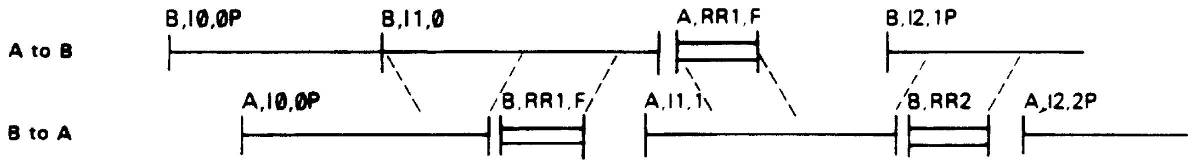
B.9.1.1 ABM start-up procedures



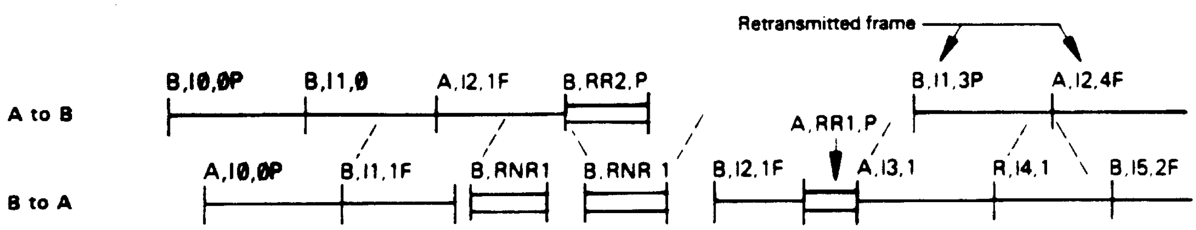
B.9.1.2 ABM information exchange — Normal acknowledgment by I frame



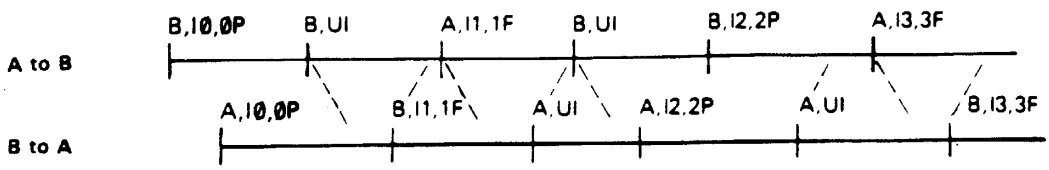
B.9.1.3 ABM information exchange — RR as preferred acknowledgment



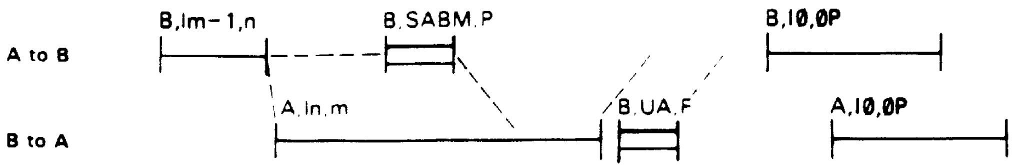
B.9.1.4 ABM information exchange — Use of RNR



B.9.1.5 ABM information exchange — Basic system extended by use of UI

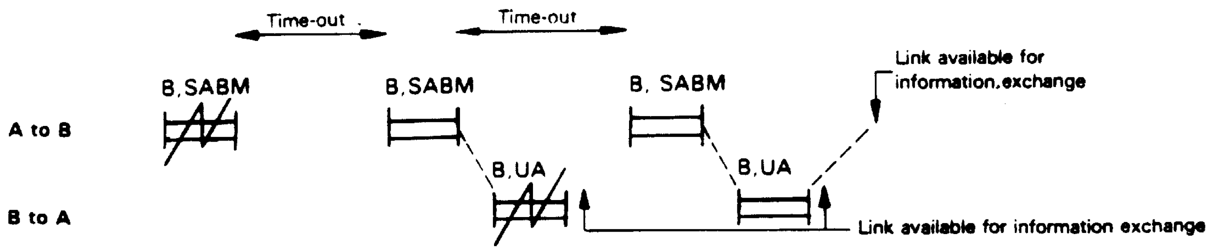


B.9.1.6 ABM resetting the numbering

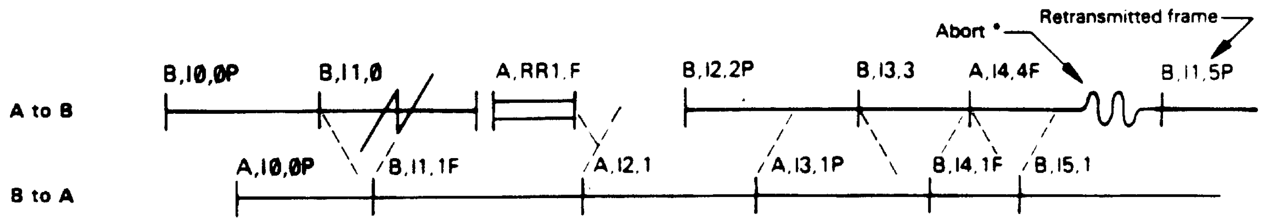


B.9.2 Asynchronous balanced mode (ABM) with transmission errors

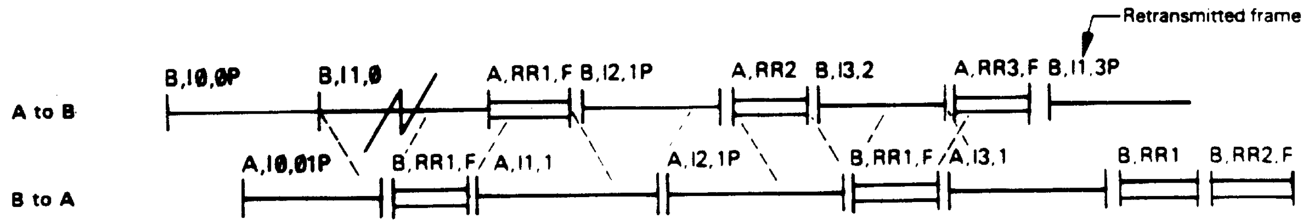
B.9.2.1 ABM start-up — command error and response error



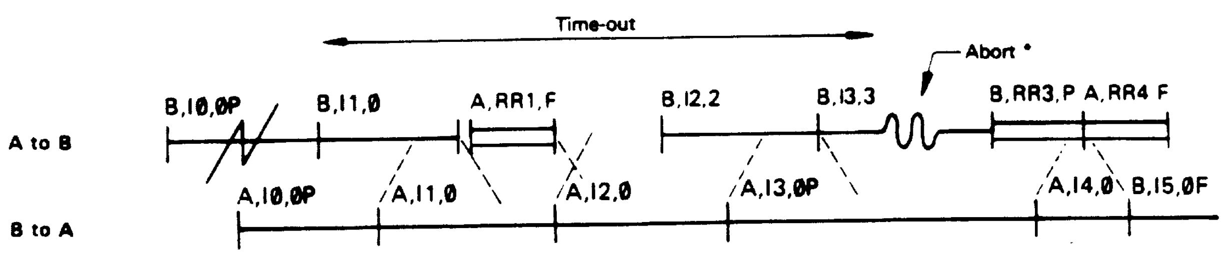
B.9.2.2 ABM information exchange — Checkpoint recovery, normal acknowledgment by I frame



B.9.2.3 ABM information exchange — Checkpoint recovery, RR as preferred acknowledgment

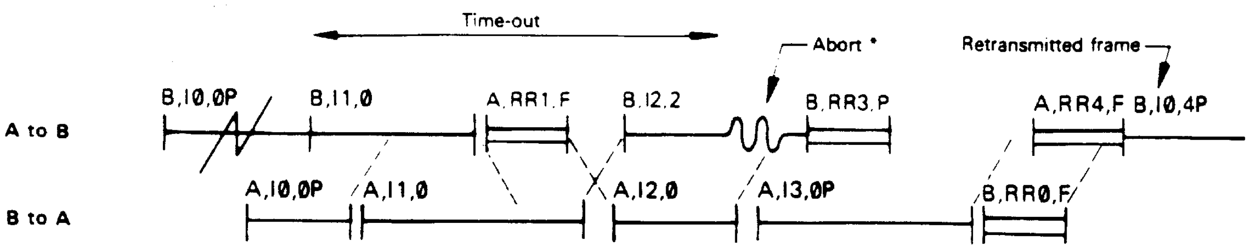


B.9.2.4 ABM information exchange — Time-out recovery, normal acknowledgment by I frame

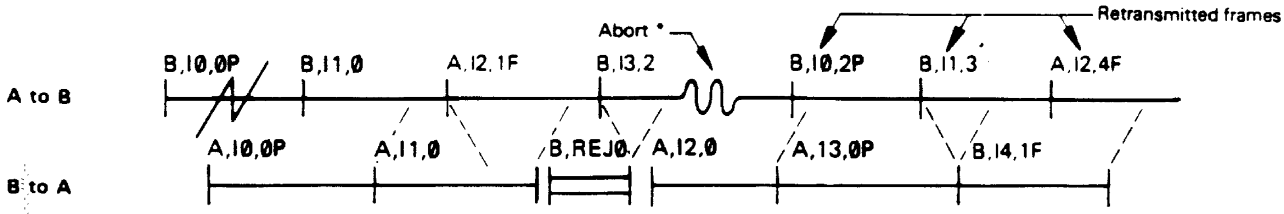


* Optional : Frame may be completed or aborted.

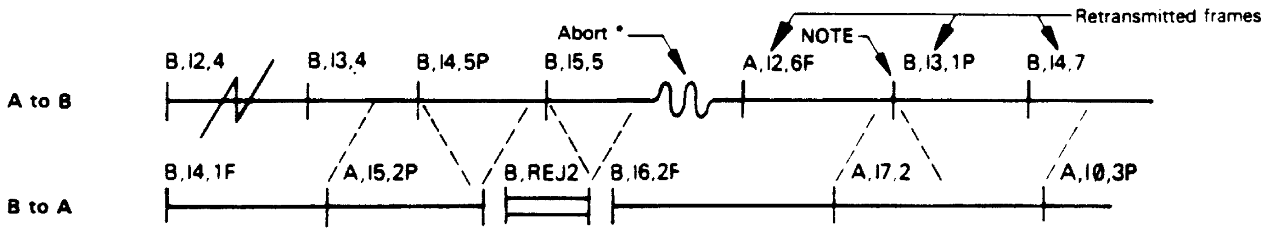
B.9.2.5 ABM information exchange — Time-out recovery, RR as preferred acknowledgment



B.9.2.6 ABM information exchange — Basic systems extended by use of REJ (see B.9.2.4 for comparison)

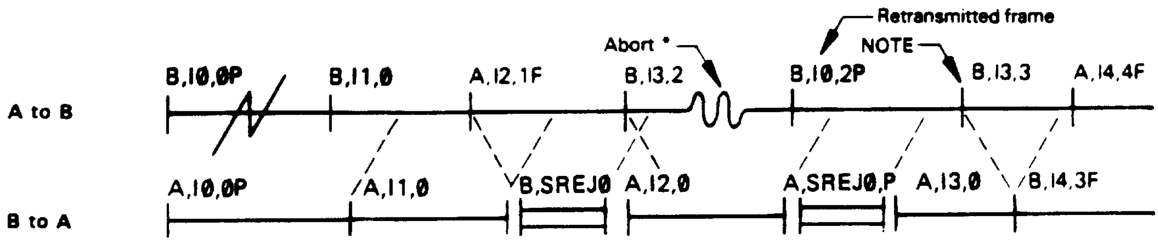


B.9.2.7 ABM information exchange — System extended by use of REJ, P/F checkpoint inhibited



NOTE — Receipt of B 16,2 F normally would have resulted in retransmission of I2 but inhibited due action following B,REJ2.

B.9.2.8 ABM information exchange — System extended by use of SREJ (see B.9.2.4 for comparison)



NOTE — A, SREJO, P not actioned due to previous action taken on B, SREJO.

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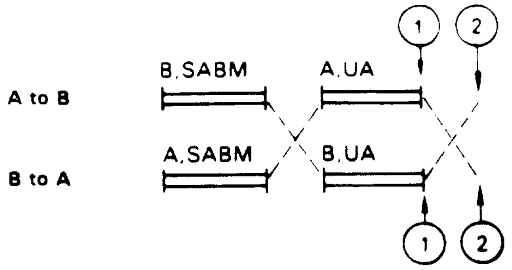
* Optional : Frame may be completed or aborted.

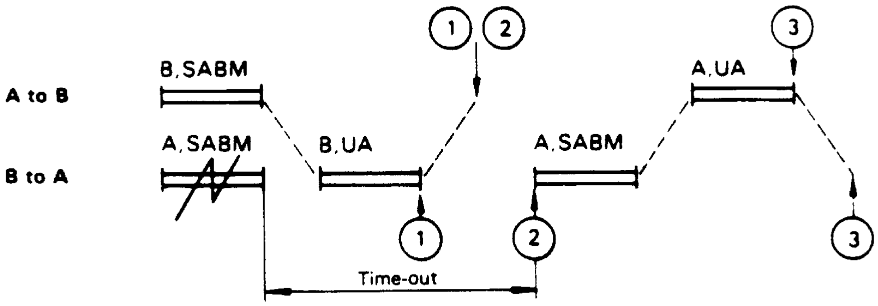
B.9.3 Asynchronous balanced mode (ABM) contention situations

B.9.3.1 ABM contention — SABM and SABM



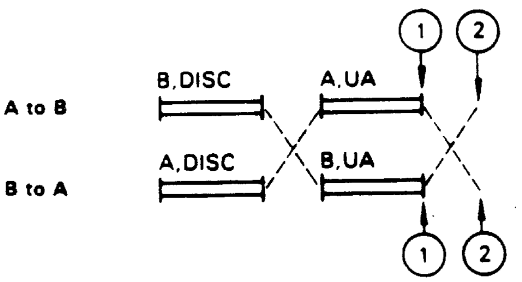
Procedure may be completed at either (1) or (2) with link available for information information transfer

B.9.3.2 ABM contention — SABM and SABM, with transmission errors



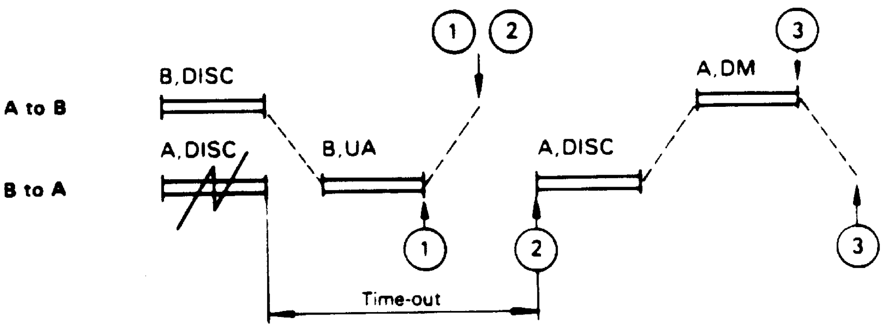
Procedure may be completed at either (1), (2) or (3) with link available for information transfer.

B.9.3.3 ABM contention — DISC and DISC



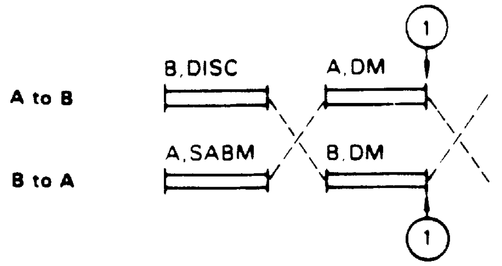
Procedure may be completed at either (1) or (2) with link in disconnected mode.

B.9.3.4 ABM contention — DISC and DISC, with transmission errors



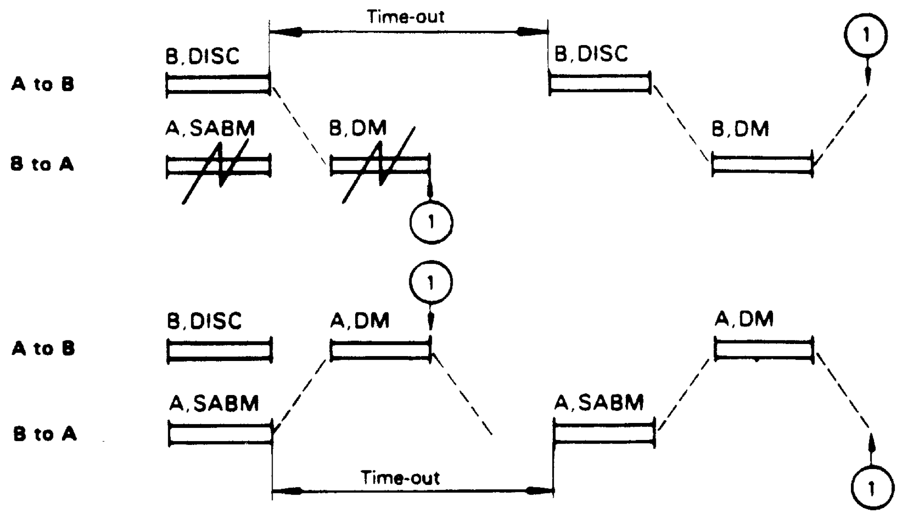
Procedure may be completed at either (1), (2) or (3) with link in disconnected mode.

B.9.3.5 ABM contention — DISC and SABM



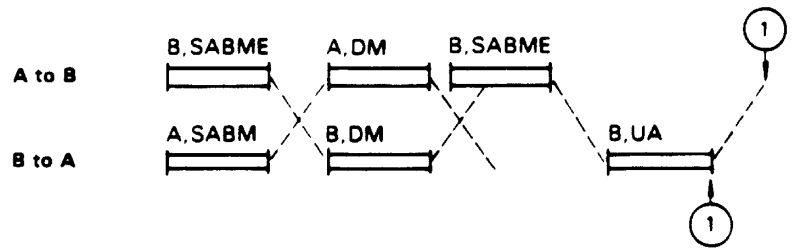
Procedure is completed at (1) with link in disconnected mode.

B.9.3.6 ABM contention — DISC and SABM, with transmission errors



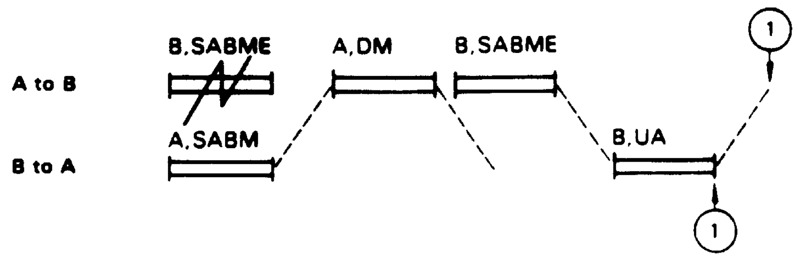
Procedure is completed at (1) with link in disconnected mode.

B.9.3.7 ABM contention — SABME and SABM

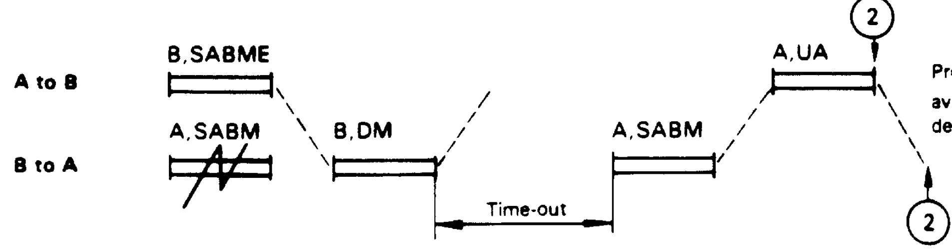


Procedure is completed at (1) with link available for information transfer in extended mode.

B.9.3.8 ABM contention — SABME and SABM, with transmission errors



Procedure is completed at (1) with link available for information transfer in extended mode.



Procedure is completed at (2) with link available for information transfer in unextended mode.

B.10 Examples of the use of multi-selective reject procedure

This clause shows examples of the use of the multi-selective reject procedure and some implementation specifics.

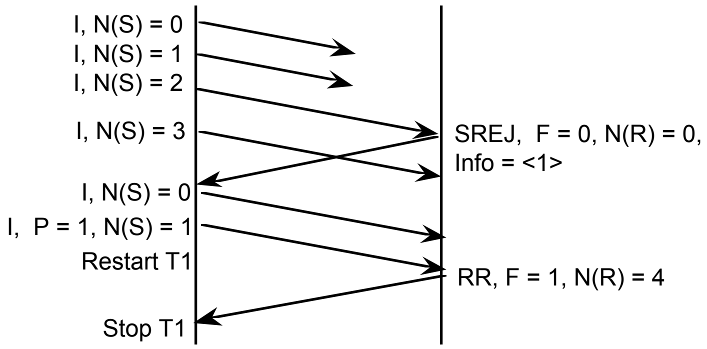
Clauses 5.6.2.1, 5.6.2.2, 5.6.2.3.1 and 5.6.2.3.2 describe mechanisms for recovering lost I frames. There is no prohibition regarding implementation of more than one mechanism. However, if more than one mechanism is implemented, it is recommended that only one mechanism be used at a time. That is, a different mechanism should not be used to recover lost I frames until the previous mechanism has completed according to its definition (as given in the above clauses) or the data station perceives by time-out that the mechanism will not succeed in I frame recovery. The following subclauses show examples of recovery using the multi-selective reject procedure of 5.6.2.3.2. Combined stations send SREJ responses but not SREJ commands.

For a combined station, after retransmission of I frames caused by the receipt of an SREJ frame with the P/F bit set to 0, if there is no outstanding poll condition (i.e., the station is not waiting for a frame with the F bit set to “1” as a response to a frame with the P bit set to “1”), then a poll is sent, either by transmitting an RR command (or RNR command if the station is in the busy condition) with the P bit set to “1” or by setting the P bit to “1” in the last retransmitted I frame.

For a combined station, after retransmission of I frames caused by the receipt of an SREJ frame with the P/F bit set to 1, if any frames are retransmitted, then a poll is sent, either by transmitting an RR command (or RNR command if the combined station is in the busy condition) with the P bit set to “1” or by setting the P bit to “1” in the last retransmitted I frame.

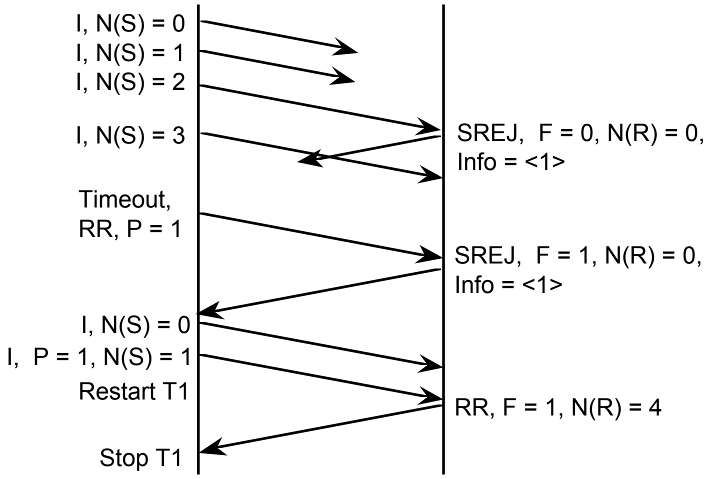
B.10.1 I frame recovery due to SREJ frame with F bit set to "0"

The following shows the frame exchange between stations when I frames are lost and recovered by retransmissions using the SREJ frame with the F bit set to "0".



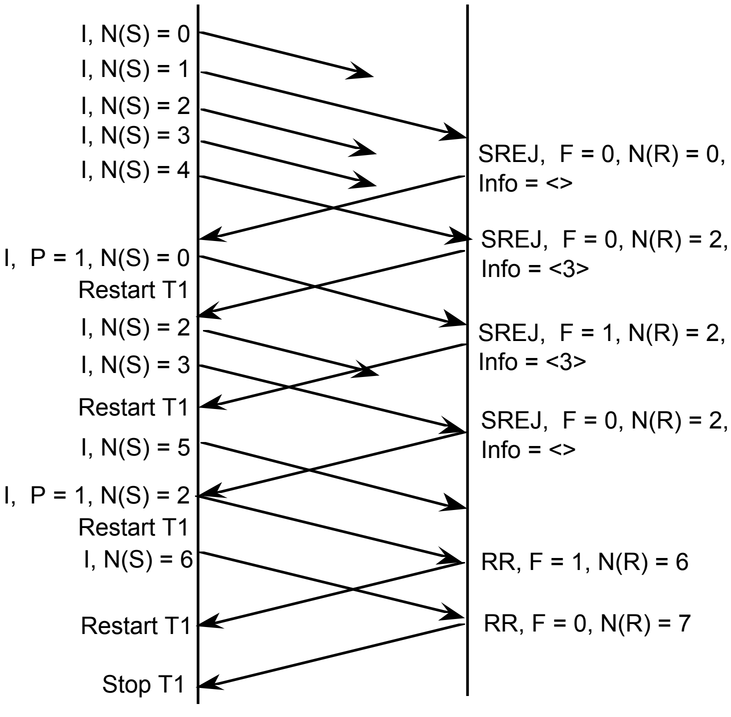
B.10.2 I frame recovery, when SREJ frame with F bit set to "0" is lost

The following shows the frame exchange between stations when I frames are lost and the resulting SREJ frame with the F bit set to "0" is also lost.



B.10.3 I frame recovery, when retransmitted I frames are lost

The following shows a more complex exchange of frames between stations where retransmitted I frames are lost.



Annex C
(informative)

Time-out function considerations for NRM, ARM and ABM

C.1 Introduction

In order to detect a no-reply or lost-reply condition, each primary/combined station shall provide a response time-out function. Also, in ARM and ABM, in order to detect a no-reply or lost-reply condition, each secondary/combined station shall provide a command time-out function. In any case, the expiry of the time-out function shall initiate appropriate error recovery procedures.

The duration of a time-out period is system dependent.

C.2 Primary/combined station command reply time-out function

C.2.1 NRM

Start condition:

Transmission of a frame with the P bit set to "1".

Restart condition:

Receipt of an error-free frame with the F bit set to "0".

Stop condition:

Receipt of an error-free frame with the F bit set to "1".

C.2.2 ARM (TWA) and ABM (TWA)

Start condition:

Transmission of a frame with the P bit set to "1".

Restart condition:

Transmission of a command frame.

Stop condition:

Receipt of an error-free frame with the F bit set to "1".

C.2.3 ARM (TWS) and ABM (TWS)

Start conition:

Transmission of a frame with the P bit set to "1".

Stop condition:

Receipt of an error-free frame with the F bit set to "1".

C.2.4 NDM, ADM and IM

Start condition:

Transmission of a frame with the P bit set to "1".

Stop condition:

Receipt of an error-free frame with the F bit set to "1".

C.3 Primary/secondary/combined station I frame reply time-out function

C.3.1 NRM

Not used.

C.3.2 ARM (TWA) and ABM (TWA)

Start condition:

Transmission of an I frame.

Restart condition:

Transmission of a frame.

Stop condition:

Receipt of an error-free frame with the expected N(R).

C.3.3 ARM (TWS) and ABM (TWS)

Start condition:

Transmission of an I frame.

Stop condition:

Receipt of an error-free frame with the expected N(R).

C.3.4 NDM, ADM and IM

Not used.

C.4 Secondary/combined station command request time-out function

C.4.1 NRM, NDM and IM

Not used.

C.4.2 ARM, ADM and ABM

Start condition:

Transmission of an unnumbered response frame which requests a command.

Stop condition:

Receipt of an error-free command frame.

C.5 No-activity time-out function (for switched circuit application)

Start condition:

Physical connection established

Restart condition:

Receipt of an error-free frame.

Stop condition:

Initialization of the disconnect procedure at the interface.

Annex D
(informative)

Examples of typical HDLC procedural subsets

D.1 Introduction

The HDLC procedures are designed to cover a wide range of applications (for example, two-way alternate [TWA], two-way simultaneous [TWS] data communication between computers, concentrators and terminals) and a wide range of configurations (for example, multipoint or point-to-point, switched or non-switched, half-duplex or duplex).

This International Standard defines a number of necessary characteristics, including frame formats, operational modes, commands, responses and exception recovery techniques. These functions, used in various combinations, provide the full range of capabilities included in HDLC.

The majority of HDLC implementations will not require the full range of capabilities provided by this International Standard. Therefore, this annex describes several typical subsets of the HDLC procedures to provide uniform HDLC implementations intended to meet the majority of applications required in the immediate future. Use of these suggested typical subsets will help to promote interoperability among independent HDLC implementations designed to satisfy similar operational requirements.

Other procedural subsets may be chosen to meet new or additional requirements provided that they conform to the classes defined in this International Standard.

D.2 Selection parameters

In order to define these typical HDLC procedural subsets, the following application parameters have been considered:

— data communication (TWA, TWS); and

— configuration [point-to-point (pt-pt), multipoint (mpt)].

From these parameters, three typical procedural subsets have been selected as examples and are summarized in table D.1.

Table D.1 — Typical HDLC procedural subsets

Parameters		**Typical HDLC procedural subsets**	
Data communication	**Configuration**	**No.**	**Definition**
TWA	mpt/pt-pt[1)]	1	UNC
TWS	mpt/pt-pt[1)]	2	UNC 2
	pt-pt	3	BAC 2,8[2)]

NOTES

1) Point-to-point may be viewed as a specific multipoint configuration.

2) BAC 2,8,10.1 is recommended in some cases.

The optional functions 2, 8 and 10.1 are recapitulated in table D.2 (see also table 13).

Table D.2 — Optional functions 2, 8 and 10.1

Option	Functional description	Command	Response	Comment
2	Provides the ability for more timely reporting of I frame sequence errors	Add REJ	Add REJ	
8	Limits the procedures to allow I frames to be commands only		Delete I	
10.1	Provides the ability to use extended sequence numbering (modulo 128)	Add SABME Delete SABM		Use extended control field format (modulo 128) instead of basic control field format.

D.3 Common features

The following common features have been established for all procedural subsets described in clause D.4:

— data integrity and recovery is assured by P/F checkpointing;

— time-outs are used in conjunction with the P/F mechanism; and

— each subset may be used with either half-duplex or duplex transmission.

D.4 Typical procedural subsets

D.4.1 Subset 1: TWA, multipoint or point-to-point, UNC (no options)

Commands	Responses
I	I
RR	RR
RNR	RNR
SNRM	UA
DISC	DM
	FRMR

This procedural subset uses the P/F bit for polling of information and status, for last frame indication and for checkpointing. The subset is suitable for two-way alternate operation on point-to-point or multipoint configurations. In two-way alternate, multipoint configurations operating over duplex physical facilities, the primary station may at any time transmit frames with the P bit set to "0" to non-polled secondary stations. Primary and secondary stations shall be able to receive all listed responses and commands from the remote data station.

D.4.2 Subset 2: TWS, multipoint or point-to-point, UNC 2

Commands	Responses
I	I
RR	RR
RNR	RNR
REJ	REJ
SNRM	UA
DISC	DM
	FRMR

This procedural subset uses the P/F bit for polling of information and status, for last frame indication and for checkpointing. The REJ frame is used by a data station to request retransmission of I frames. The subset is suitable for multipoint or point-to-point configurations where the primary and secondary stations are both capable of two-way simultaneous communication. Some point-to-point data links may be considered as specific multipoint data links. Primary and secondary stations shall be able to receive all listed responses and commands from the remote data station.

D.4.3 Subset 3

D.4.3.1 Non-extended sequence numbering: TWS, point-to-point, BAC 2,8

Commands	Responses
I	
RR	RR
RNR	RNR
REJ	REJ
SABM	UA
DISC	DM
	FRMR

This procedural subset uses the P/F bit for polling of status, and for checkpointing. The REJ frame is used by a data station to request retransmission of I frames. The subset is suitable for two-way simultaneous communication on point-to-point data links when symmetrical control of the data link is desirable. Both combined stations shall be able to receive all listed commands and responses.

NOTE X.25 LAPB without options is compatible with this procedure.

D.4.3.2 Extended sequence numbering: TWS, point-to-point, BAC 2,8,10.1

Commands	Responses
I	
RR	RR
RNR	RNR
REJ	REJ
SABME	UA
DISC	DM
	FRMR

This procedural subset is applicable in the same conditions as the non-extended one, when higher performance is needed on data links with specific characteristics such as long round-trip delays and short information field lengths.

D.4.3.3 Extended sequence numbering - modulo 2 147 483 648: TWS, point-to-point, BAC 3.3, 8, 10.3

Commands	Responses
I	
RR	RR
RNR	RNR
SREJ	SREJ
SM	UA
DISC	DM
	FRMR

This procedural subset is applicable in the same situations as the non-extended one, when high performance is needed on data links with specific characteristics, such as high bandwidth and long delay.

Annex E
(informative)

Illustrative examples of 16/32-bit FCS negotiation

E.1 General case

Assume the stations are known as X and Y, with both initially assuming the role of the initiator. Also, assume, for this example, that both X and Y are willing to operate with a 32-bit FCS. The sequence of exchanges, in the absence of transmission errors, would be as follows.

- X and Y each send an XID command parameter negotiation frame using a 16-bit FCS, while indicating in the information field that it supports the 32-bit FCS, and prepares to process incoming frames in both the 16-bit FCS and the 32-bit FCS modes simultaneously.

- Since each is processing incoming frames in both the 16-bit FCS and the 32-bit FCS modes simultaneously, each receives the other's XID command frame in 16-bit FCS. They each analyze the content of the information field and find that the other also supports a 32-bit FCS. It is therefore determined that the FCS process to be used for data interchange will be the 32-bit FCS. Because each received an XID command frame after having sent an XID command frame, a collision situation exists. The rules given in 7.4.2.3 are used to determine the roles of initiator and responder from this point forward. Based on the comparison of Unique Identifier values, it is assumed, for this example, that X is the initiator and Y is the responder. Consequently, Y responds with an XID response parameter negotiation frame using a 16-bit FCS, with the information field indicating Y's selection of a 32-bit FCS. While Y is responding to X's XID command frame, X responds to Y's XID command frame with an XID response frame that does not contain an HDLC parameters data link layer subfield, thereby indicating that its parameter values have not yet been determined. This is the way that X notifies Y that X is assuming the initiator role, is assuming that Y is the responder, and is expecting Y to select the parameter values to be used from the "menu" of parameters that X transmitted. X and Y both continue to process incoming frames in both 16-bit FCS and 32-bit FCS modes.

- X receives the XID response negotiation frame from Y with a 16-bit FCS and observes in the information field that Y selects 32-bit FCS. X then sends the appropriate mode-setting command in 32-bit FCS mode and disables the unusable 16-bit FCS mechanism.

- Y receives the XID response frame from X with a 16-bit FCS and without an HDLC parameters data link layer subfield. Y treats this frame as an indication that X has assumed the initiator role, and so awaits the mode-setting command from X that should result from Y's earlier return of an XID response parameter negotiation frame that indicated Y's selection of a 32-bit FCS. When Y receives the mode-setting command in 32-bit FCS mode, it returns the appropriate mode-setting response frame in the 32-bit FCS mode, and disables the unusable 16-bit FCS mechanism. Y is now sending and receiving in 32-bit FCS mode.

- When X receives the mode-setting response in 32-bit FCS mode, X is now sending and receiving in 32-bit FCS mode.

- At the end of the data link connection either X or Y may initiate a logical disconnect of the data link by sending the appropriate disconnect-type frame in 32-bit FCS mode. That station will then reactivate the 16-bit FCS mode and proceed to receive and process all frames received in both the 16-bit FCS mode and the 32-bit FCS mode simultaneously.

- When the other station receives the appropriate disconnect command, it enables the 16-bit FCS mechanism and returns the appropriate mode-setting response frame in the 16-bit FCS mode. The station then enters the disconnected phase wherein it proceeds to receive and process frames received in both the 16-bit FCS mode and the 32-bit FCS mode simultaneously.

E.2 Constrained case

Assume that the roles of initiator and responder are determined by which is the calling station and called station, respectively. Further assume that collision situations do not occur and that the only station types concerned are those that support 16-bit FCS only and those that support 16-bit and 32-bit FCS.

In the following example, assume the stations are known as A and B, with A being the initiator (calling station) and B being the responder (called station). Also, assume that both A and B support 16-bit and 32-bit FCS, and that both are willing to operate with a 32-bit FCS. The sequence of exchanges, in the absence of transmission errors, would be as follows.

- A sends an XID command parameter negotiation frame using a 16-bit FCS, while indicating in the information field that it also supports 32-bit FCS, and prepares to process incoming frames in 16-bit FCS. B is processing incoming frames in both 16-bit FCS mode and 32-bit FCS mode simultaneously, so it receives A's XID frame in 16-bit FCS. B analyzes the content of the information field and finds that A supports a 32-bit FCS. B responds with an XID response parameter negotiation frame using a 16-bit FCS, with the information field indicating B's selection of 32-bit FCS. B continues to process incoming frames in both 16-bit and 32-bit FCS modes.

- A receives the XID response parameter negotiation frame from B with a 16-bit FCS and observes in the information field that B selects 32-bit FCS. A then sends the appropriate mode-setting command in 32-bit FCS mode and prepares to process incoming frames in 32-bit FCS instead of in 16-bit FCS.

- When B receives the mode-setting command in 32-bit FCS, it returns the appropriate mode-setting response in 32-bit FCS mode and disables the unusable 16-bit FCS mechanism. B now is sending and receiving in 32-bit FCS mode.

- When A receives the mode-setting response in 32-bit FCS mode, A is also sending and receiving in 32-bit FCS mode.

Annex F
(informative)

Guidelines for communicating with LAPB X.25 DTEs

If a DTE designed in accordance with this International Standard establishes a circuit switched connection to a remote X.25 LAPB station which does not support the requirements specified in 8.1 of this standard, the local DTE, after sending an XID command frame may receive either

a) a DM response frame with the data link layer address of "A" (as defined in ISO/IEC 7776), or

b) an unsolicited SABM/SABME command frame with address "B" (as defined in ISO/IEC 7776), or

c) nothing, following N2 attempts

from the remote DTE.

In the case of a) and b) above, the local DTE (conforming to this International Standard) may wish to assume the role of an X.25 DCE and react in accordance with ISO/IEC 7776.

In the case of c), the local DTE will tentatively send an SABM/SABME command frame with the address of "A". If, in turn, the local DTE receives a UA response frame with the address "A", the local DTE will take the role of an X.25 DCE. Otherwise, it will terminate its action and abandon the call.

Annex G
(informative)

Examples of information field encoding in multi-selective reject frames

G.1 General

This annex indicates, by example, how the information field of multi-selective reject frames can be encoded to utilize span lists, as well as individual frame identification. A span list identifies a sequence of contiguously numbered I frames that are in need of retransmission. The examples shown are for modulo 128, although the approach is equally applicable to modulo 8, modulo 32 768, and modulo 2 147 483 768. In each case, the first I frame in need of retransmission is indicated in the control field, and the remaining I frames in need of retransmission are indicated in the information field.

G.2 Example

Example 1 is a case where I frames 4, 6, 9, 10, 11, 12 and 15 are in need of retransmission.

A	C			Information Field								FCS
		x	4	0	6	1	9	1	12	0	15	
				ind		span				ind		

Example 2 is a case where I frames 4, 6, 9, 10, 11, 12, 15, 16, 17, and 19 are in need of retransmission.

A	C			Information Field																FCS
		x	4	0	6	1	9	1	12	1	15	1	17	0	19					
				ind		span				span				ind						

Example 3 is a case where I frames 4, 5, 6, 9, 11, 12, 13, 15, 17, 18, and 19 are in need of retransmission.

A	C			Information Field																FCS
		x	4	1	5	1	6	0	9	1	11	1	13	0	15	1	17	1	19	
				span				ind		span				ind		span				

In all of the foregoing examples, because the bit that precedes the N(R) value in the control field is the P/F bit, it is shown as having a value of *x*, where *x* can be either “0” or “1”.

Annex H
(normative)

Frame format types

The following frame format types have been defined, where, by convention, a value of 0 in the length subfield implies that the receiver should scan for the next flag sequence to terminate the frame.

H.1 Frame format type 0

FLAG	FR FMT	ADDR FIELD(S)	CTL	INFOR-MATION	FCS	FLAG
1	1	n_a>=1	n_c>=1	n>=0	2	1

Total frame length 5 to 127 octets

This frame format is intended for use in bandwidth limited environments where small frame sizes are necessary. This format attempts to minimize header overhead to the greatest degree possible.

H.2 Frame format type 1

FLAG	FRAME FORMAT	ADDR FIELD(S)	CTL	INFOR-MATION	FCS	FLAG
1	2	n_a>=1	n_c>=1	n>=0	p=1, 2, 4	1

Total frame length 5 to 4095 octets

This frame format is defined to be similar to basic mode HDLC with a length field. The segmentation subfield is not used. This frame format is used with those media where the advantages gained by having a length field, e.g., avoiding bit or octet insertion for transparency, are required.

H.3 Frame format type 2

FLAG	FRAME FORMAT	ADDRESS FIELD(S)	CTRL	HCS	INFORMATION	FCS	FLAG
1	2	n_a>=1	n_c>=1	p=1, 2, 4	n>=0	p=1, 2, 4	1

Total frame length 5 to 2047 octets

This frame format is used in those environments where additional error protection and/or longer frame sizes are needed. Type 2 requires the use of the segmentation subfield, thus reducing the length field to 11 bits. Frames that do not have an information field, e.g., as with some supervisory frames, or an information field of zero length do not contain an HCS and an FCS, only an FCS. The HCS and FCS polynomials will be the same. The HCS may be 1, 2, or 4 octets in length.

H.4 Frame format type 3

FLAG	FRAME FORMAT	DESTINATION ADDRESS	SOURCE ADDRESS	CONTROL	HCS	INFORMATION	FCS	FLAG
1	2	n_a >= 1	n_a >= 1	1	p=1,2,4	n >= 0	p=1, 2, 4	1

Total frame length 7 to 2047 octets

This frame format is used in those environments where additional error protection, identification of both the source and the destination, and/or longer frame sizes are needed. Type 3 requires the use of the segmentation subfield, thus reducing the length field to 11 bits. Frames that do not have an information field, e.g., as with some supervisory frames, or an information field of zero length do not contain an HCS and an FCS, only an FCS. The HCS and FCS polynomials will be the same. The HCS may be 1, 2, or 4 octets in length.

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