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

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

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Contents

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. 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.

International Standard ISO/IEC 4335 was prepared by Joint Technical Committee ISO/IEC JTC1, *Information technology*.

This fourth edition cancels and replaces the third edition (ISO 4335 : 1987), which has been technically revised.

Annexes A, B and C of this International Standard are for information only.

Introduction

General

High-level data link control (HDLC) procedures are designed to permit synchronous or start/stop, code-transparent data transmission. This International Standard describes the HDLC elements of procedures. Further studies are in progress to identify and define additional elements of procedures which may be included at a later date.

In HDLC procedures, 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. 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.

Data sequence integrity between the data source and the data sink is effected by means of a numbering scheme, which is cyclic within a modulus specified in this International Standard 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, 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, and the frames they transmit are referred to as response frames.

For the transfer of data between the primary station and the secondary stations, two cases of data link control are considered (see figures 1 and 2). In the first case, the data station comprising the data source performs a primary station data link control function and controls the data station comprising the data sink that is associated with a secondary station data link control function, by select-type commands.

In the second case, the data station comprising the data sink performs a primary station data link control function and controls the data station comprising the data source that is associated with a secondary 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 control may be combined so that the data link becomes capable of two-way alternate communication, or two-way simultaneous communication.

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 and is capable of transmitting and receiving both command and response frames.

For the transfer of data between combined stations, the data link control functions illustrated in figure 3 are utilized. The data source in each combined station controls the data sink in the other combined 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 station to solicit acknowledgements and status responses from the other combined station.

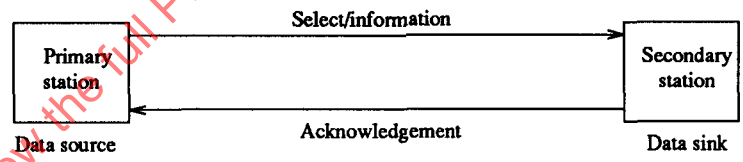


Figure 1 — Unbalanced data link configuration (case 1)

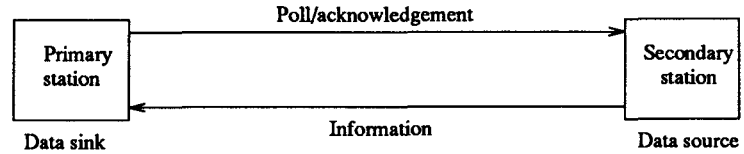


Figure 2 — Unbalanced data link configuration (case 2)

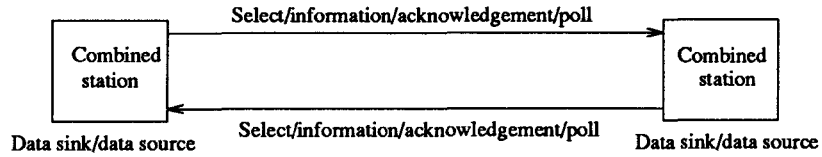


Figure 3 — Balanced data link configuration

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

1 Scope

This International Standard specifies elements of data link control procedures for synchronous or start/stop, code-transparent data transmission using the HDLC frame structure specified in ISO 3309 and 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 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 HDLC elements of procedures are to be considered as a common basis for establishing different types of 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 a particular system implementation.

2 Normative references

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

ISO/IEC 2382-9 : 1984, *Information technology - Vocabulary - Part 9 : Data communication.*

ISO/IEC 3309 : 1991, *Information technology - Telecommunications and information exchange between systems - High-level data link control (HDLC) procedures - Frame structure.*

3 Definitions

For the purposes of this International Standard, the following definitions apply (see also ISO/IEC 2382-9).

3.1 abort : A function invoked by a sending primary, secondary or combined station causing the recipient to discard (and ignore) all bit sequences transmitted by the sender since the preceding flag sequence.

3.2 accept : The condition assumed by a data station (primary, secondary or combined station) upon accepting a correctly received frame for processing.

3.3 address field (A) : The sequence of eight (or any multiple of eight, if extended) bits immediately following the opening flag sequence of a frame identifying the secondary/combined station sending (or designated to receive) the frame.

3.4 address field extension : Enlarging the address field to include more addressing information.

3.5 basic status : A secondary/combined station's capability to send or receive a frame containing an information field.

3.6 centralized control : A control in which all the primary station functions of the data link are centralized in one data station.

3.7 combined : 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 level.

3.8 command : In data communication, an instruction represented in the control field of a frame and transmitted by the primary/combined station. It causes the addressed secondary/combined station to execute a specific data link control function.

3.9 command frame :

a) All frames transmitted by a primary station.

b) Those frames transmitted by a combined station that contain the address of the other combined station.

3.10 contention mode : A mode of transmission in which a transmitter can send on its own initiative.

3.11 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.

3.12 control field (C) : The sequence of eight (or sixteen, 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 station, designated by the address field, as a command instructing the performance of some specific function; and

b) the receiving primary/combined station as a response from the secondary/combined station, designated by the address field, to one or more commands.

3.13 control field extension : Enlarging the control field to include additional control information.

3.14 data communication : See ISO/IEC 2382-9, term 09.01.03.

3.15 data link : An assembly of two or more terminal installations and the interconnecting line operating according to a particular method that permits information to be exchanged.

NOTE — In this context, the term "terminal installation" does not include the data source and the data sink.

3.16 data link level : The conceptual level of control or processing logic existing in the hierarchical structure of a data station (primary, secondary or combined station) that is responsible for maintaining control of the data link.

NOTE — The data link level functions provide an interface between the data station high level 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.

3.17 data transmission : See ISO/IEC 2382-9, term 09.01.02.

3.18 duplex transmission : See ISO/IEC 2382-9, term 09.03.01.

3.19 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.

3.20 flag sequence (F) : the unique sequence of eight bits (01111110) employed to delimit the opening and closing of a frame.

3.21 frame : The sequence of address, control, information, and FCS fields, bracketed by opening and closing flag sequences.

NOTE — A valid frame is at least 32 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.

3.22 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.

3.23 half-duplex transmission : See ISO/IEC 2382-9, term 09.03.02.

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

3.25 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 and UI frames are not interpreted at the data link level.

3.26 interframe time fill : The sequence or condition transmitted between frames.

3.27 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.

3.28 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.

3.29 primary station : The data station that supports the primary station control functions of the data link, i.e. that generates commands for transmission and interprets received responses.

NOTE — Specific responsibilities assigned to the primary station include:

a) initialization of control signal interchange;

b) organization of data flow; and

c) actions regarding error control and error recovery functions at the data link level.

3.30 primary/secondary station : The general case where the station may be either a primary station or a secondary station.

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

3.32 response frame:

a) All frames transmitted by a secondary station.

b) Those frames transmitted by a combined station that contain the address of the transmitting combined station.

3.33 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.

3.34 secondary station status : The current condition of a secondary station with respect to processing the series of commands received from the primary station.

3.35 two-way alternate data communication : See ISO/IEC 2382-9, term 09.05.03.

3.36 two-way simultaneous data communication : See ISO/IEC 2382-9, term 09.05.02.

3.37 unnumbered commands : The commands that do not contain sequence numbers in the control field.

3.38 unnumbered responses : The responses that do not contain sequence numbers in the control field.

4 Data link channel states

4.1 Active data link channel state

4.1.1 General

A data link channel is in an active state when the primary station, a secondary station or a combined 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.

4.1.2 Abort

4.1.2.1 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.

4.1.2.2 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.

4.1.3 Interframe time fill

4.1.3.1 Synchronous transmission

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

4.1.3.2 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.

4.1.4 Intraframe time fill

4.1.4.1 Synchronous transmission

There is no provision for time fill within a frame.

4.1.4.2 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).

4.2 Idle data link channel state

4.2.1 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 level shall be considered to indicate that the remote data station has relinquished its right to continue transmission.

4.2.2 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 timeout function. The duration of this timer is not a subject of this International Standard.

5 Modes

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

5.1 Operational modes

The three operational modes are:

a) normal response mode (NRM);

b) asynchronous response mode (ARM); and

c) asynchronous balanced mode (ABM).

5.1.1 Normal response mode (NRM)

In NRM, which is an unbalanced data link operation 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.

5.1.2 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).

5.1.3 Asynchronous balanced mode (ABM)

In ABM, which is a balanced data link operation 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 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 station; 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 is 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 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), 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 level 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.

5.2.1 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. A 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 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. A 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, 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).

5.2.3 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 regenerated 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.

6 Control field and parameters

6.1 Control field formats

6.1.1 General

The three formats defined for the control field (see table 1) are used to perform numbered information transfer, numbered supervisory functions and unnumbered control functions and unnumbered information transfer.

6.1.2 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".

Table 1 — Control field formats

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)

6.1.3 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".

6.1.4 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.

6.2 Parameters

6.2.1 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 or 128. The sequence numbers cycle through the entire range. The control field formats for modulo 8 are shown in table 1. The control field formats for modulo 128 are shown in table 4 (see 7.4).

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 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.

6.2.2 Frame state variables and sequence numbers

6.2.2.1 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.

6.2.2.2 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.

6.2.2.3 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.

6.2.2.4 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 rate). 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.

6.2.2.5 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 7.2.4 for definition of the use of the SREJ command and response.)

6.2.3 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.

6.3 Functions of the poll/final (P/F) bit

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.)

6.3.1 Functions of the poll bit

6.3.1.1 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.

6.3.1.2 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".

6.3.1.3 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 6.3.2.2.

6.3.2 Functions of the final bit

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".

6.3.2.1 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.

6.3.2.2 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, SIM, DISC) and the reset (RSET) command.

6.3.3 Use of the P/F bit to assist in error recovery (see also clause 8)

6.3.3.1 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 8.2.1h) 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.

6.3.3.2 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".

6.3.3.3 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".

6.3.3.4 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".

6.3.4 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 2.

Table 2 - 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

7 Commands and responses

The set of commands and responses is summarized in table 3.

Table 3 - 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	UA - Unnumbered acknowledgement
SARM - Set asynchronous response mode	DM - Disconnected mode
SABM - Set asynchronous balanced mode	RIM - Request initialization mode
DISC - Disconnect	RD - Request disconnect
SNRME - Set normal response mode extended	UI - Unnumbered information
SARME - Set asynchronous response mode extended	XID - Exchange identification
SABME - Set asynchronous balanced mode extended	FRMR - Frame reject
SIM - Set initialization mode	TEST - Test
UP - Unnumbered poll	
UI - Unnumbered information	
XID - Exchange identification	
RSET - Reset	
TEST - Test	

7.1 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 4.

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.

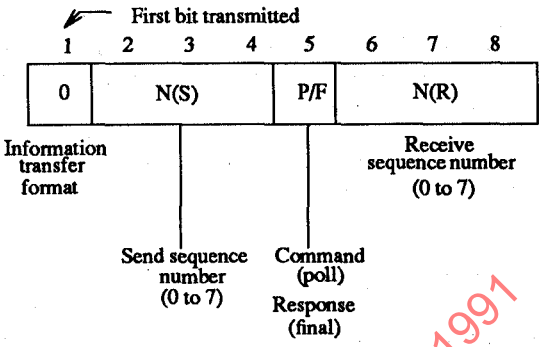


Figure 4 - Information transfer format of control field bits

(See 6.3 for a description of the functions of the P/F bit.)

7.2 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 contain an information field and, therefore, shall not increment the send state variable at the transmitter or the receive state variable at the receiver.

The encoding of the S format command/response control field shall be as shown in figure 5.

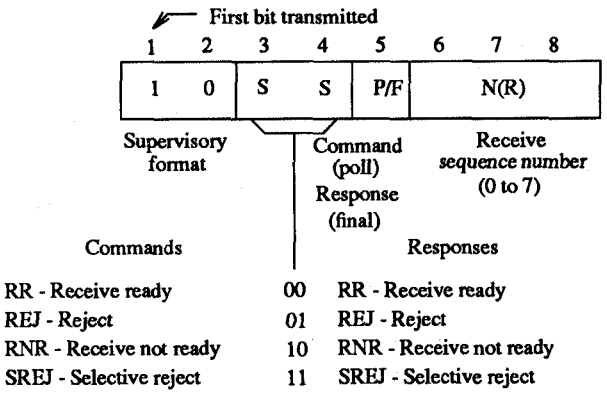


Figure 5 - Supervisory format of control field bits

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 6.3 for a description of the functions of the P/F bit.)

7.2.1 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 8.1.)

7.2.2 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 8.2.2, 8.2.3 and 8.2.4.

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.

7.2.3 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.

7.2.4 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 the single I frame numbered N(R). If the P/F bit in the SREJ frame is set to "1", then I frames numbered up to N(R) - 1 inclusive shall be considered as acknowledged. However, if the P/F bit in the SREJ frame is set to "0", then the N(R) of the SREJ frame does not indicate acknowledgement of I frames.

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

A data station may transmit one or more SREJ frames, each containing a different N(R) with the P bit set to "0", 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 8.2.3 and 8.2.4. (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 8.2.3 and 8.2.4.

I frames that may have been transmitted following the I frame indicated by the 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 requested by the SREJ frame.

(See 8.2 for sequence error recovery procedures.)

7.3 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. Thirteen command functions and eight 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.

(See 6.3 for a description of the functions of the P/F bit.)

7.3.1 Unnumbered commands

The unnumbered command encodings are shown in figure 7.

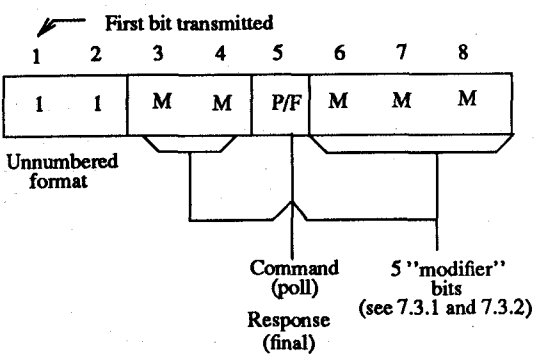


Figure 6 - Unnumbered format of control field bits

First bit transmitted

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	0	XID command
1	1	1	1	P	0	0	1	RESET command (combined station only)
1	1	0	0	P	1	1	1	TEST command

Figure 7 - Unnumbered command control field bit assignments

The SNRM, SARM, SABM, DISC, SNRME, SARME, SABME 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, a 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 or UI 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 or SABME) 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.

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.

7.3.1.1 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. No information field shall be permitted with the SNRM command. 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 higher level. 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.

7.3.1.2 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. No information field shall be permitted with the SARM command. 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 higher level. 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.

7.3.1.3 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. No information field shall be permitted with the SABM command. 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 higher level. 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.

7.3.1.4 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 level may also serve to initiate, at the physical level interface, a physical disconnect operation of the physical level; i.e. to have the addressed secondary/combined station go "on-hook". No information field shall be permitted with the DSIC command. 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 higher level. 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.

7.3.1.5 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 7.4). No information field shall be permitted with the SNRME command. 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 higher level. 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.

7.3.1.6 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 7.4). No information field shall be permitted with the SARME command. 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 higher level. Whether the content of the information field of such unacknowledged I frames in reassigned to data link control for transmission or not is decided at a higher level.

7.3.1.7 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 7.4). No information field shall be permitted with the SABME command. 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 higher level. 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.

7.3.1.8 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 level 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 higher level. 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.

7.3.1.9 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 receive 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.

7.3.1.10 Unnumbered information (UI) command

The UI command shall be used to send information (for example, status, application data, operation, interruption, temporal data, link level programs 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.

7.3.1.11 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 8.

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.

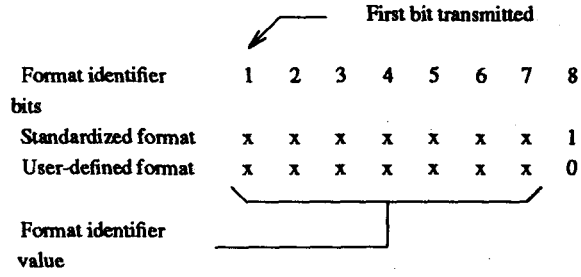


Figure 8 - XID format identifier

7.3.1.12 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 higher level. 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.

7.3.1.13 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 level 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 level.

7.3.2 Unnumbered responses

The unnumbered response encodings are shown in figure 9.

First bit transmitted

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

Figure 9 - Unnumbered response control field bit assignments

7.3.2.1 Unnumbered acknowledgement (UA) response

The UA response shall be used by the secondary/combined station to acknowledge the receipt and acceptance of SNRM, SARM, SABM, SNRME, SARME, SABME, RSET, SIM and DISC commands. No information field shall be permitted with the UA response.

7.3.2.2 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 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 8.4 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, or DISC command, as applicable.

An information field shall be returned with this response to provide the reason for the frame rejection. The information field shall contain the fields shown in figure 10.

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 10 - Information field format for FRMR response in modulo 8 operation

The functions of the fields in figure 10 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 fame 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 8.4.)

When control field extension (see 7.4) is used, the format for the information field returned with the FRMR response shall be as shown in figure 11.

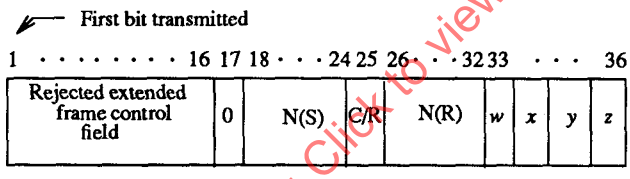


Figure 11 - Information field format for FRMR extended response in modulo 128 operation

Bit 18 and bit 26 are the low-order bits of the state variable values.

In the extended FRMR response format, 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.

7.3.2.3 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. No information field shall be permitted with the DM response.

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, or SIM, as appropriate).

7.3.2.4 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.

7.3.2.5 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.

7.3.2.6 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.

7.3.2.7 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 8 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.

7.3.2.8 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.

7.3.3 Assignment of XID format identifiers

Annex C contains information on the standardized XID formats that have been identified at the time of publication of this International Standard.

Annex C will be updated, as appropriate, in future editions of this International Standard to provide information on any additional standardized XID formats that may be recognized as subjects of other International Standards or CCITT Recommendations.

7.4 Control field formats for modulo 128

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 (U format) shall be as shown in table 4.

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

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								

8 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 level. The exception conditions described are those situations which may occur as the result of transmission errors, data station malfunction or operational situations.

8.1 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, 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".

8.2 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 8.2.3 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.

8.2.1 Poll/final (P/F) bit (checkpoint) recovery (see also 6.3)

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.

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 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 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 correspondent 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.

8.2.2 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 6.3.3.1, 6.3.3.2, 6.3.3.3 and 8.2.1), 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.

8.2.3 SREJ recovery

The SREJ command/response shall be used primarily to initiate more efficient error recovery by requesting the retransmission of a single I frame following the detection of a sequence error rather than the retransmission of the I frame requested plus all additional I frames which may have been transmitted subsequently.

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 "1", or one or more SREJ responses, each the F bit set to "0", and the "sent SREJ" 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 at 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 frame is 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) contained in each SREJ frame. After having retransmitted the frames above, 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 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 transmission of the P bit (primary station) or 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 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 transmission 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.

8.2.4 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 enquire 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.

NOTES

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.

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.

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.

4 Care should be taken if a higher level attempts to change an information field which is being retransmitted as a 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).

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.

8.3 FCS error

Any frame received with a FCS 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 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.

8.4 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 level. 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 level 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).

8.5 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.

Annex A
(informative)

Time-out function considerations

A.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 and subject to bilateral agreement.

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

A.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 "1".

Stop condition:

Receipt of an error-free frame with the F bit set to "1".

A.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".

A.2.3 ARM (TWS) and ABM (TWS)

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".

A.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".

A.3 Primary/secondary/combined station I-frame reply time-out function

A.3.1 NRM

Not used.

A.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).

A.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).

A.3.4 NDM, ADM and IM

Not used.

A.4 Secondary/combined station command request time-out function

A.4.1 NRM, NDM and IM

Not used.

A.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.

A.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.

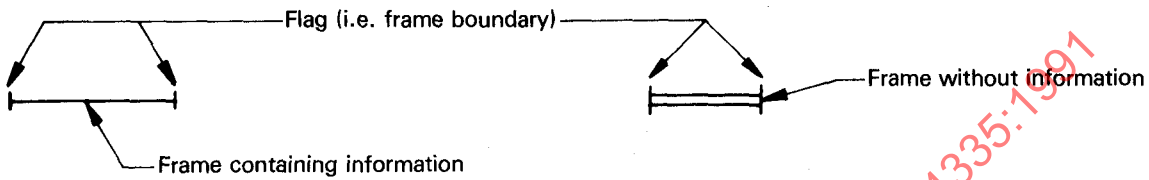
Annex B
(informative)

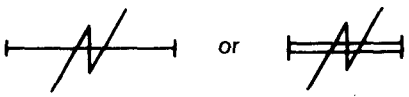
Examples of the use of commands and responses

B.1 Introduction

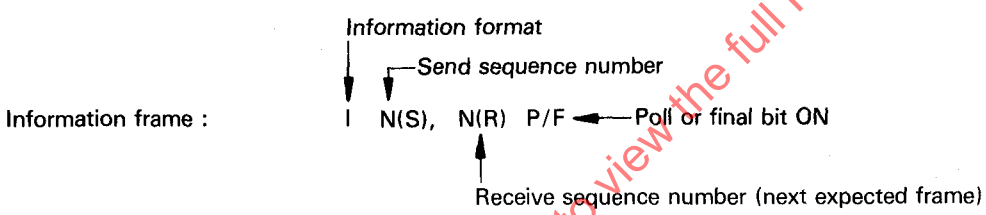
B.1.1 General notation

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

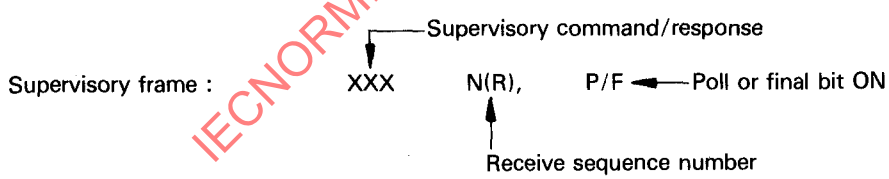


Frame with error :  or

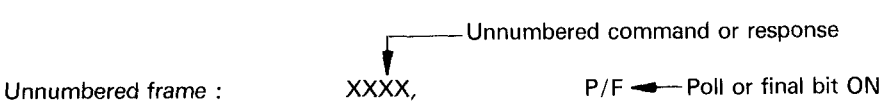
B.1.2 Notation for primary and secondary stations



Example : Pri xmits : 12,6 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).

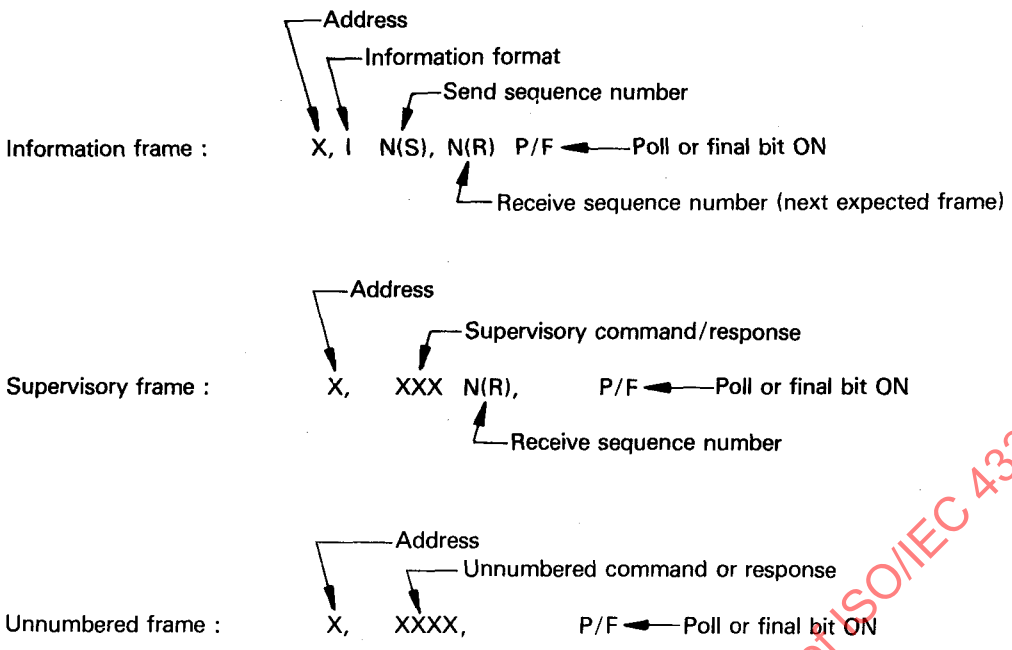


Example : Pri xmits : RR2 P. This denotes a receive ready (RR) command, N(R) = 2 (i.e. the next expected I frame from the secondary is receive sequence number 2), and the poll bit is set to "1".



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

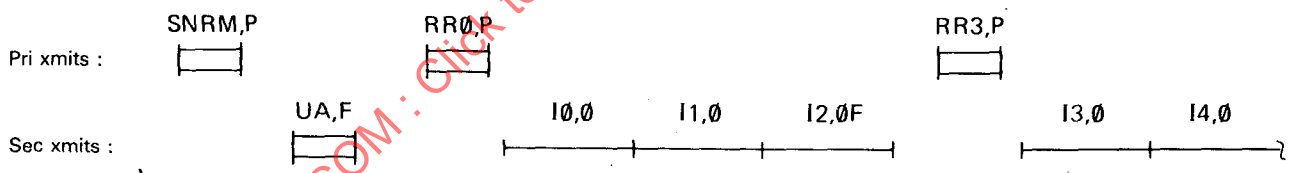
B.1.3 Notation for combined stations



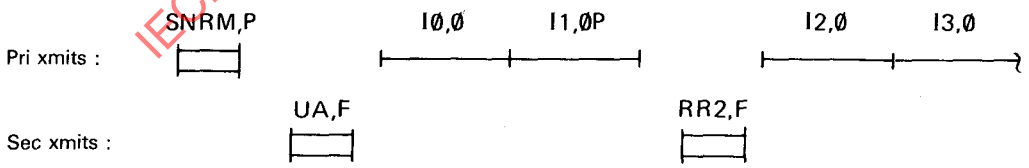
B.2 Examples of normal response mode (NRM) two-way alternate (TWA) transmission

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

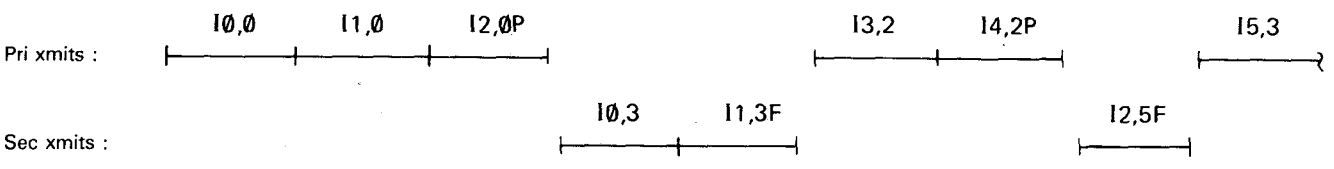
B.2.1.1 NRM start-up procedure and secondary only information transfer



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

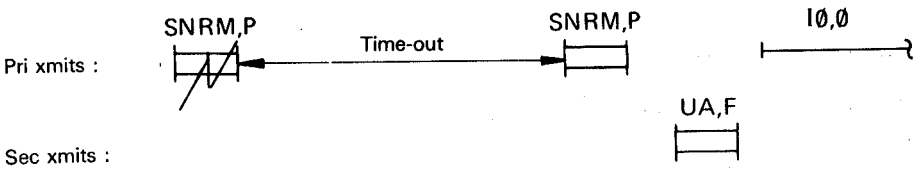


B.2.1.3 NRM information transfer by primary and secondary

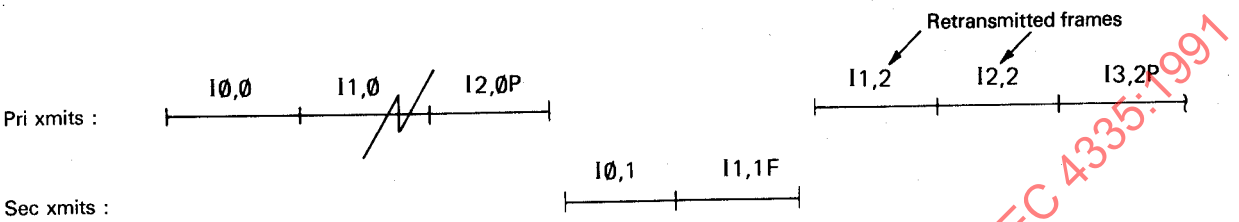


B.2.2 Normal response mode (NRM) TWA with transmission errors in command frames

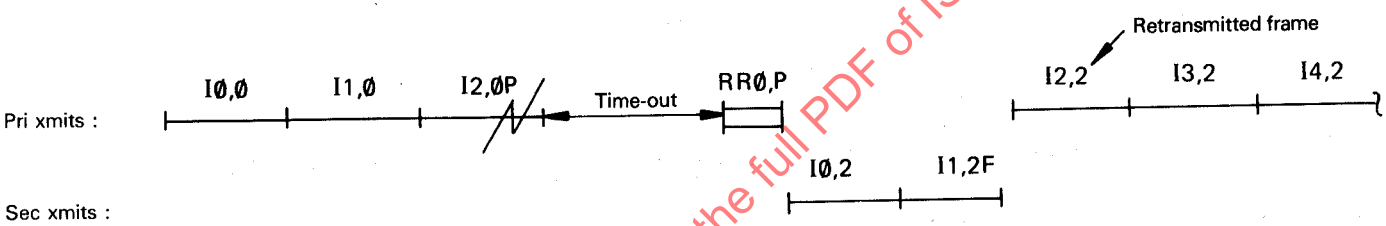
B.2.2.1 NRM start-up command error



B.2.2.2 NRM primary information frame error

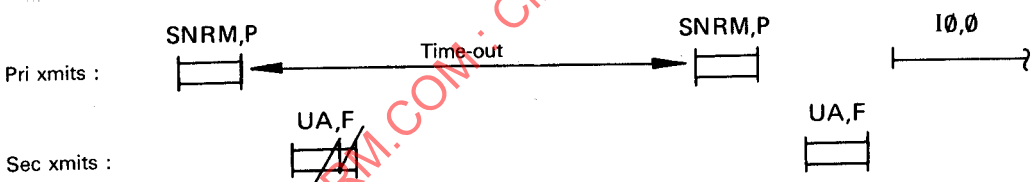


B.2.2.3 NRM primary poll frame error

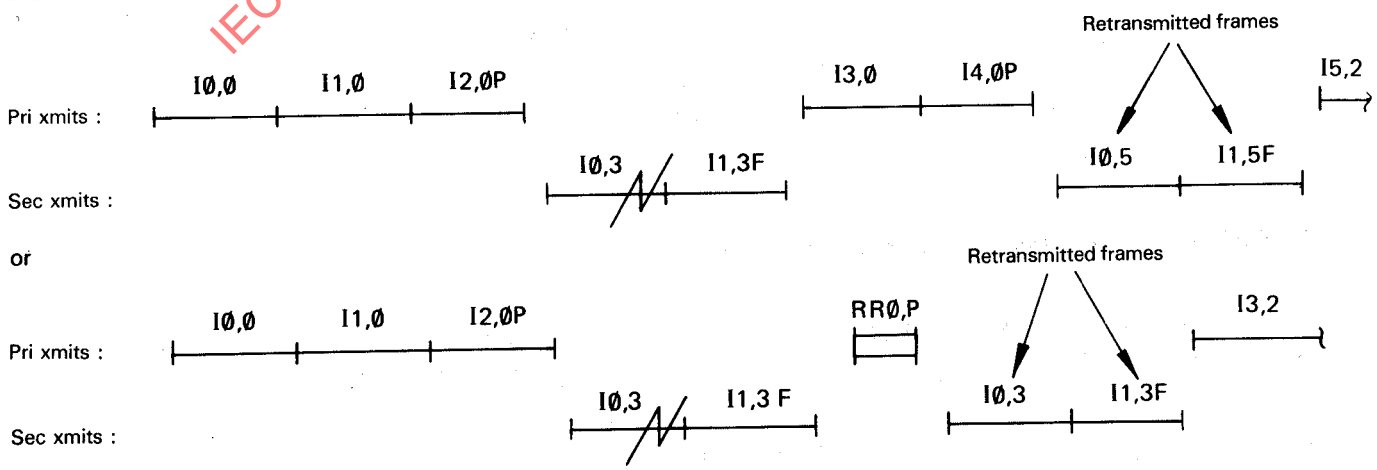


B.2.3 Normal response mode (TWA) HDX with transmission errors in response frames

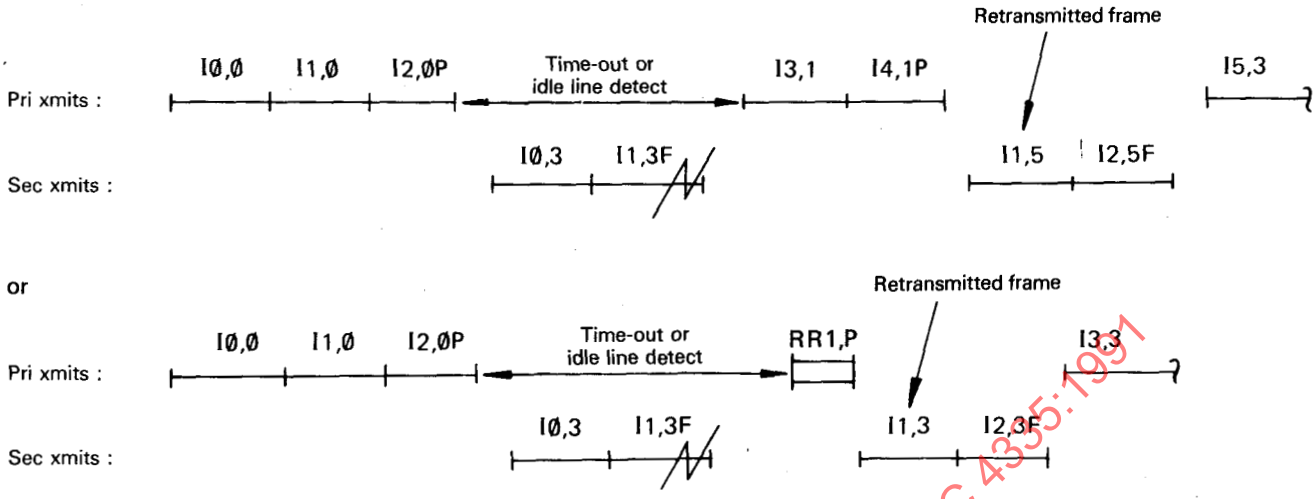
B.2.3.1 NRM start-up response error



B.2.3.2 NRM secondary information frame error



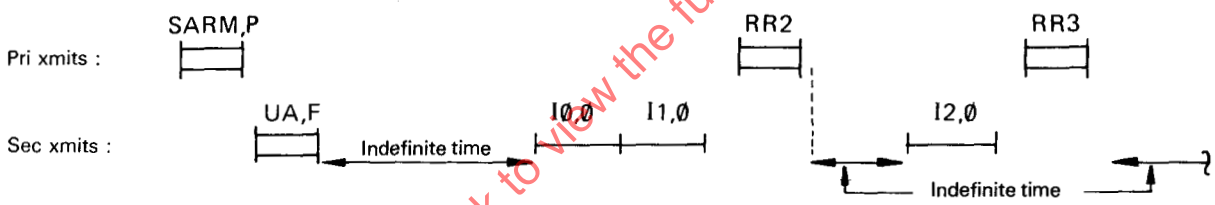
B.2.3.3 NRM secondary "final" frame error



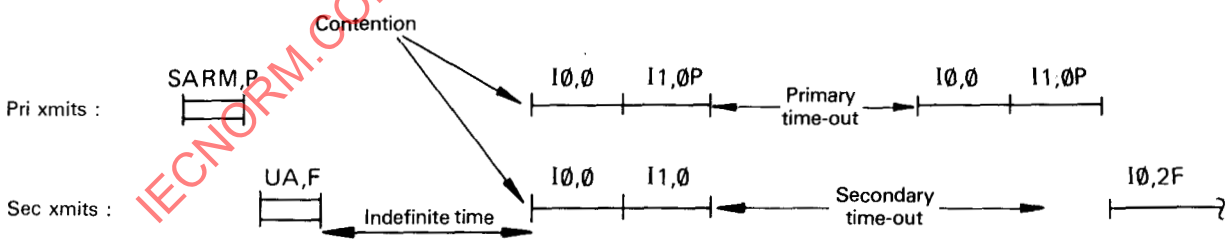
B.3 Examples of asynchronous response mode (ARM) two-way alternate (TWA) transmission

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

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

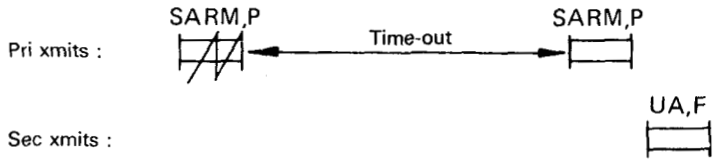


B.3.1.2 ARM primary and secondary information transfer with contention situation



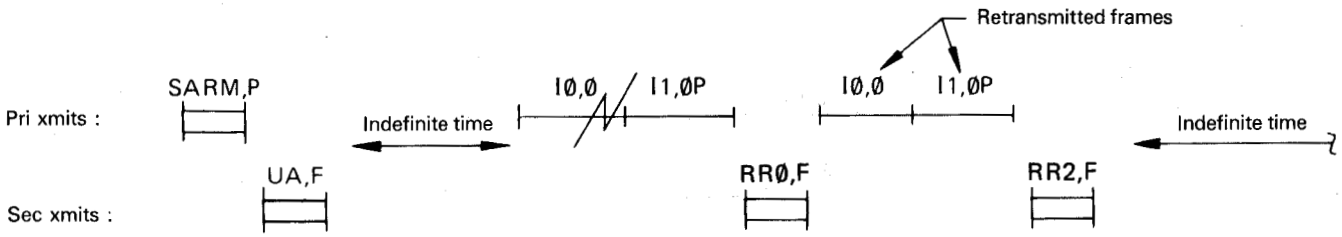
B.3.2 Asynchronous response mode (ARM) TWA with transmission errors in command frames

B.3.2.1 ARM start-up command error



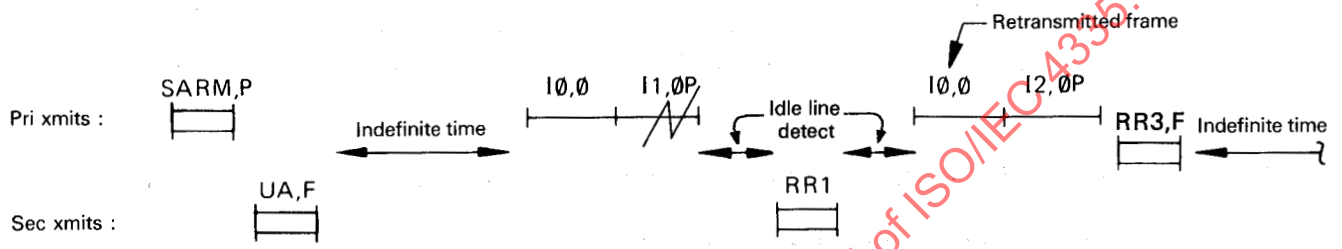
B.3.2.2 ARM primary information frame error

NOTE — Recovery procedure is identical to NRM operation.



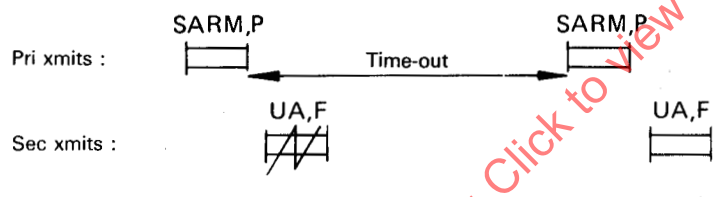
B.3.2.3 ARM primary "poll" information frame error

NOTE — Recovery procedure is identical to NRM operation.

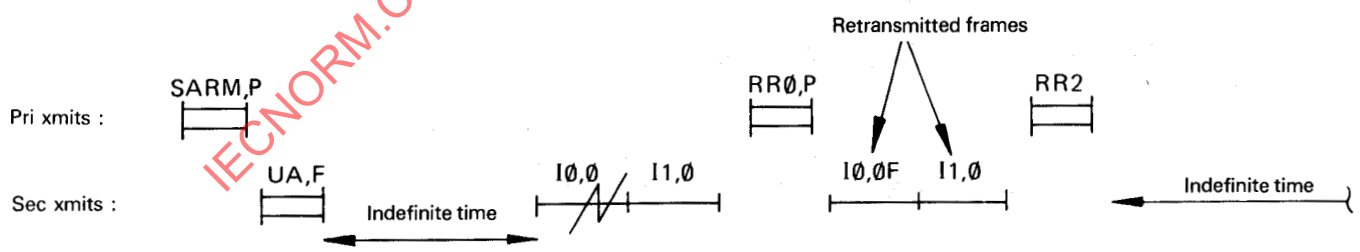


B.3.3 Asynchronous response mode (ARM) TWA with transmission errors in response frames

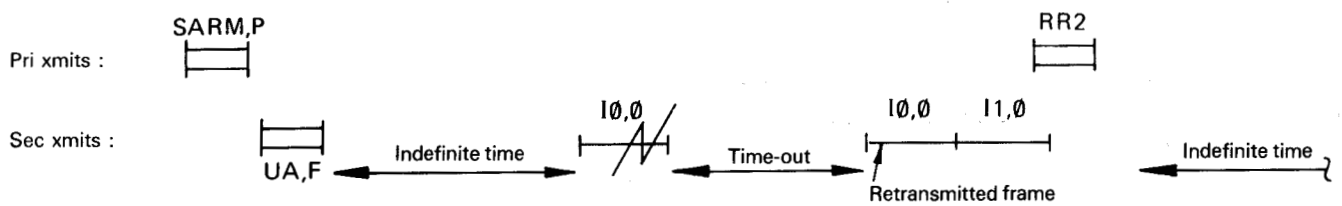
B.3.3.1 ARM start-up



B.3.3.2 ARM secondary information frame error



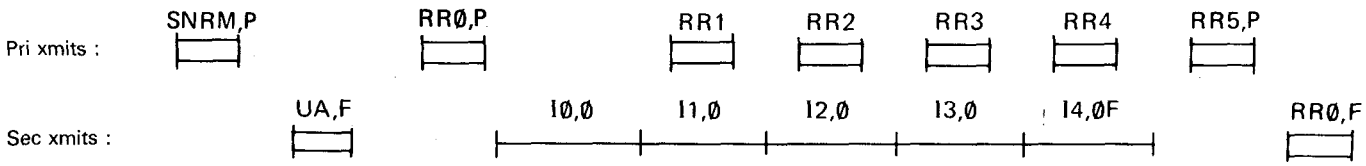
B.3.3.3 ARM secondary "final" information frame error



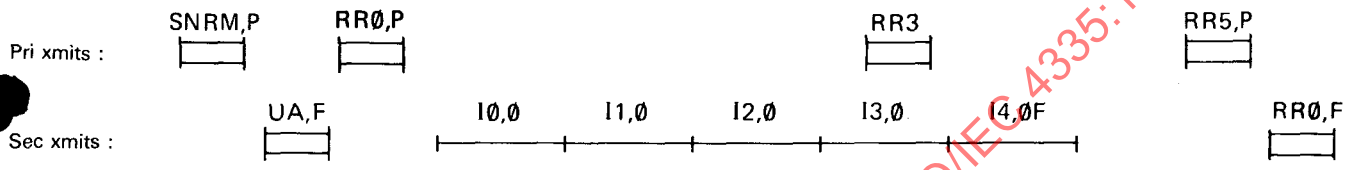
B.4 Examples of normal response mode (NRM) two-way simultaneous (TWS) transmission

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

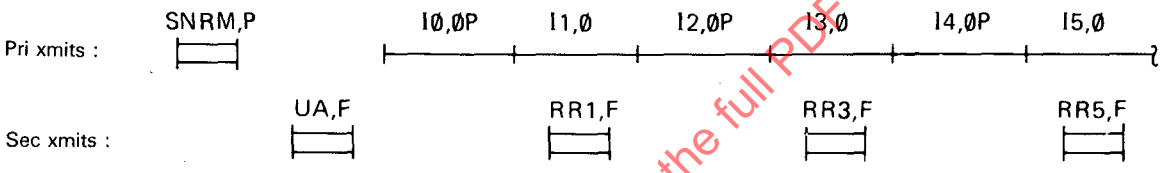
B.4.1.1 NRM start-up procedure and secondary only information transfer



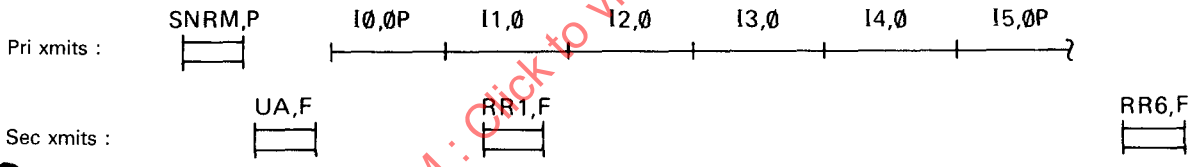
or (where primary acknowledgments are returned for several response frames)



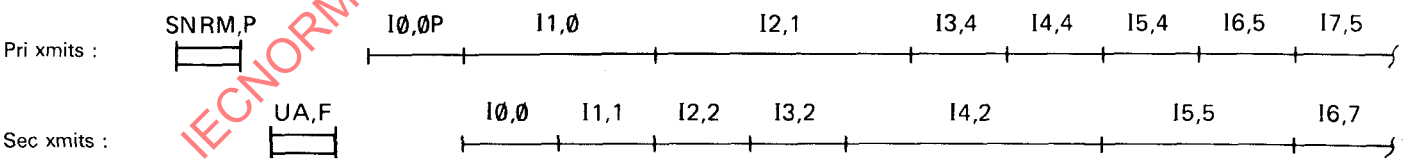
B.4.1.2 NRM start-up procedure and primary only information transfer



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

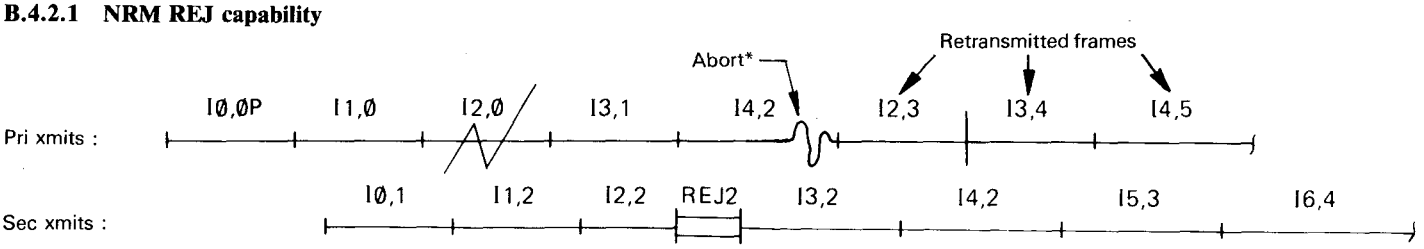


B.4.1.3 NRM start-up procedure and primary/secondary information transfer



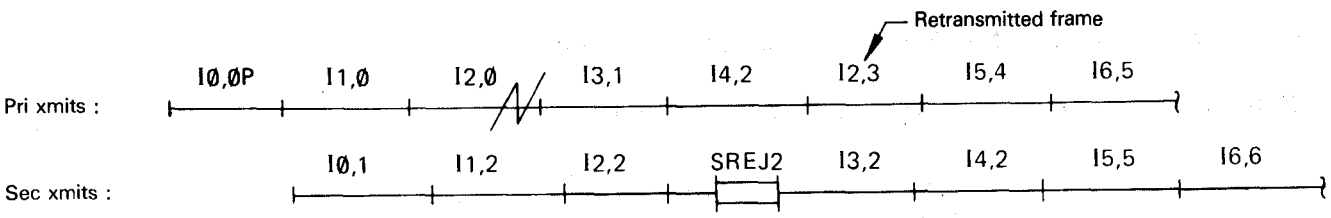
B.4.2 Normal response mode (NRM) TWS with transmission errors in command frames

B.4.2.1 NRM REJ capability



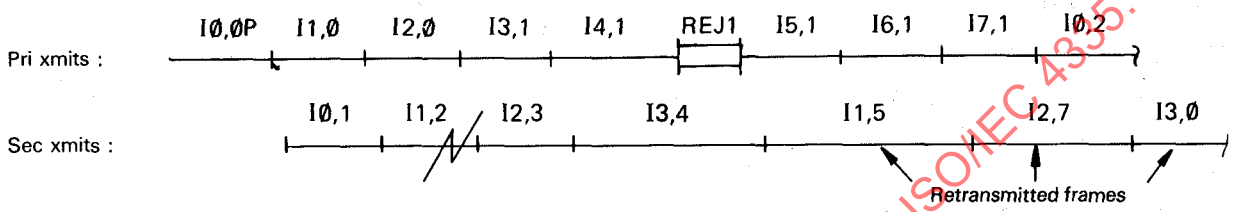
* Optional : Frame may be completed or aborted.

B.4.2.2 NRM SREJ capability

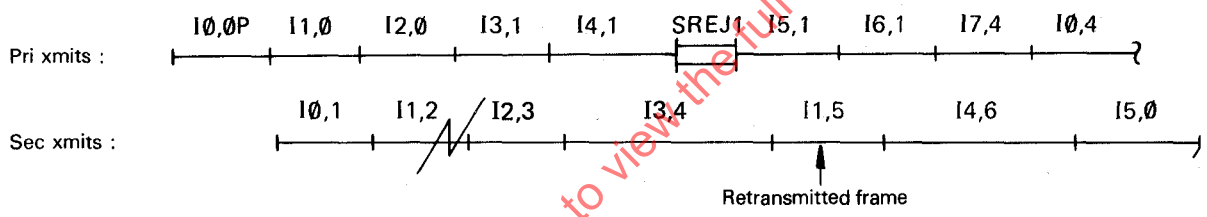


B.4.3 Normal response mode (NRM) TWS with transmission errors in response frames

B.4.3.1 NRM REJ capability



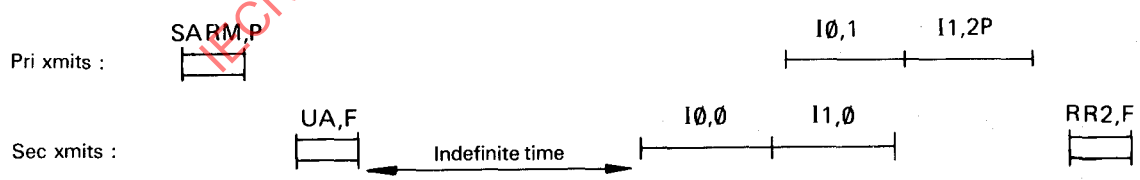
B.4.3.2 NRM SREJ capability



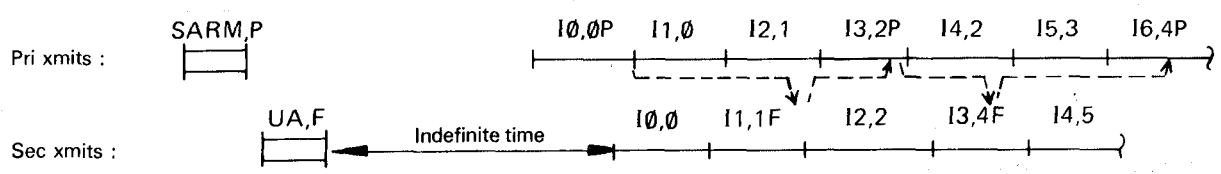
B.5 Examples of asynchronous response mode (ARM) two-way simultaneous (TWS) transmission

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

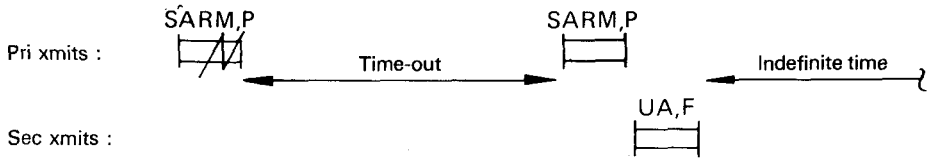


B.5.1.2 ARM start-up procedure and continuous primary/secondary information transfer

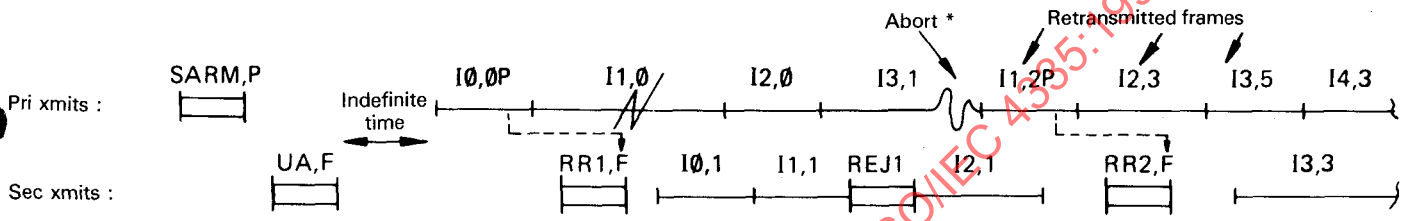


B.5.2 Asynchronous response mode (ARM) TWS with transmission errors in command frames

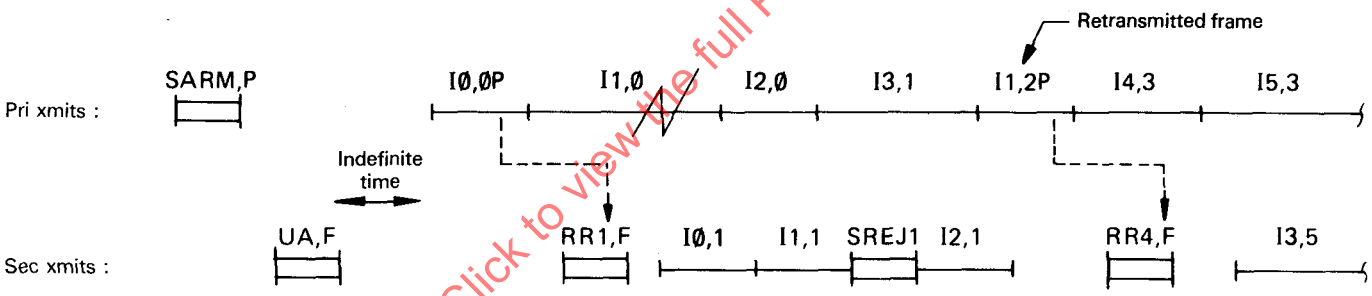
B.5.2.1 ARM start-up command error



B.5.2.2 ARM REJ capability

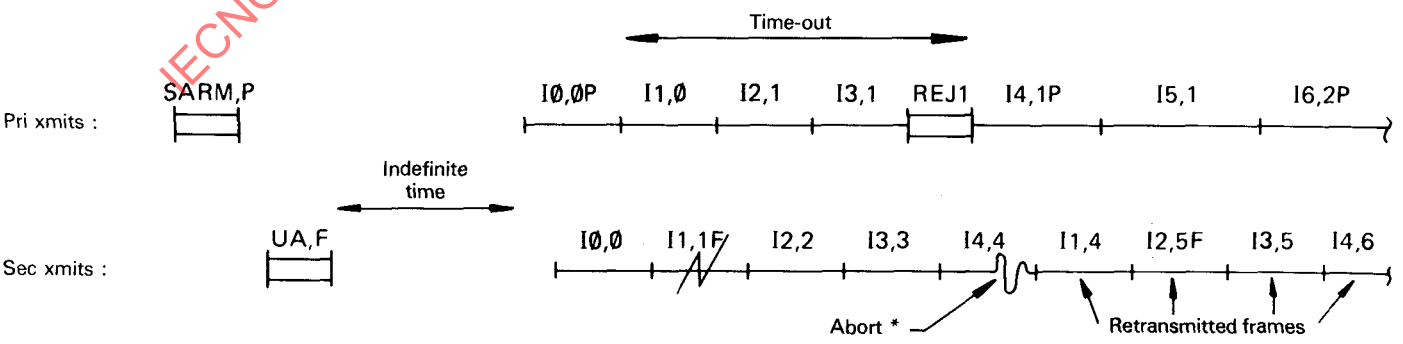


B.5.2.3 ARM SREJ capability



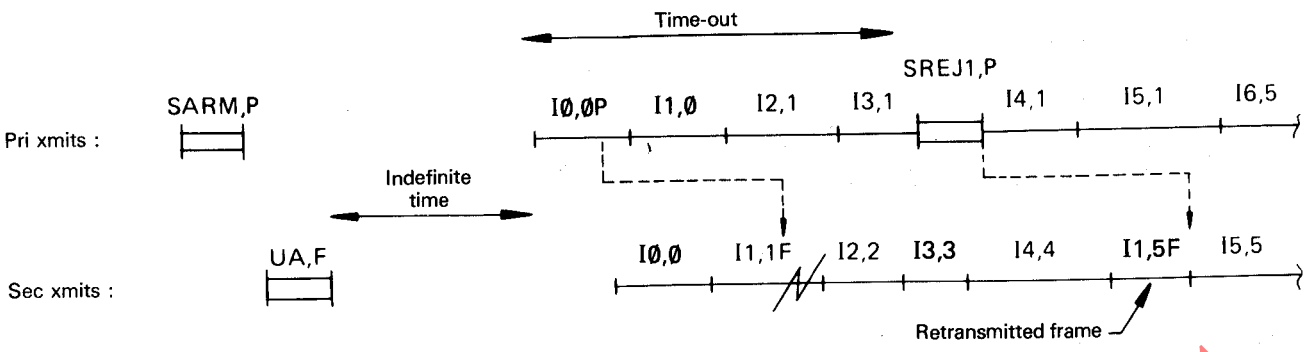
B.5.3 Asynchronous response mode (ARM) TWS with transmission errors in response frames

B.5.3.1 ARM REJ capability

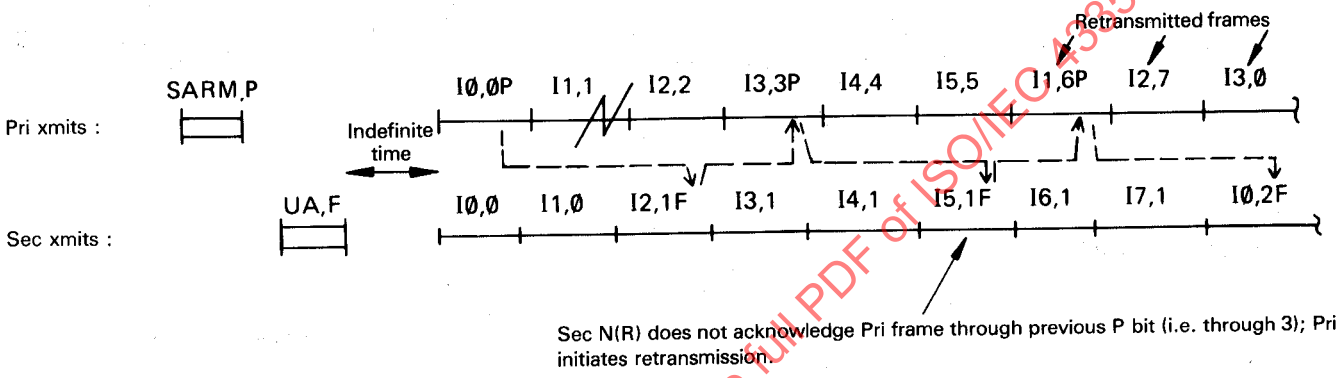


* Optional : Frame may be completed or aborted.

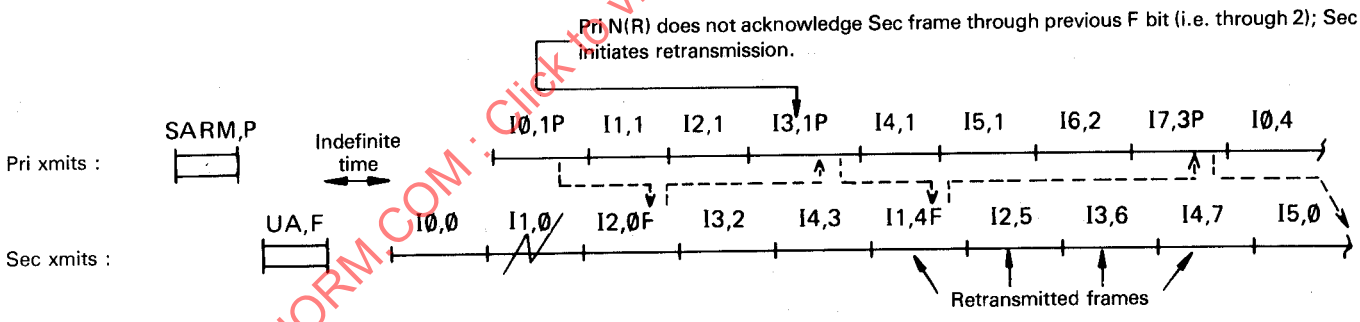
B.5.3.2 ARM SREJ capability



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

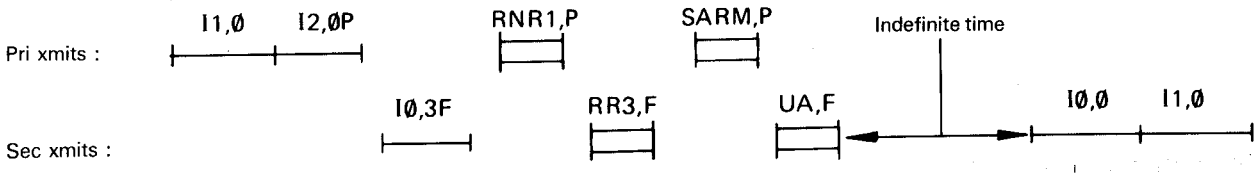


B.6 Examples of changing control mode

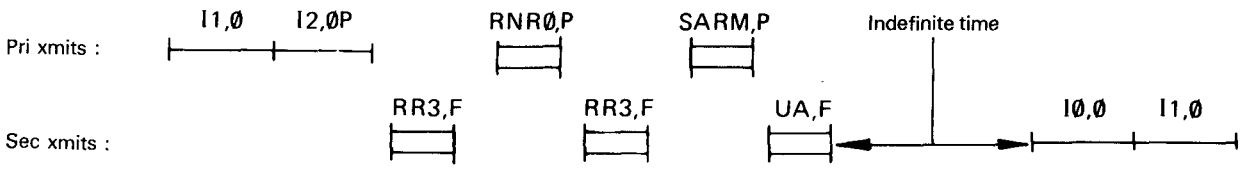
B.6.1 Normal response mode (NRM) to asynchronous response mode (ARM) change

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

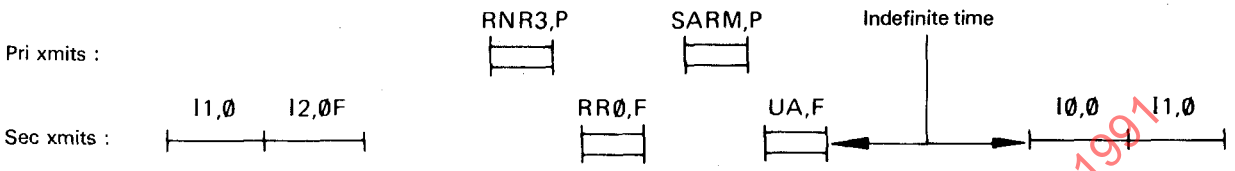
Example A



Example B

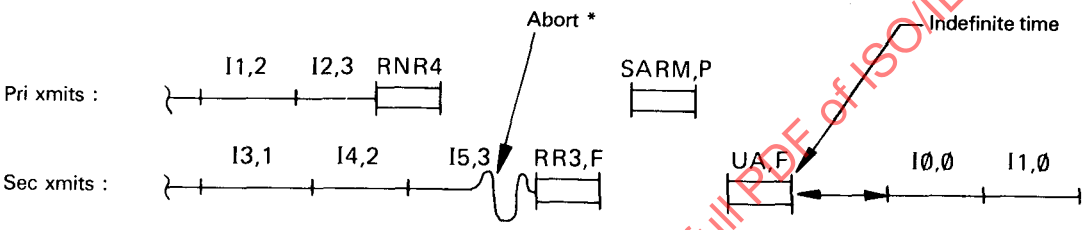


Example C

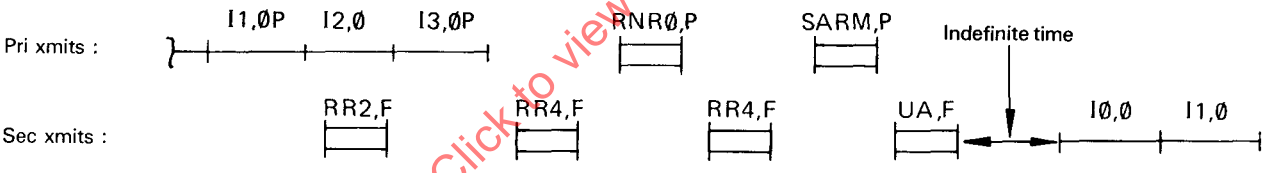


B.6.1.2 Two-way simultaneous (TWS) transmission NRM to ARM mode change

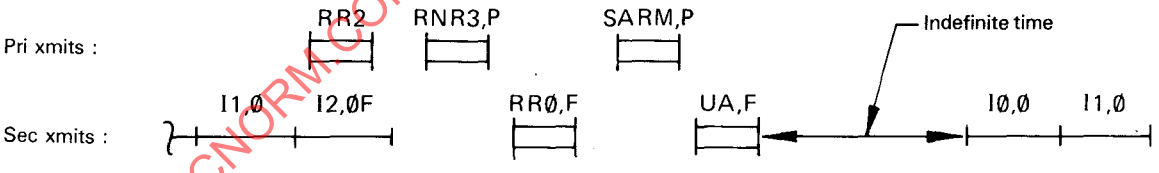
Example A



Example B



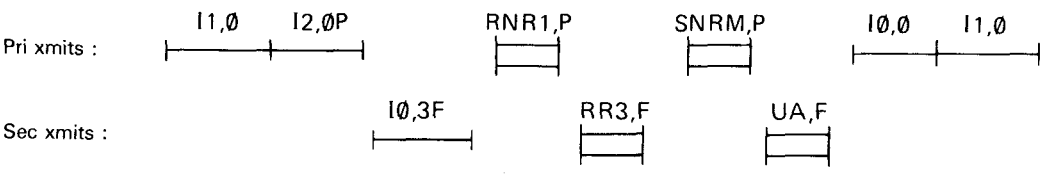
Example C



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.