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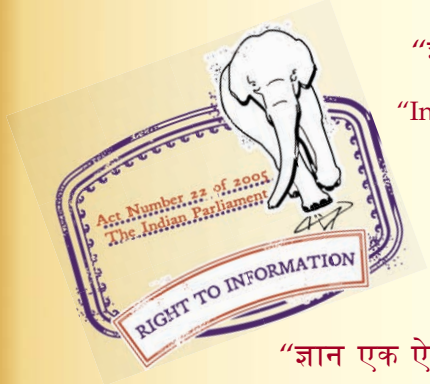


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"Knowledge is such a treasure which cannot be stolen"

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*Indian Standard*

# HIGH LEVEL DATA LINK CONTROL PROCEDURES

## PART 2 CONSOLIDATION OF ELEMENTS OF PROCEDURES

[ ISO Title : Data Communication — High Level Data Link Control Procedures — Consolidation of Elements of Procedures ]

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*Indian Standard*

# HIGH LEVEL DATA LINK CONTROL PROCEDURES

## PART 2 CONSOLIDATION OF ELEMENTS OF PROCEDURES

[ ISO Title : Data Communication—High Level Data Link Control Procedures—Consolidation of Elements of Procedures ]

**National Foreword**

This Indian Standard (Part 2) which is identical with ISO 4335-1984 'Data communication—high level data link control procedures—consolidation of elements of procedures', issued by the International Organization for Standardization (ISO), was adopted by the Indian Standards Institution on the recommendation of the Computers, Business Machines and Calculators Sectional Committee and approved by the Electronics and Telecommunication Division Council.

Wherever the words 'International Standard' appear, referring to this standard, they should be read as 'Indian Standard'.

**Cross References**

| *International Standard* | *Corresponding Indian Standard* |
|---|---|
| ISO 2302/9-1984 Data processing—vocabulary—Part 09 : Data communication Bilingual edition | IS : 1885 (Part 52/Sec 10)-1980 Data processing, Section 10 Data communication (Technically equivalent) |
| ISO 3309-1984 Information processing systems—Data communication—High-level data link control procedures—Frame structure | IS : 11418 (Part 1)-1986 High level data link control procedures : Part 1 Frame structure (Identical) |

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# 0 Introduction

## 0.1 General

High-level data link control (HDLC) procedures are designed to permit synchronous, 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 acknowledgment, 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 acknowledgment 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.

## 0.2 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 acknowledgments 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.

## 0.3 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 acknowledgments are always transmitted in the opposite direction. The poll-type commands may be used by each combined station to solicit acknowledgments and status responses from the other combined station.

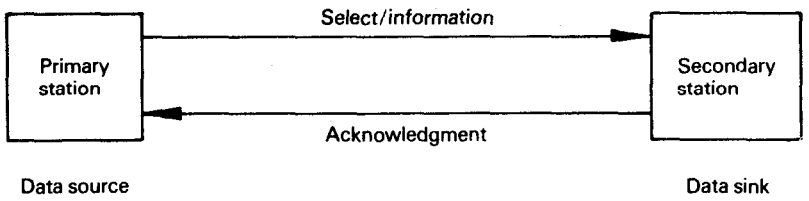



**Figure 1 — Unbalanced data link configuration (case 1)**

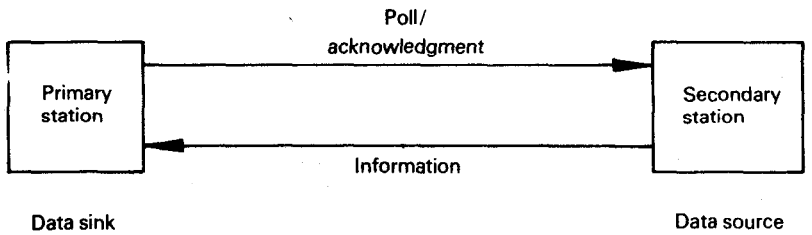



**Figure 2 — Unbalanced data link configuration (case 2)**

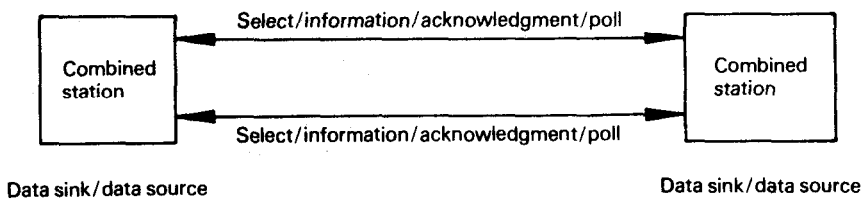



**Figure 3 — Balanced data link configuration**

## 1 Scope and field of application

This International Standard specifies elements of data link control procedures for synchronous, 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, 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 References

ISO 2382/9, *Data processing — Vocabulary — Part 09 : Data communication.*

ISO 3309, *Data communication — High-level data link control procedures — Frame structure.*

## 3 Definitions

For the purposes of this International Standard, the following definitions apply (see also ISO 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 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.

**3.12 control field extension** : Enlarging the control field to include additional control information.

**3.13 data communication** : See ISO 2382/9, term 09.01.03.

**3.14 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.

**3.15 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) (transmit) bit insertion and (receive) bit deletion;

b) address/control field interpretation;

c) command/response generation, transmission and interpretation; and

d) frame check sequence computation and interpretation.

**3.16 data transmission** : See ISO 2382/9, term 09.01.02.

**3.17 duplex transmission** : See ISO 2382/9, term 09.03.01.

**3.18 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.

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

**3.20 frame** : The sequence of contiguous bits, 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.

**3.21 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.

**3.22 half-duplex transmission** : See ISO 2382/9, term 09.03.02.

**3.23 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.

**3.24 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.

**3.25 interframe time fill** : The sequence of flag sequences transmitted between frames.

NOTE — This International Standard does not provide for time fill within a frame.

**3.26 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.

**3.27 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.

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

**3.29 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.

**3.30 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.

**3.31 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.

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

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

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

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

**3.36 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

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.

### 4.1.3 Interframe time fill

Interframe time fill shall be accomplished by transmitting contiguous flags between frames. There is no provision for time fill within a frame.

## 4.2 Idle data link channel state

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.

# 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 operational mode, the secondary station shall initiate transmission only as the result of receiving explicit permission to do so from the primary station. After receiving permission, the secondary station shall initiate a response transmission. The response transmission

shall consist of one or more frames while maintaining an active data link channel state. The last frame of the response transmission shall be explicitly indicated by the secondary station. Following indication of the last frame, the secondary station shall stop transmitting until explicit permission is again received from the primary station.

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

### 5.2 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), unnumbered information (UI), 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 in a disconnected mode shall be limited to :

a) accepting and responding to one of several appropriate mode setting commands (SNRM, SARM, SNRME, SARME, SIM and 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), or request disconnect (RD) response frame at a respond opportunity to solicit a specific action on the part of the primary station; and

f) transmitting, in ADM only, an unsolicited XID response frame at the respond opportunity to request an XID exchange.

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 SABM, 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 or TEST command.

A secondary/combined station in a disconnected mode (NDM or ADM) shall, as a minimum capability, be capable of generating the disconnected mode (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 disconnect (DISC) command shall respond with the DM response. A secondary/combined station in the initialization mode receiving a DISC command shall respond with the unnumbered acknowledgment (UA) response if it is capable of actioning the command. A secondary/combined 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 transmit or accept information. 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 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 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. 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, 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 transmit or accept information. 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 request for a mode setting command (DM), or a request for initialization (RIM) if the secondary station, or combined station as a receiver of commands, determines it is unable to function.

In this mode, if capable, a secondary station, or combined station as a receiver of commands, shall action only mode setting, XID 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 with the P bit set to "1", shall be responded to with a DM response, or, if the secondary station, or combined station as a receiver of commands, determines it is unable to function, with the RIM response. Any command with the P bit set to "0", other than the implemented mode setting, XID, 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 set initialization mode (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.

**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)

### 6.1.2 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".

### 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 numbers). The modulus equals 8 for the unextended control field format and 128 for the extended control field format. The sequence numbers cycle through the entire range. (See 7.4 for the description of the extended control field format and modulus.)

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

#### 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 range). The value of the receive state variable shall be incremented by one on receipt of an error-free, in-sequence I frame whose send sequence number N(S) equals the receive state variable.

**6.2.2.5** Receive sequence number N(R)

All I frames and S format frames shall contain N(R), the N(S) sequence number of the next expected I frame. Prior to transmission of an I frame or S format frame, the N(R) shall be set to equal the current value of the receive state variable. N(R) indicates that the station transmitting the N(R) has correctly received all I frames numbered up to N(R) – 1 inclusive.

[See 7.3.2.2 for definitions of the range of values of N(R).]

**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 acknowledgment 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 with 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. In all cases, the N(R) of a correctly received I frame or S format frame 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 receiving 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<br>RNR — Receive not ready<br>REJ — Reject<br>SREJ — Selective reject | RR — Receive ready<br>RNR — Receive not ready<br>REJ — Reject<br>SREJ — Selective reject |
| **Unnumbered format commands** | **Unnumbered format responses** |
| SNRM — Set normal response mode | UA — Unnumbered acknowledgment |
| 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.

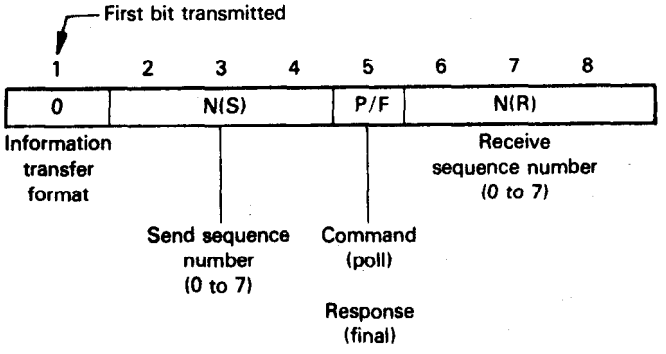



**Figure 4 — Information transfer format of control field bits**

The I frame control field shall contain two sequence numbers :

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

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

(See 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 acknowledgment, 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.

An S format frame shall contain an N(R), receive sequence number, which 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.

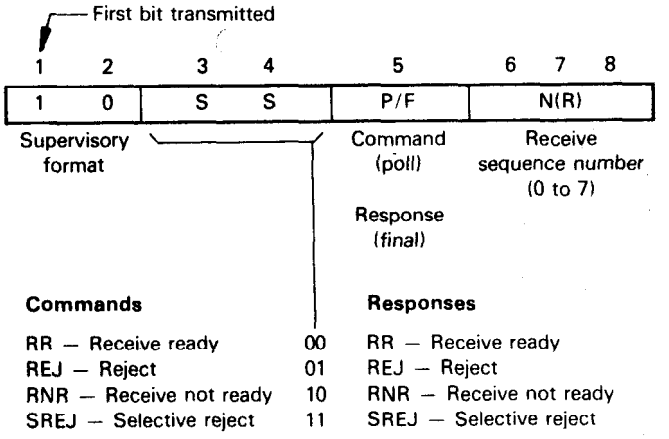



**Figure 5 — Supervisory format of control field bits**

(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 a RNR frame by that 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. Another REJ frame or a SREJ frame shall not be transmitted until the first REJ exception condition has been cleared unless other conditions have been detected as indicated in 8.2.1, 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). I frames numbered up to N(R) − 1 inclusive shall be considered as acknowledged. The I frame numbered N(R) shall not be considered as accepted.

The 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.

After a data station transmits a SREJ frame, it shall not transmit a SREJ frame or a REJ frame for an additional sequence error until the first SREJ error condition has been cleared. (To do so would acknowledge as correctly received all I frames up to N(R) − 1 inclusive, where N(R) is the receive sequence number in the second SREJ or REJ frame.)

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.

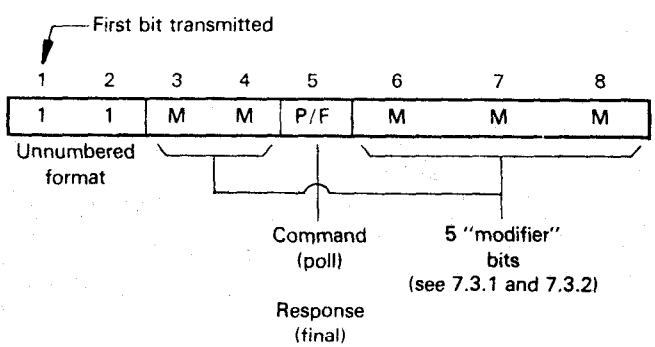



**Figure 6 — Unnumbered format of control field bits**

(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.

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 | 1 | XID command |
| 1 | 1 | 1 | 1 | P | 0 | 0 | 1 | RSET command (combined station only) |
| 1 | 1 | 0 | 0 | P | 1 | 1 | 1 | TEST command |

**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 in the unextended control field format 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 adressed 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 in the unextended control field format 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 in the unextended control field format 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 DISC 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 all control fields shall be two octets 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 in the extended control field format 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 all control fields shall be two octets 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 in the extended control field format 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.

**7.3.1.7** 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 all control fields shall be two octets 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 in the extended control field format 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 receives a UP command with the P bit set to "0" shall respond when :

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

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

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 response, 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.

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

The encoding of the format identifier field 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.

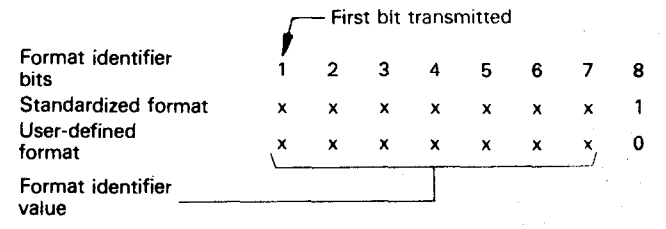



**Figure 8 – XID format identifier**

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.

**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 acknowledgment (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. The UA response shall be transmitted in the unextended or extended control field format as directed by the received command. 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 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**

The functions of these fields shall be as follows :

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

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

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

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

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

f) *x* set to "1" shall indicate that the control field received and returned in bits 1 to 8 inclusive was considered invalid

because the frame contained an information field which is not permitted with this command or response. Bit *w* shall be set to "1" in conjunction with this bit.

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

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

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

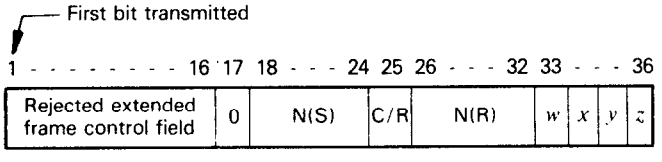



**Figure 11 — Information field format for FRMR extended response**

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

**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, TEST or RD response, as appropriate); i.e. no commands (other than the XID 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.

**7.3.2.7** Exchange identification (XID) response

The XID response shall be used to reply to a XID command. 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 a XID command shall, if capable, send the XID response, unless a UA response is pending or a FRMR condition exists.

If a 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.

In an asynchronous disconnected mode, a secondary station may send an unsolicited XID response at a respond opportunity to request a XID exchange. However, the XID response shall not be sent as a response to any received command other than the 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

The XID format identifiers described in 7.3.1.11 and 7.3.2.7 shall be assigned according to the following procedure.

Applications for the assignment of XID format identifiers shall be made to the Secretariat of ISO/TC 97/SC 6 (ANSI) through the national standards body of the country where the application originated. Where no national standards body exists, applications shall be made through the ISO Central Secretariat. The submission shall include at least a description of the intended application and a detailed description of the format and fields. When approved, a format identifier value will be assigned and will be included in annex C.

## 7.4 Extended control field formats

The control field may be extended by the addition of a second contiguous octet immediately following the basic control field. This capability shall provide for an N(S) and N(R) of modulo 128.

When the secondary/combined station operational environment regarding control field format is not known by the primary/combined station, a mode setting command sent by the primary/combined station shall be expressed in basic format.

Control field extension for the information transfer command/response format (I format), the supervisory command/response format (S format), and the unnumbered command/response format (U format) shall be as shown in table 4.

**Table 4 — Extended control field formats**

| 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 | U | M | M | M | P/F | x | x | x | x | x | x | x |

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

# 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 with 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 accepted 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 acknowledgment 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 a SREJ frame with the P/F bit set to "0" has 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 first 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 a SREJ response with the F bit set to "0", has 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 first 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 acknowledgment 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, SREJ recovery retransmission shall take precedence over 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, when the response/command time-out function runs out, or when a P/F checkpoint cycle that was initiated concurrent with or following the transmission of the REJ frame is completed. When the data station perceives by time-out or by the checkpointing mechanism 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 a SREJ frame with the P/F bit set to "0" and the "sent SREJ" exception condition is 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 original SREJ frame. When a combined station sends a SREJ command with the P bit set to "0" or "1", or a SREJ response with the F bit set to "0", and the "sent SREJ" condition is not cleared when the combined station is ready to issue the next frame with the P/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 original 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 a SREJ frame with the same N(R) (i.e. same value and same numbering cycle) as that of the previously sent frame with the P/F bit set to "1". 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 a SREJ frame with the same N(R) (i.e. same value and same numbering cycle) as that of the previously sent frame with the F bit set to "1".

With respect to each direction of transmission on the data link, only one "sent SREJ" exception condition from a given data station to another given data station shall be established at a time. A "sent SREJ" exception condition shall be cleared when the requested I frame is received, when the response/command time-out function runs out, or when a P/F checkpoint cycle that was initiated concurrent with or following the transmission of the SREJ frame is completed.

When a data station perceives by time-out or by the checkpointing mechanism 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 the SREJ frame shall initiate retransmission of the single I frame indicated by the N(R) contained in the SREJ frame. New I frames may be transmitted subsequently if they become available.

When a primary/secondary station receives and actions a SREJ frame with the P/F bit set to "0", it shall disable actioning of the next SREJ frame if the SREJ frame has the P/F bit set to "1" and has the same N(R) (i.e. same value and same numbering cycle) as the original SREJ frame. When a combined station receives and actions a SREJ command with the P bit set to "0" or "1", or a SREJ response with the F bit set to "0", it shall disable actioning of the next SREJ frame if the SREJ frame has the F bit set to "1" and has the same N(R) (i.e. same value and same numbering cycle) as the original SREJ frame.

NOTE — To improve transmission efficiency, it is recommended that the SREJ command/response be transmitted as the result of the detection of a sequence error where only a single I frame is missing [as determined by receipt of the out-of-sequence N(S)].

### 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. Alternatively, a data station which has timed-out waiting for a reply may retransmit one or all unacknowledged I frames as a mechanism to solicit the status of the remote data 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 the 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

## Time-out function considerations

(This annex does not form part of this International Standard.)

### 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 "0".

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

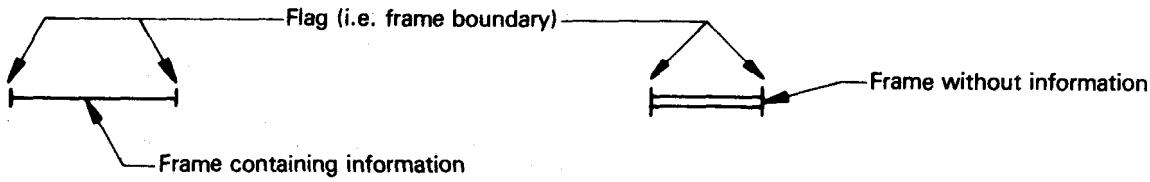
## Examples of the use of commands and responses

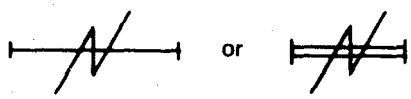
(This annex does not form part of this International Standard.)

### B.1 Introduction

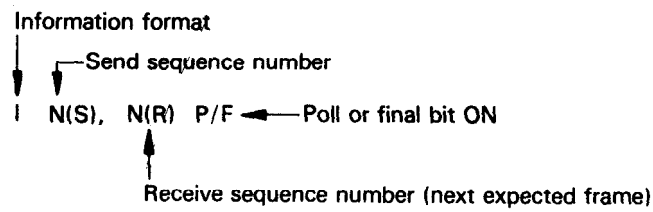
#### B.1.1 General notation

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

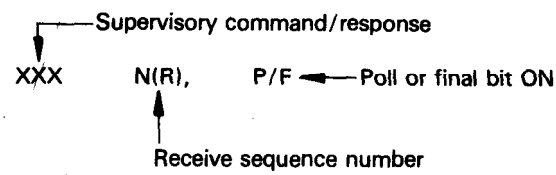



Frame with error :  or

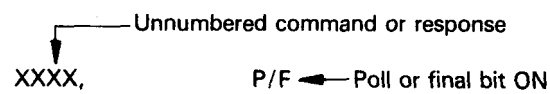
#### B.1.2 Notation for primary and secondary stations




*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).

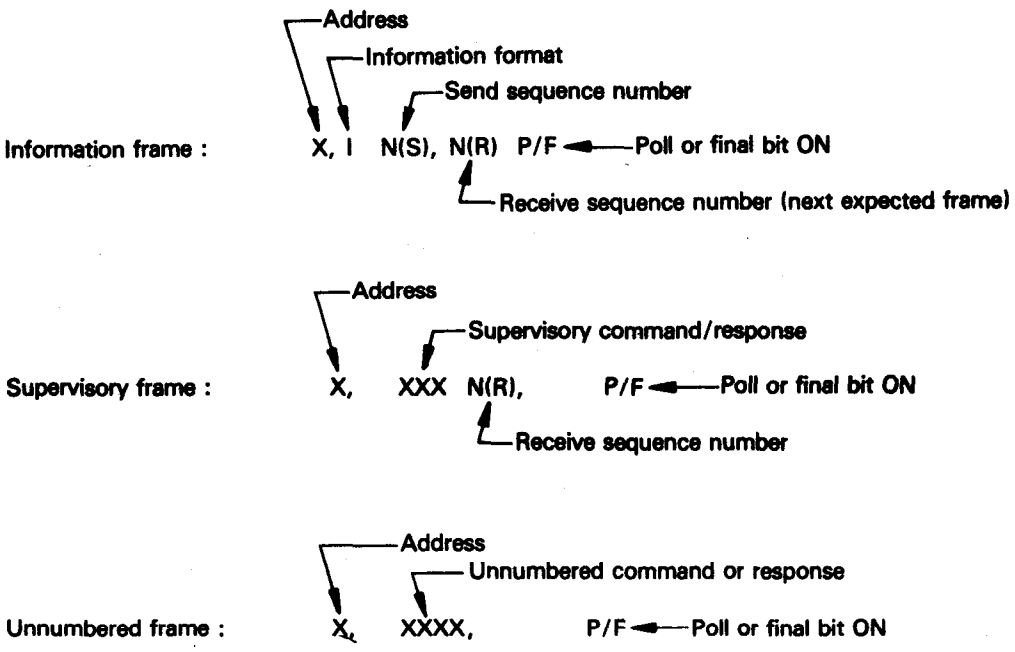



*Example :* Pri xmits : RR2 P. This denotes a receive ready (RR) command, N(R) = 2 (i.e. the next expected I frame from the secondary is receive sequence number 2), and the poll bit is set to "1".




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

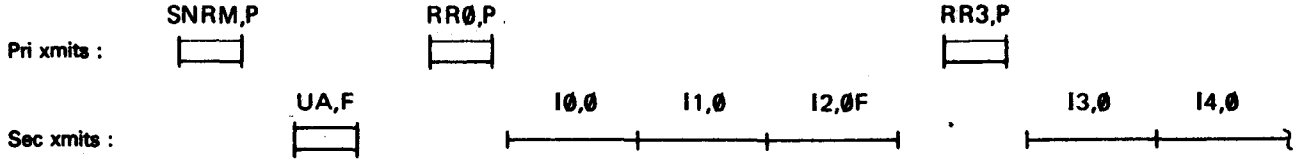
### B.1.3 Notation for combined stations



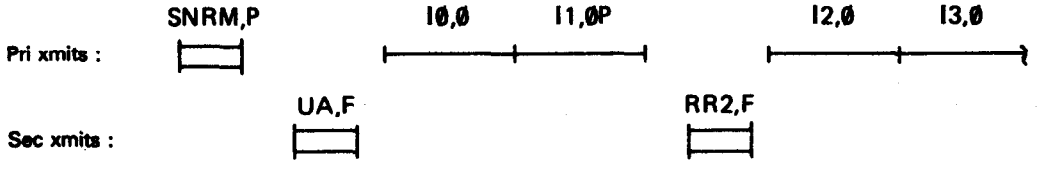

## B.2 Examples of normal response mode (NRM) two-way alternate (TWA) transmission

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

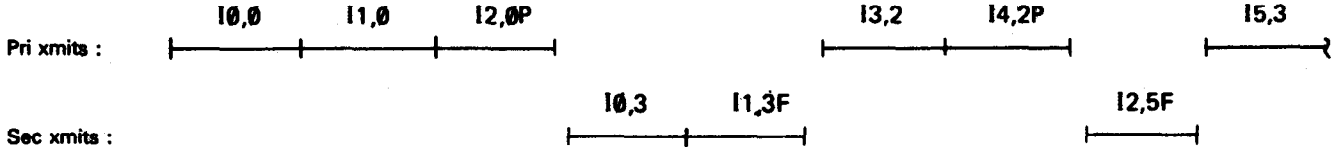
### B.2.1.1 NRM start-up procedure and secondary only information transfer




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

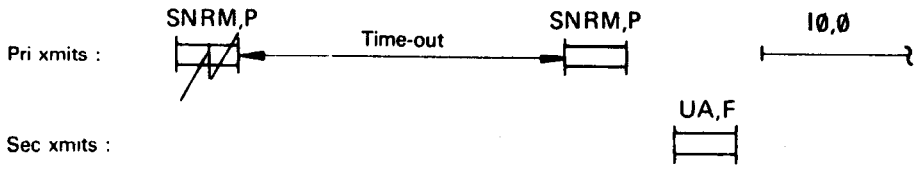



### B.2.1.3 NRM information transfer by primary and secondary

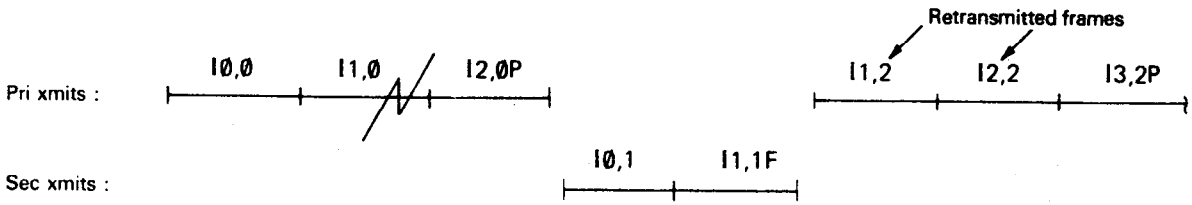


### B.2.2 Normal response mode (NRM) TWA with transmission errors in command frames

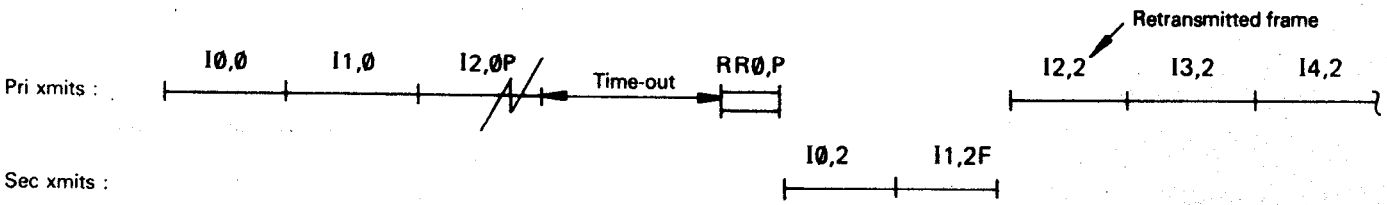
#### B.2.2.1 NRM start-up command error




#### B.2.2.2 NRM primary information frame error

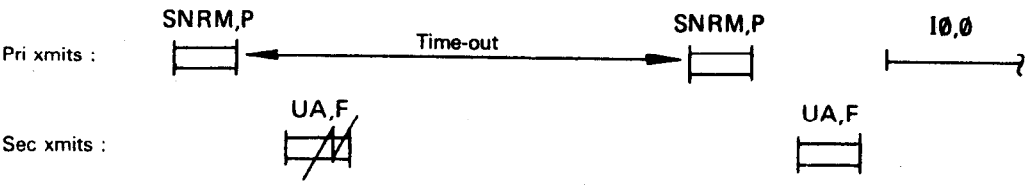



#### B.2.2.3 NRM primary poll frame error

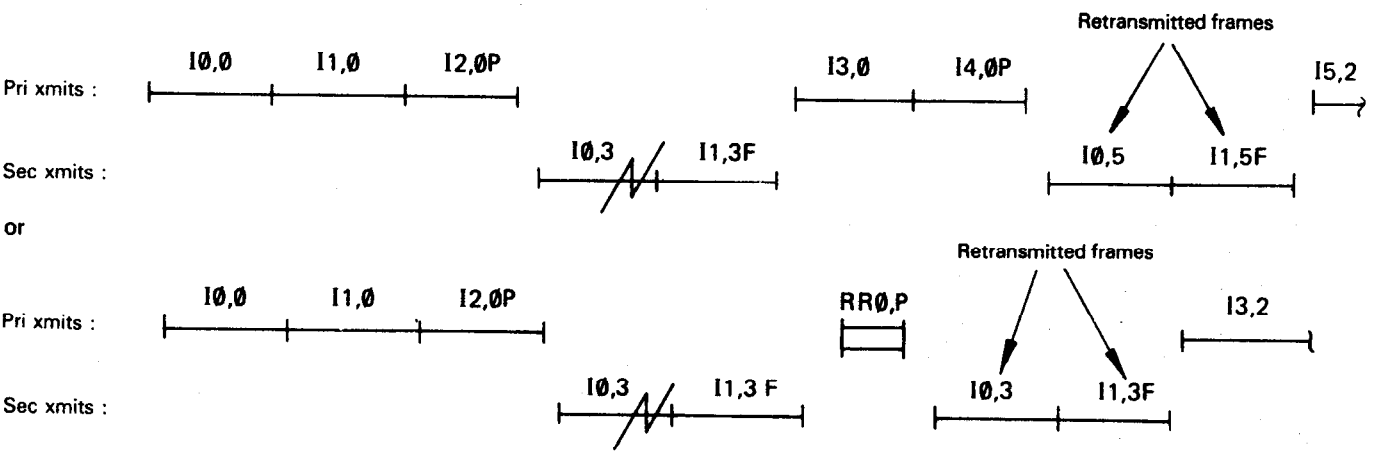



### B.2.3 Normal response mode (TWA) HDX with transmission errors in response frames

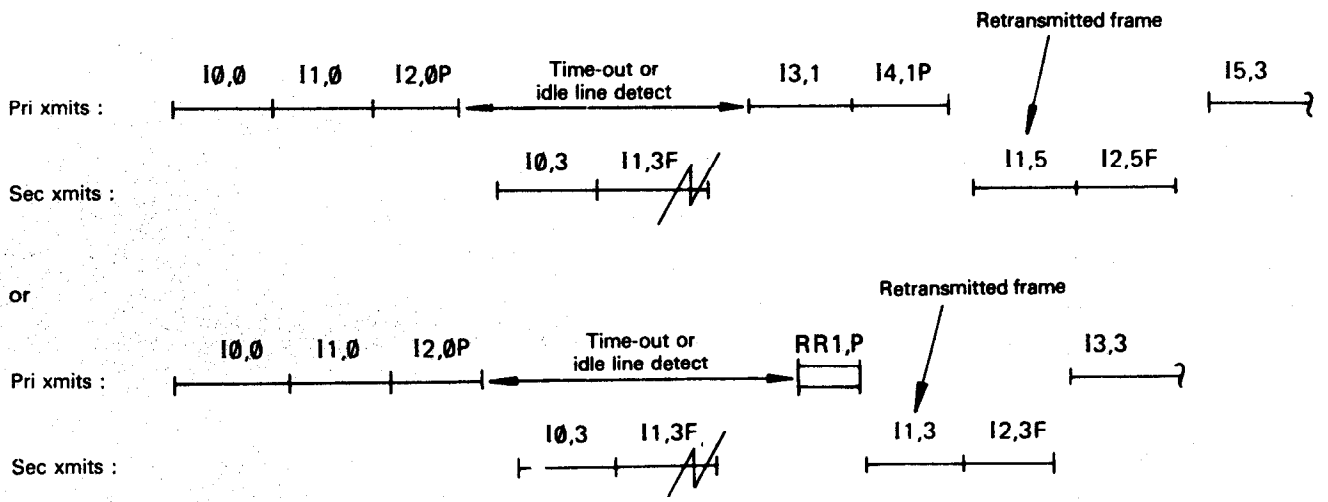
#### B.2.3.1 NRM start-up response error




#### B.2.3.2 NRM secondary information frame error



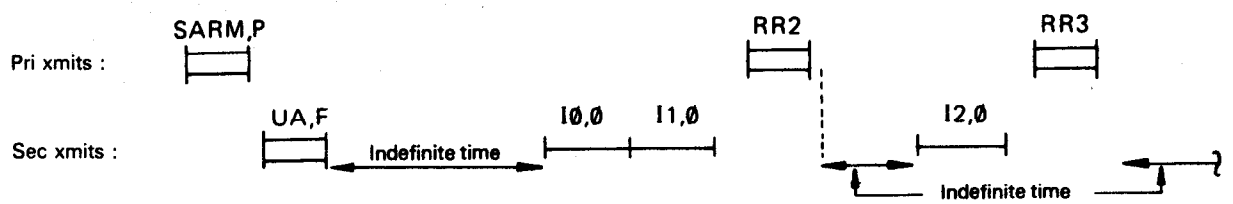
#### B.2.3.3 NRM secondary "final" frame error



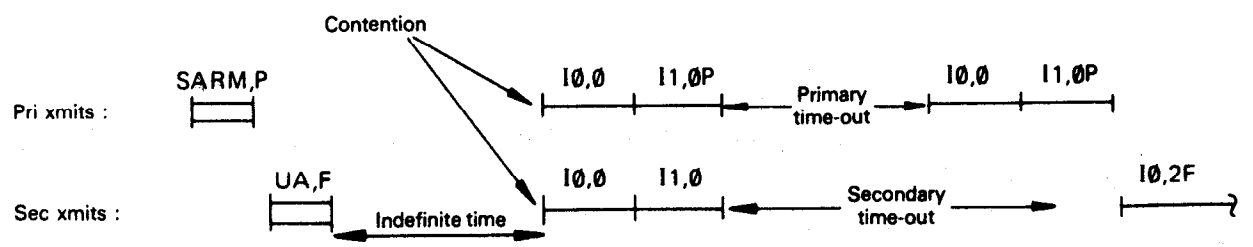

## B.3 Examples of asynchronous response mode (ARM) two-way alternate (TWA) transmission

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

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

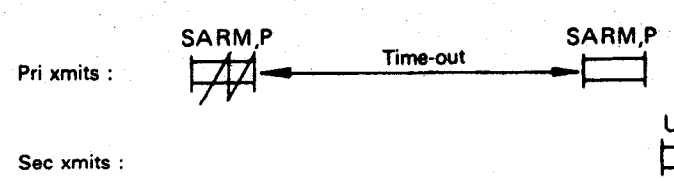



#### B.3.1.2 ARM primary and secondary information transfer with contention situation



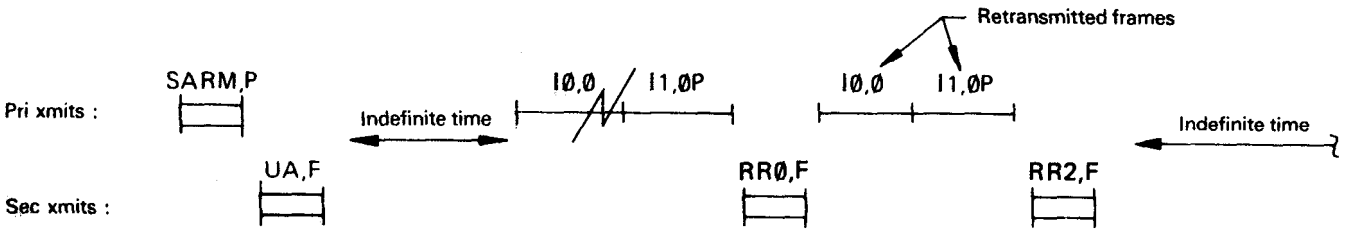

### B.3.2 Asynchronous response mode (ARM) TWA with transmission errors in command frames

#### B.3.2.1 ARM start-up command error



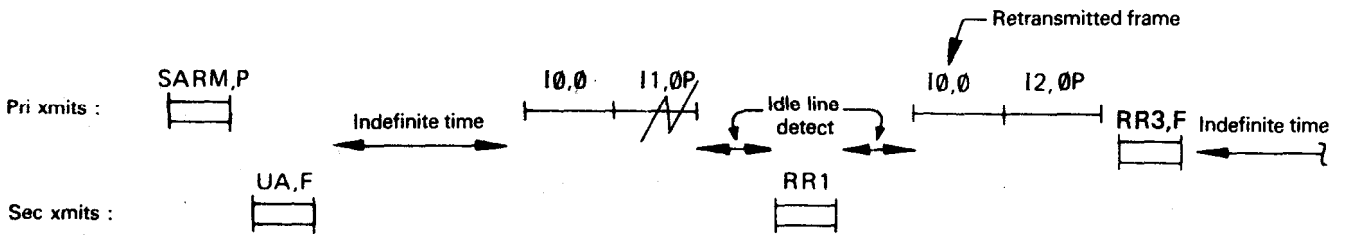
### B.3.2.2 ARM primary information frame error

NOTE — Recovery procedure is identical to NRM operation.



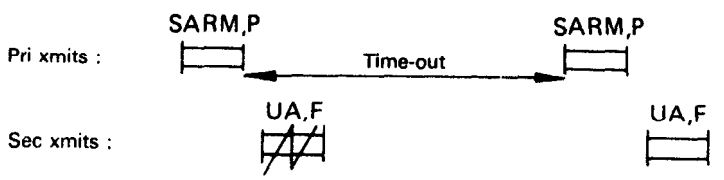

### B.3.2.3 ARM primary "poll" information frame error

NOTE — Recovery procedure is identical to NRM operation.

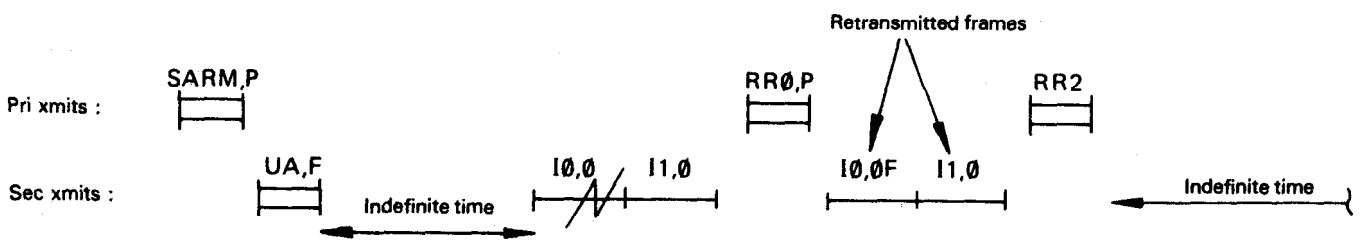



## B.3.3 Asynchronous response mode (ARM) TWA with transmission errors in response frames

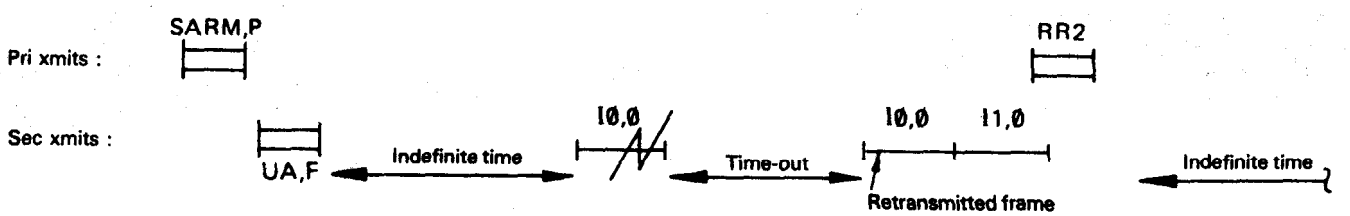
### B.3.3.1 ARM start-up




### B.3.3.2 ARM secondary information frame error



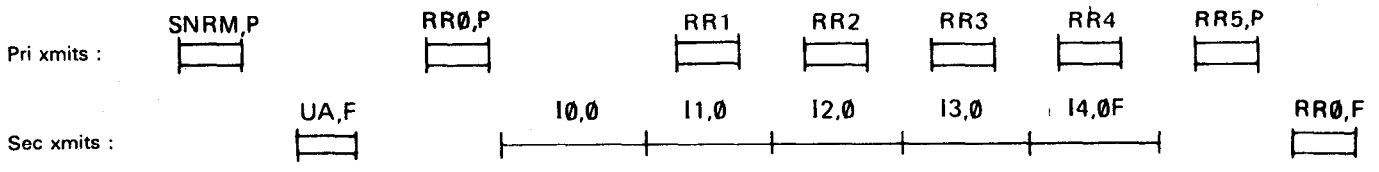

### B.3.3.3 ARM secondary "final" information frame error



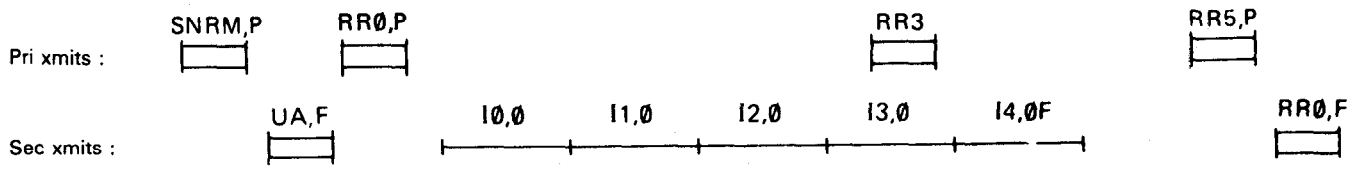
## B.4 Examples of normal response mode (NRM) two-way simultaneous (TWS) transmission

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

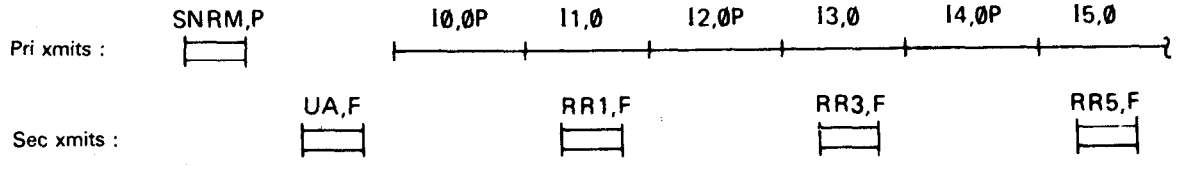
#### B.4.1.1 NRM start-up procedure and secondary only information transfer



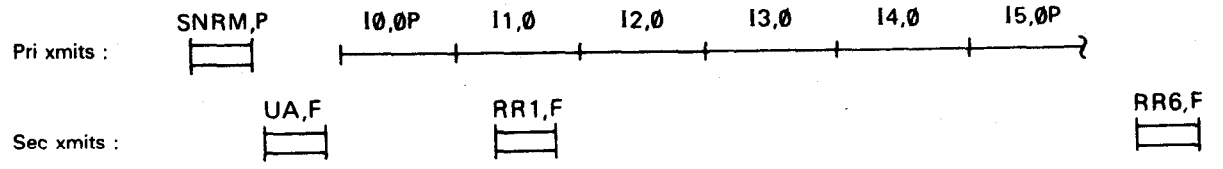

or (where primary acknowledgments are returned for several response frames)



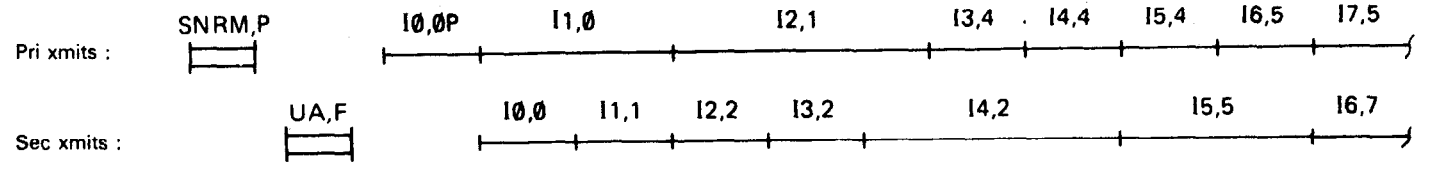

#### B.4.1.2 NRM start-up procedure and primary only information transfer




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

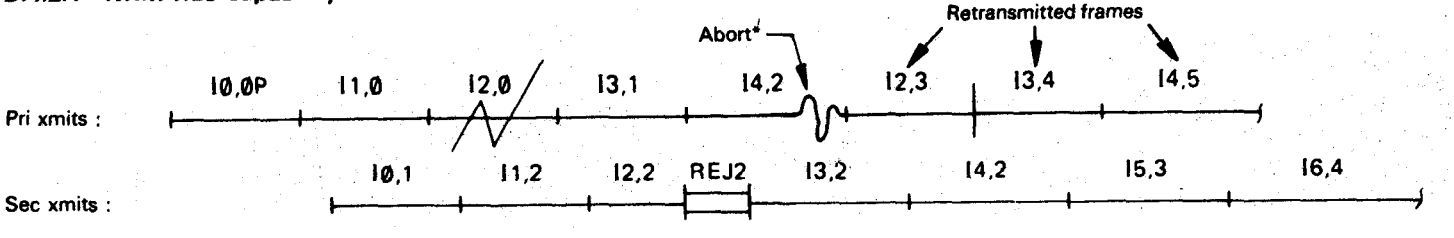



#### B.4.1.3 NRM start-up procedure and primary/secondary information transfer



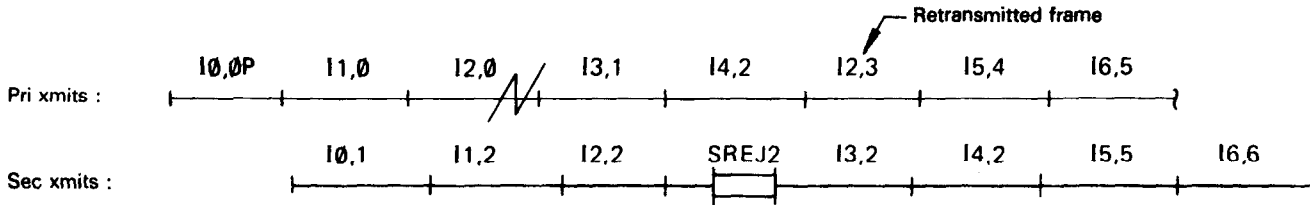

### B.4.2 Normal response mode (NRM) TWS with transmission errors in command frames

#### B.4.2.1 NRM REJ capability



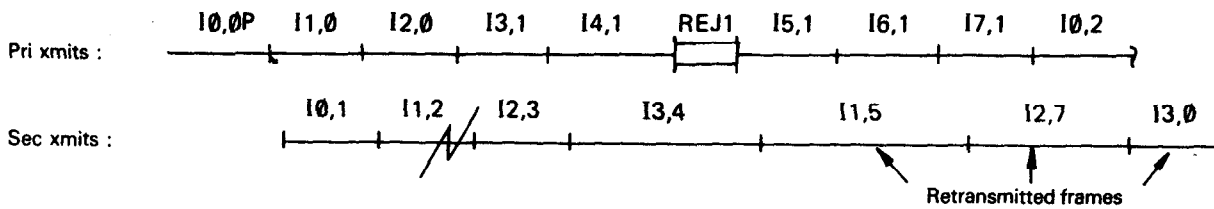

* Optional : Frame may be completed or aborted.

#### B.4.2.2 NRM SREJ capability

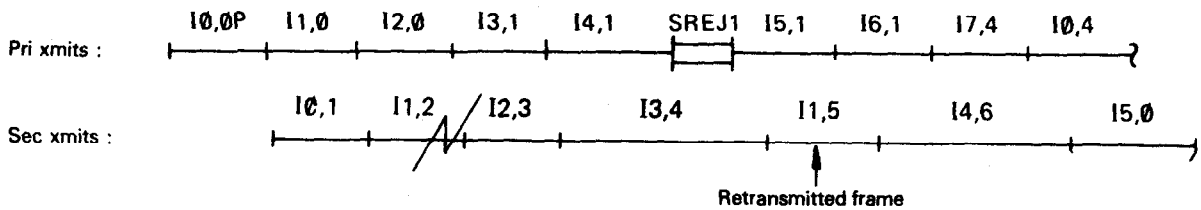



### B.4.3 Normal response mode (NRM) TWS with transmission errors in response frames

#### B.4.3.1 NRM REJ capability



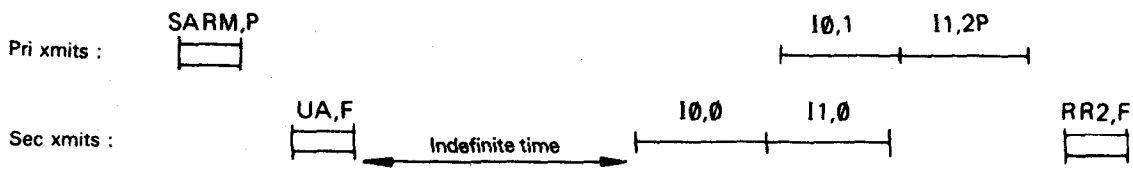

#### B.4.3.2 NRM SREJ capability



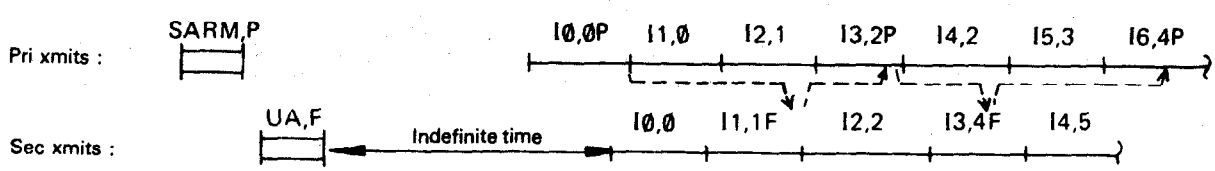

## B.5 Examples of asynchronous response mode (ARM) two-way simultaneous (TWS) transmission

### 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

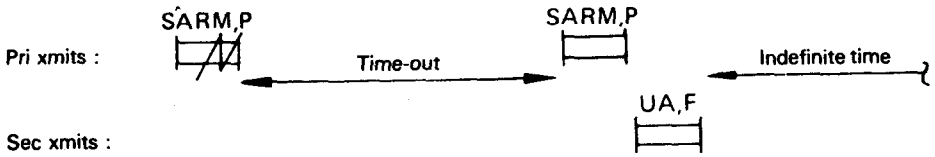



#### B.5.1.2 ARM start-up procedure and continuous primary/secondary information transfer

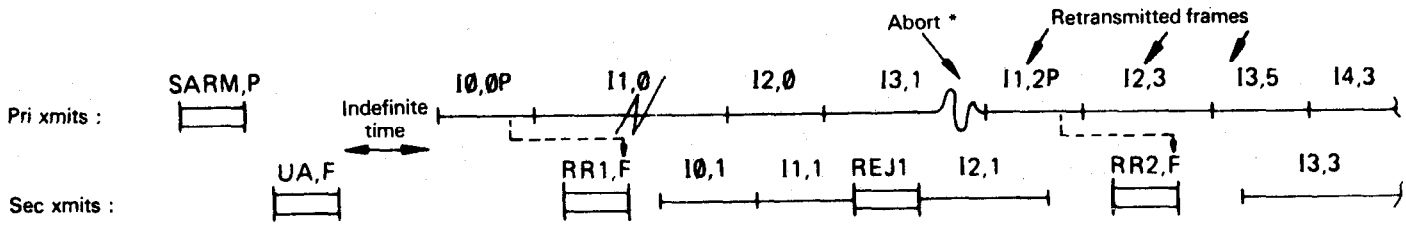


### B.5.2 Asynchronous response mode (ARM) TWS with transmission errors in command frames

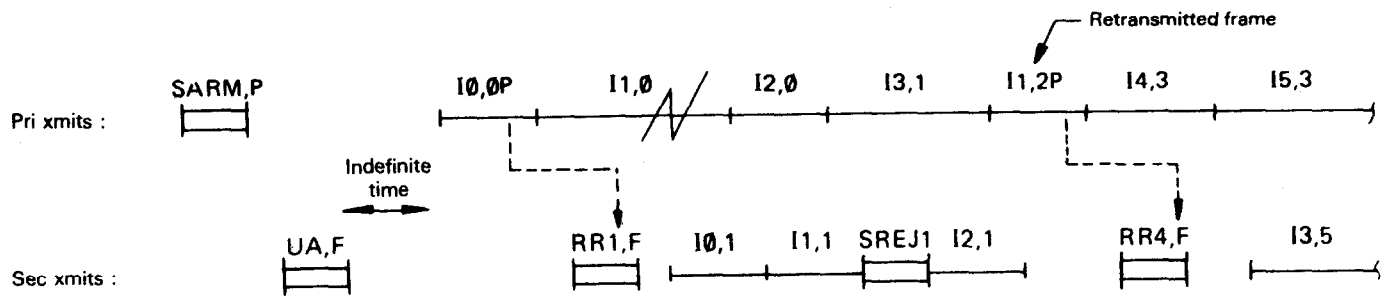
#### B.5.2.1 ARM start-up command error




#### B.5.2.2 ARM REJ capability

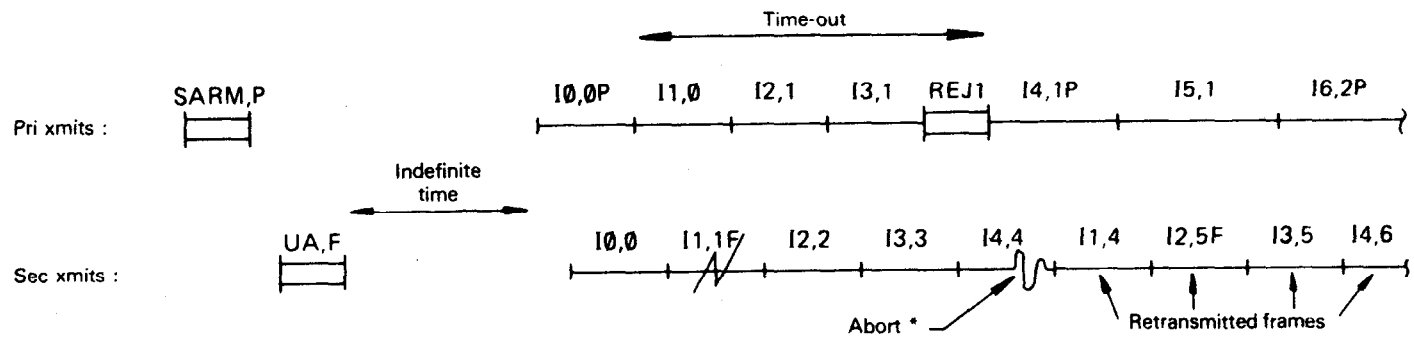



#### B.5.2.3 ARM SREJ capability



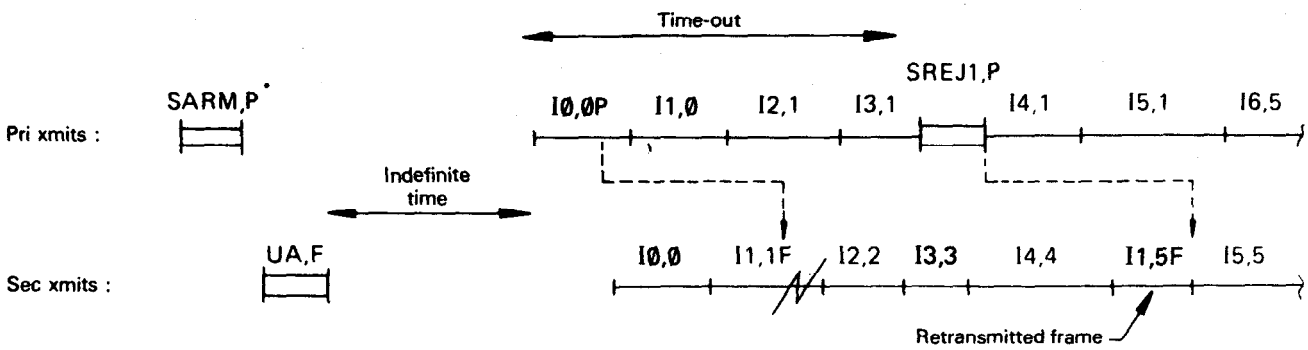

### B.5.3 Asynchronous response mode (ARM) TWS with transmission errors in response frames

#### B.5.3.1 ARM REJ capability

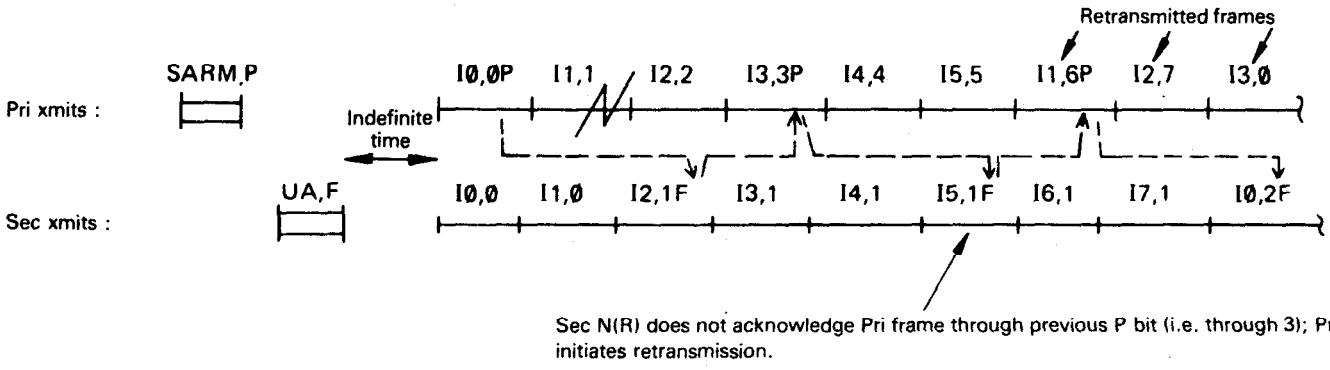



* Optional : Frame may be completed or aborted.

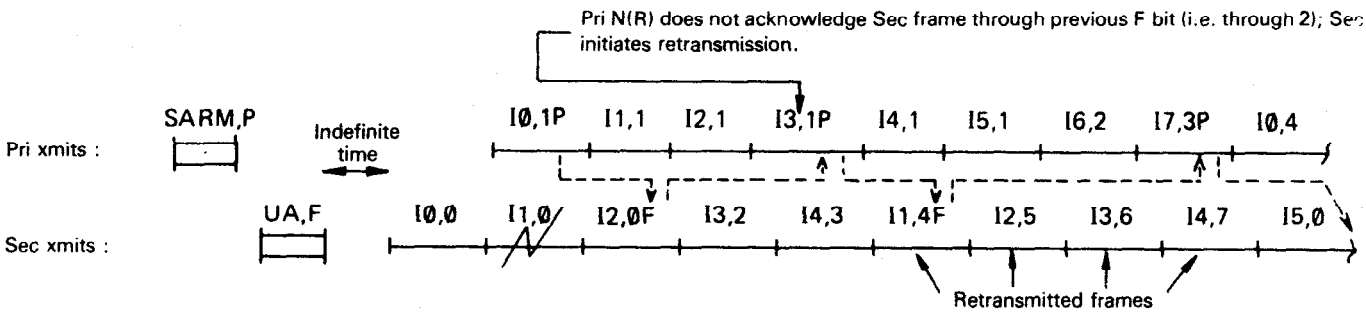
#### B.5.3.2 ARM SREJ capability




#### 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

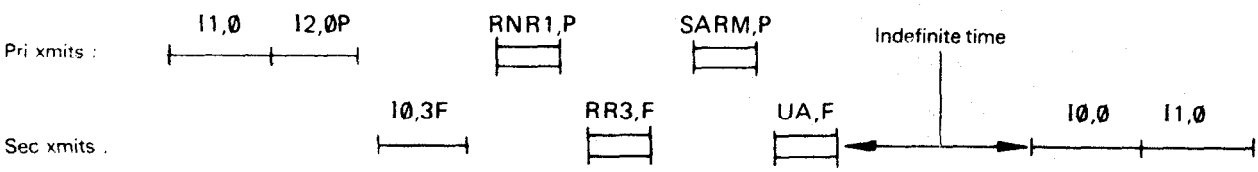



## B.6 Examples of changing control mode

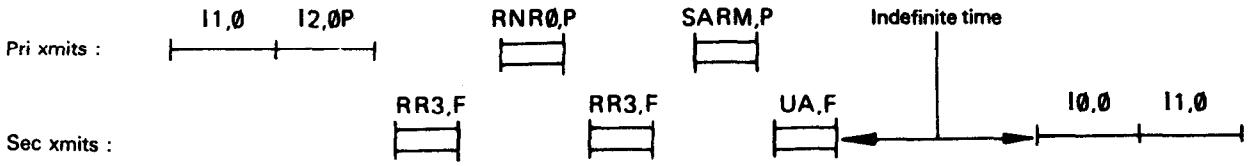
### B.6.1 Normal response mode (NRM) to asynchronous response mode (ARM) change

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

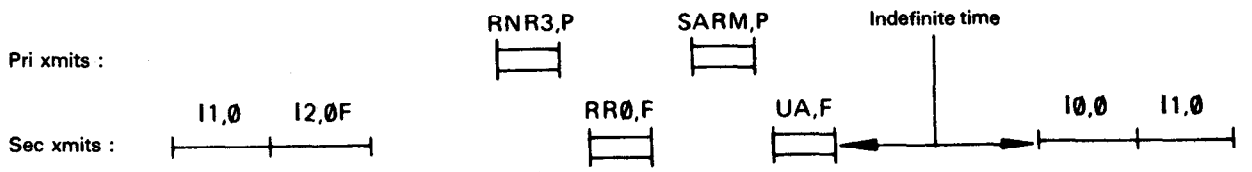
*Example A*



*Example B*

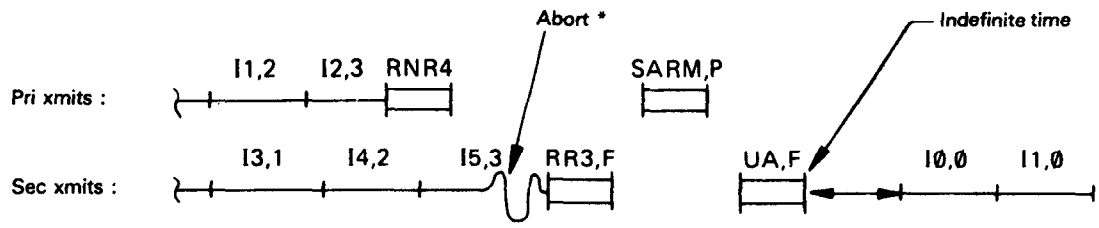



*Example C*

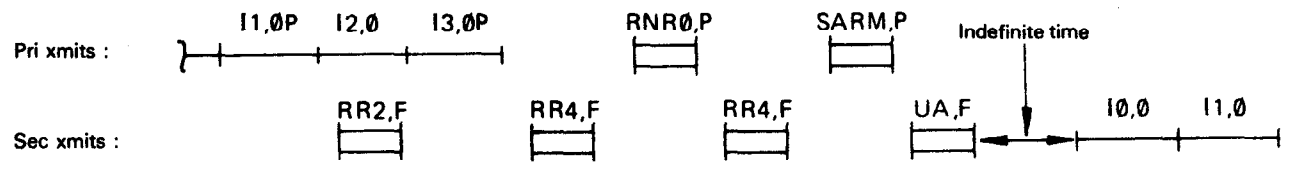



### B.6.1.2 Two-way simultaneous (TWS) transmission NRM to ARM mode change

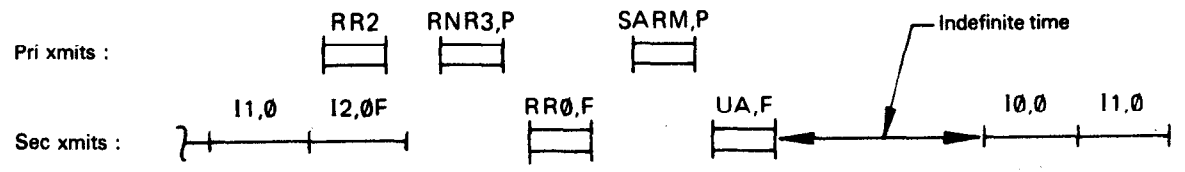
*Example A*




*Example B*



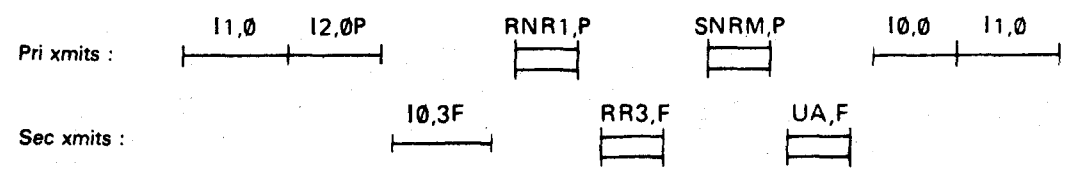

*Example C*




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

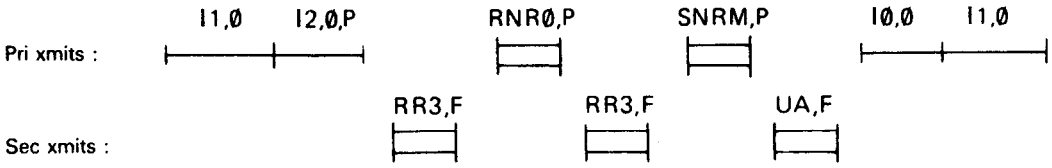
### B.6.2.1 Two-way alternate (TWA) transmission ARM to NRM mode change

*Example A*

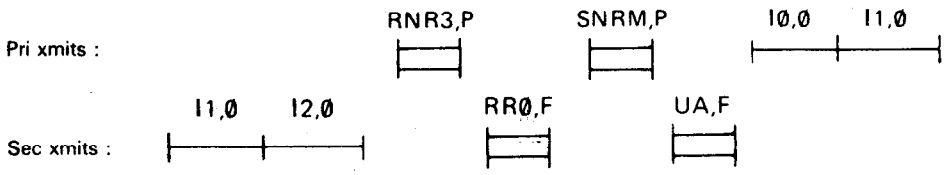



* Optional : Frame may be completed or aborted.

*Example B*

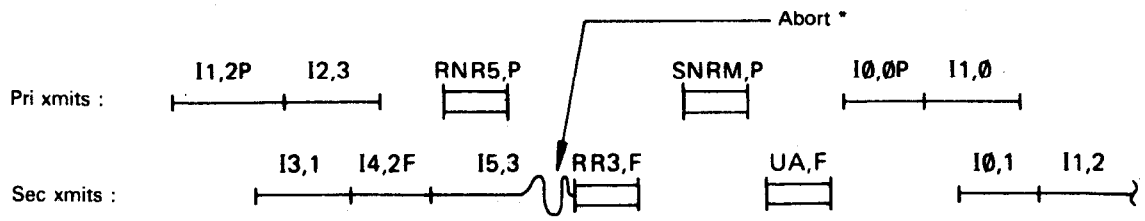



*Example C*

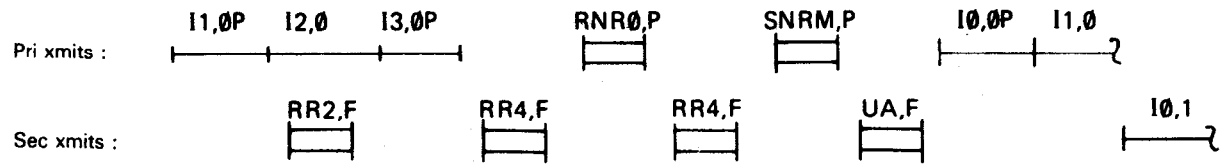



### B.6.2.2 Two-way simultaneous (TWS) transmission ARM to NRM mode change

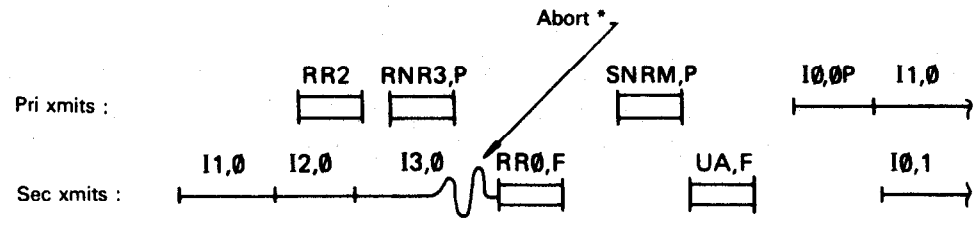
*Example A*




*Example B*

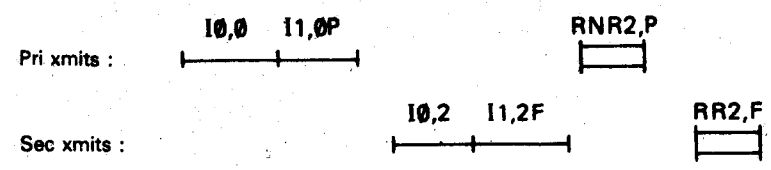



*Example C*



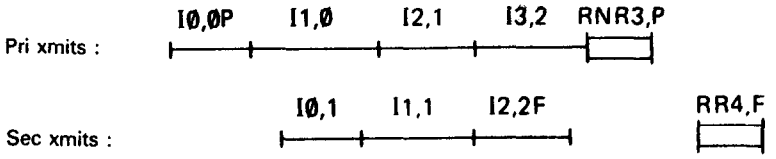

## B.7 Examples of end of operation (general closing procedure)

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

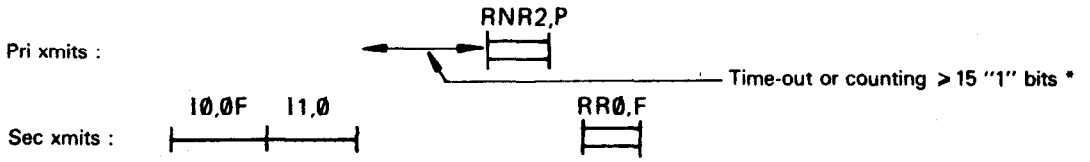



* Optional : Frame may be completed or aborted.

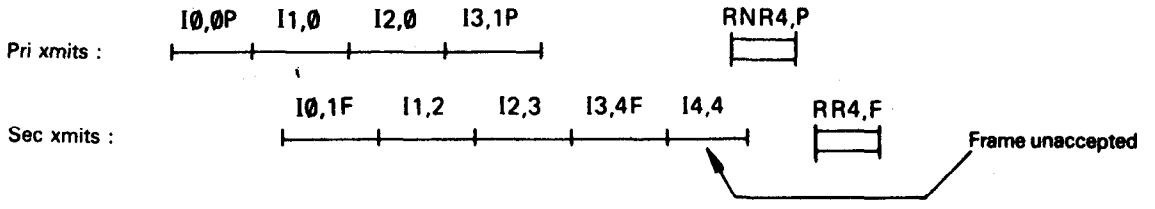
### B.7.2 Normal response mode (NRM), two-way simultaneous (TWS) transmission




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




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

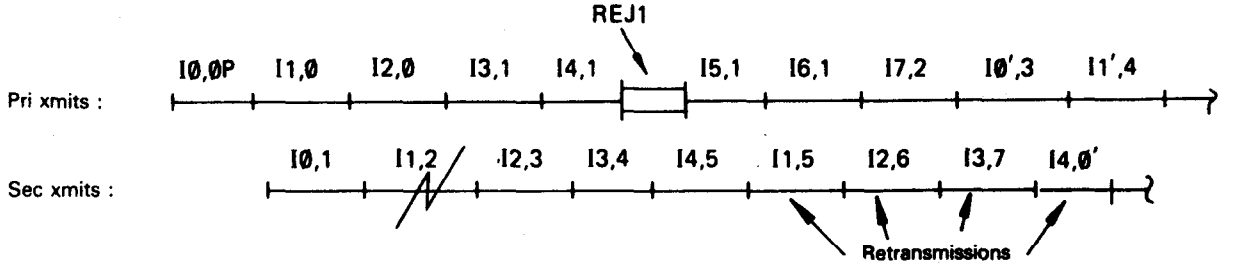



## B.8 Examples of exception recovery procedures

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

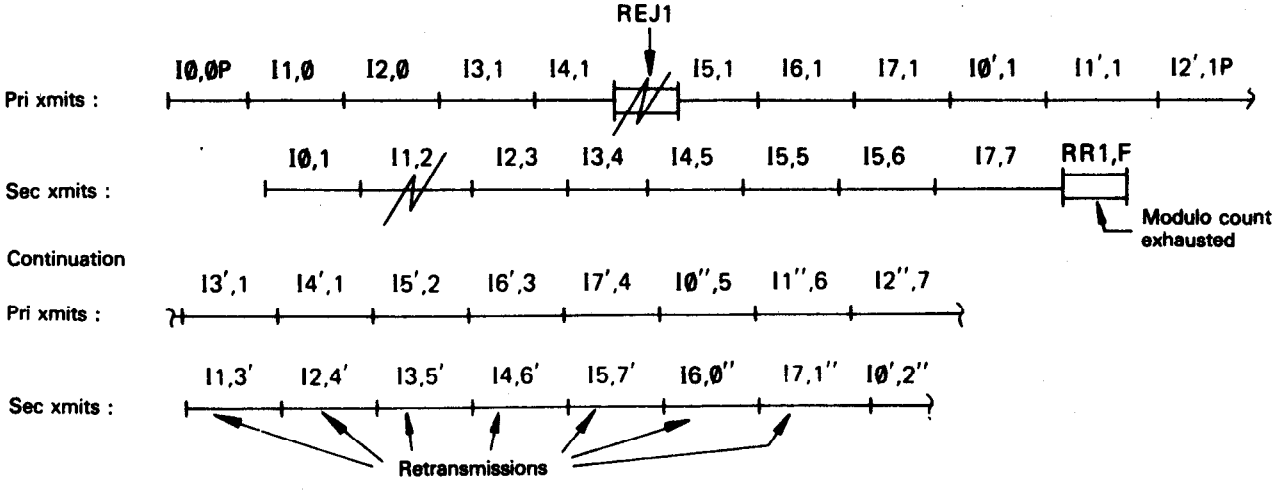
#### B.8.1.1 NRM — TWS with information frame exception

**B.8.1.1.1** REJ received correctly



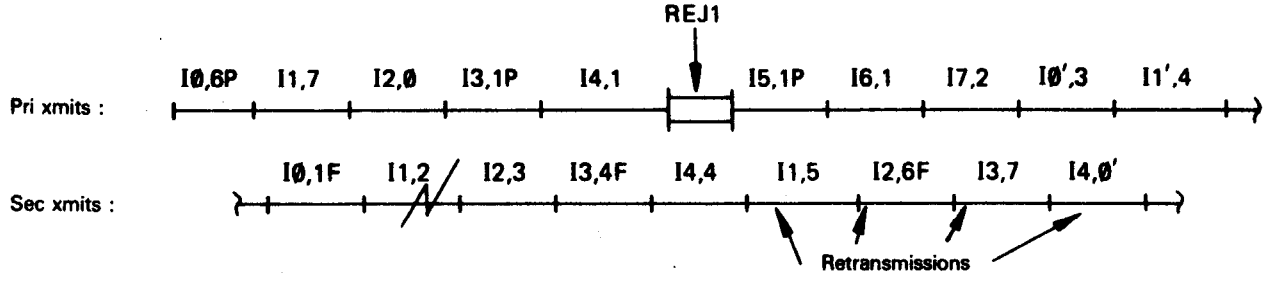

* The method of counting 15 binary "1" bits is still subject to further study with respect to possible impact on ISO 3309.

**B.8.1.1.2** REJ not received correctly

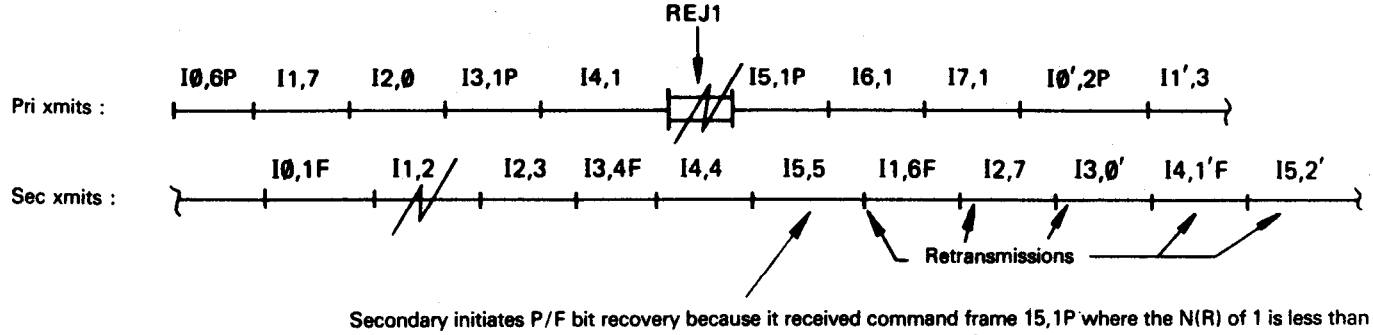



**B.8.1.2 ARM – TWS information frame exception**

**B.8.1.2.1** REJ received correctly




**B.8.1.2.2** REJ not received correctly

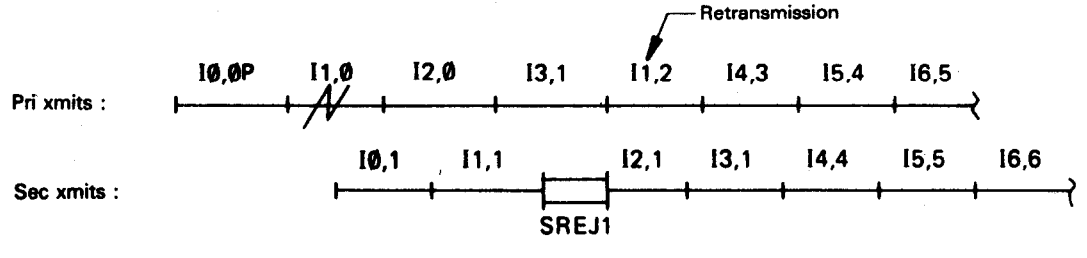



Secondary initiates P/F bit recovery because it received command frame 15,1P where the N(R) of 1 is less than N(S) of 3 in the last response frame with the final bit set to "1" (13,4F).

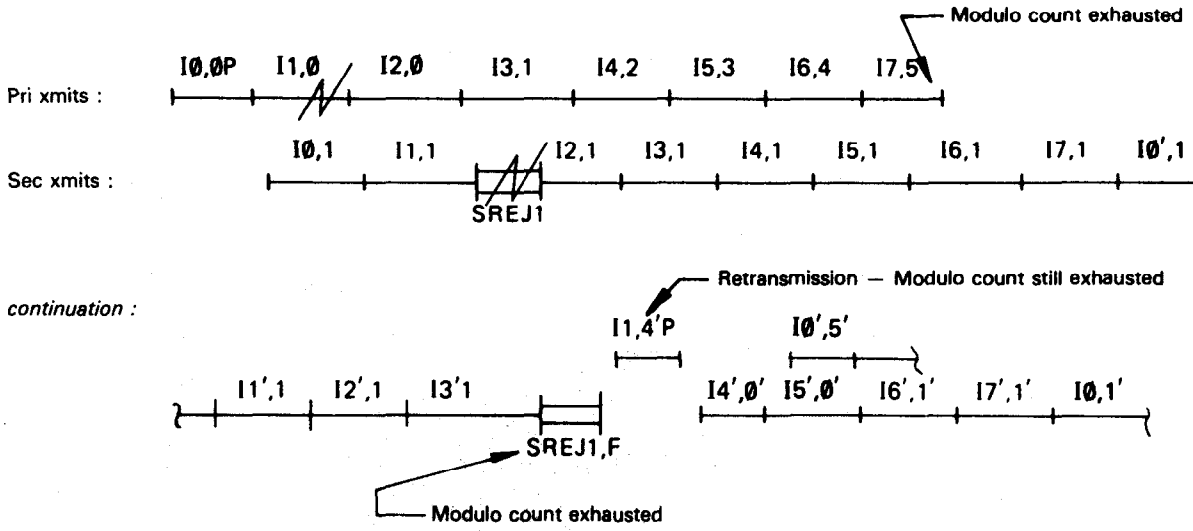
**B.8.2 SREJ/REJ exception recovery for TWS operation**

**B.8.2.1 NRM – TWS with information frame exception**

**B.8.2.1.1** SREJ received correctly

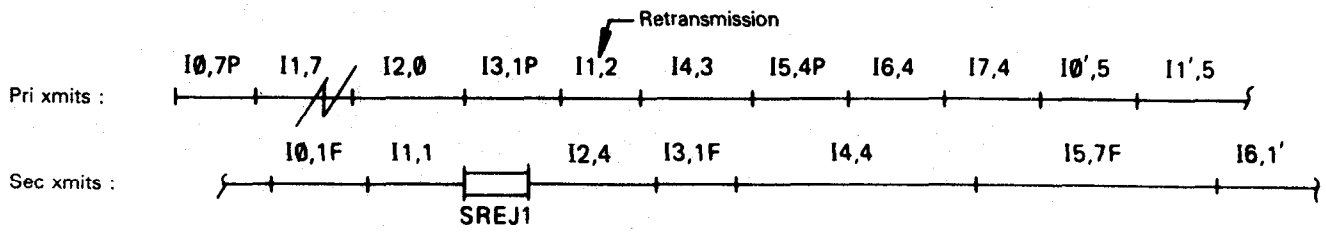


**B.8.2.1.2** SREJ not received correctly

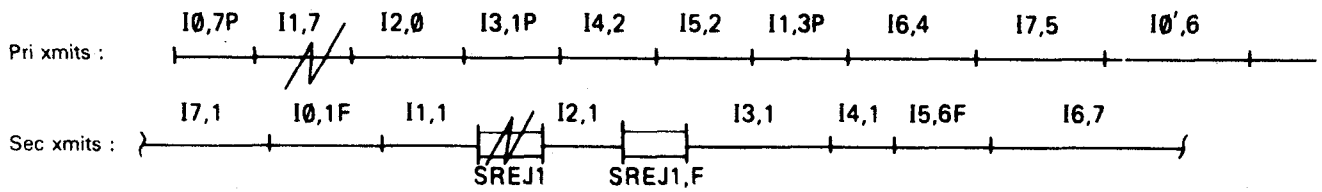



**B.8.2.2 ARM — TWS with I frame exception condition**

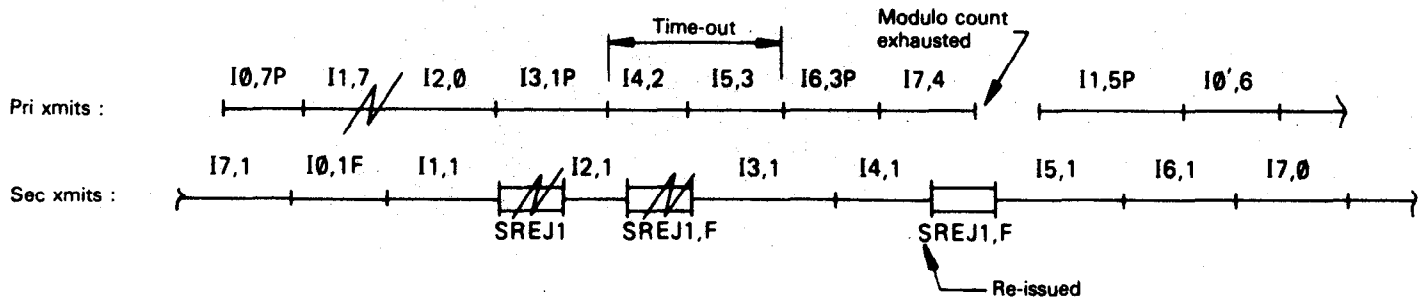
**B.8.2.2.1** SREJ received correctly




**B.8.2.2.2** SREJ not received correctly



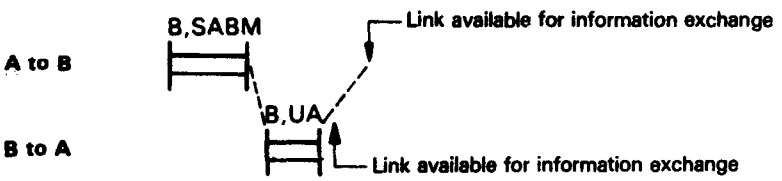

**B.8.2.2.3** Second SREJ not received correctly



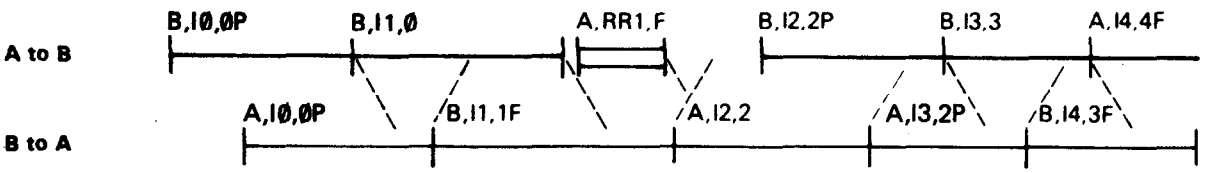
## B.9 Examples of asynchronous balanced mode (ABM)

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

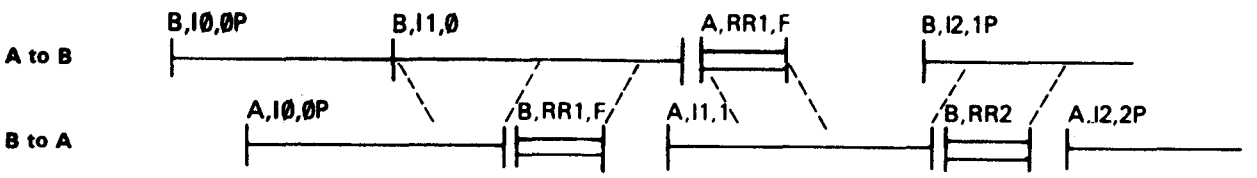
#### B.9.1.1 ABM start-up procedures



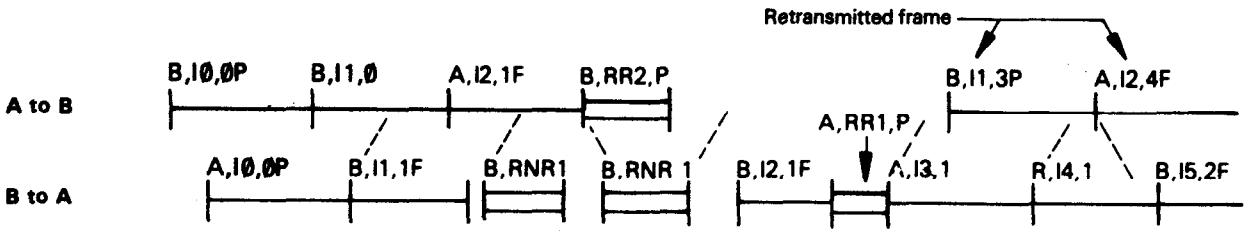

#### B.9.1.2 ABM information exchange — Normal acknowledgment by I frame



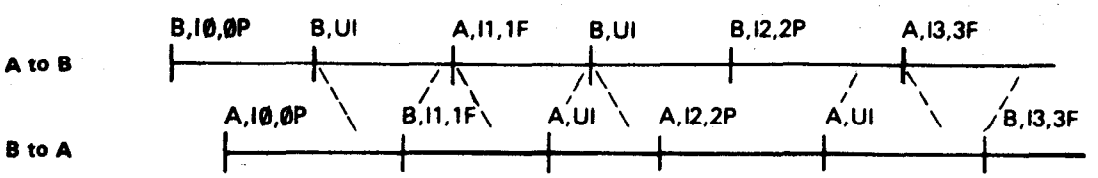

#### B.9.1.3 ABM information exchange — RR as preferred acknowledgment



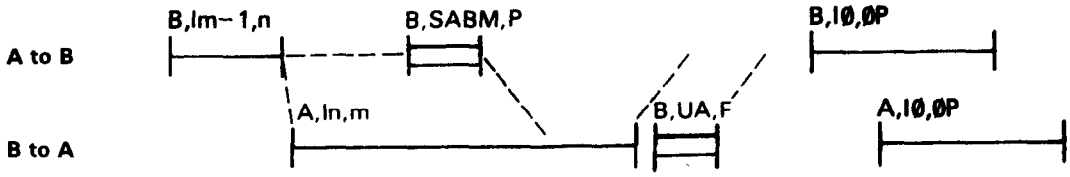

#### B.9.1.4 ABM information exchange — Use of RNR




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

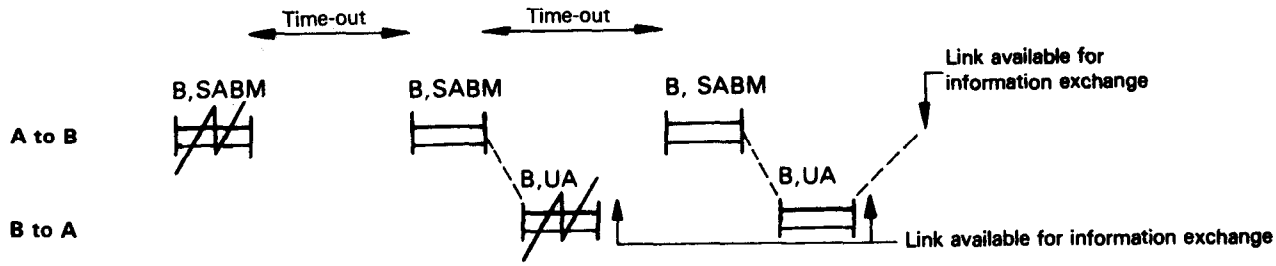


#### B.9.1.6 ABM resetting the numbering

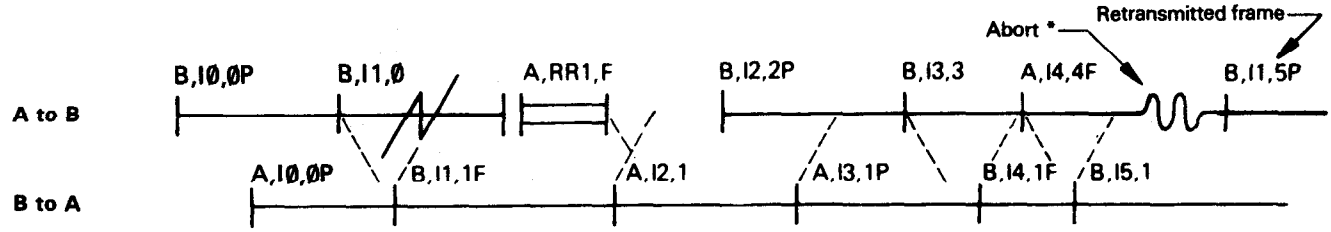



### B.9.2 Asynchronous balanced mode (ABM) with transmission errors

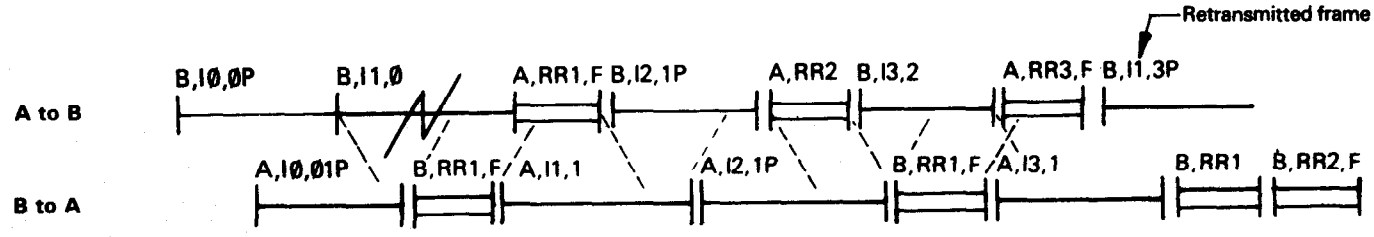
#### B.9.2.1 ABM start-up — command error and response error



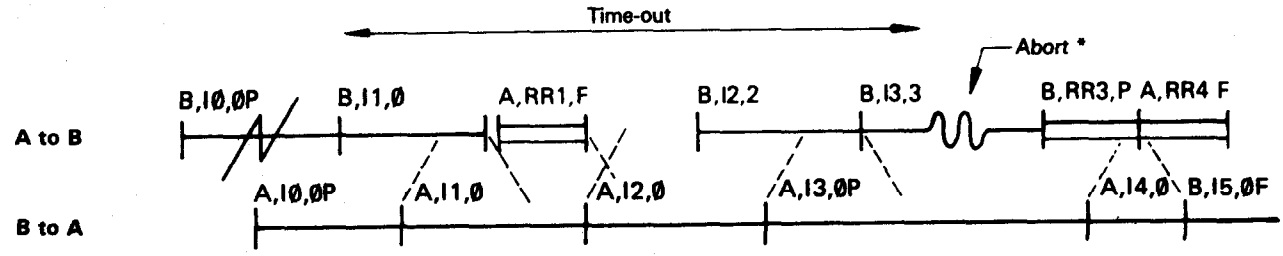

#### B.9.2.2 ABM information exchange — Checkpoint recovery, normal acknowledgment by I frame




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

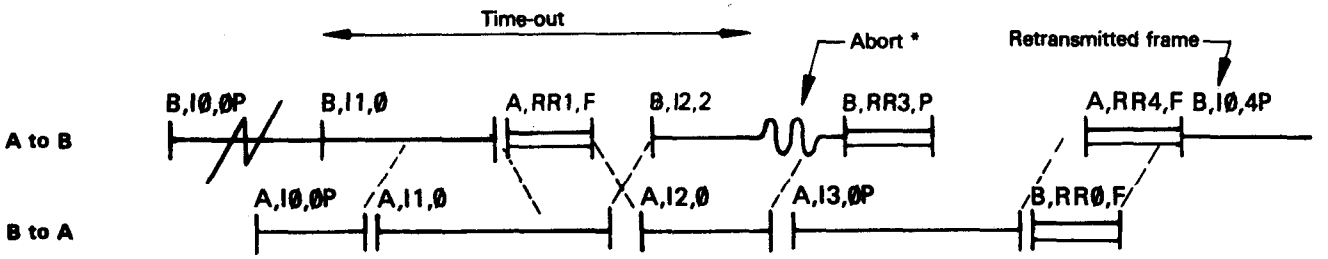



#### B.9.2.4 ABM information exchange — Time-out recovery, normal acknowledgment by I frame

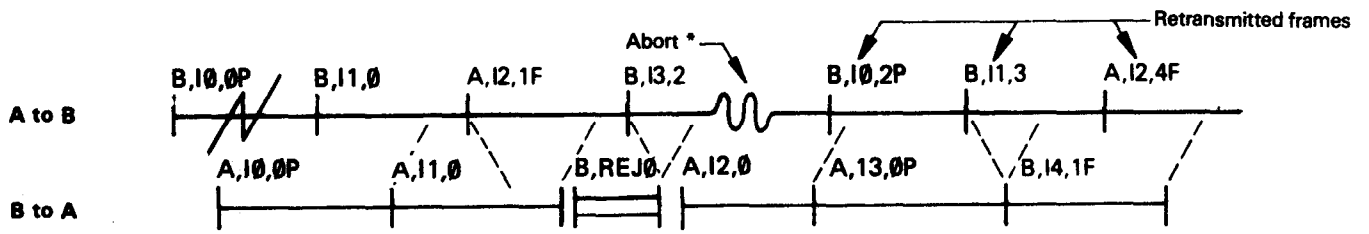



* Optional : Frame may be completed or aborted.

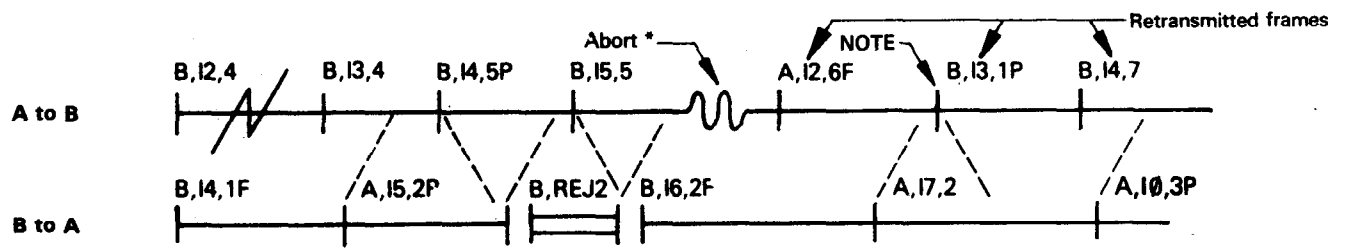
**B.9.2.5 ABM information exchange — Time-out recovery, RR as preferred acknowledgment**




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

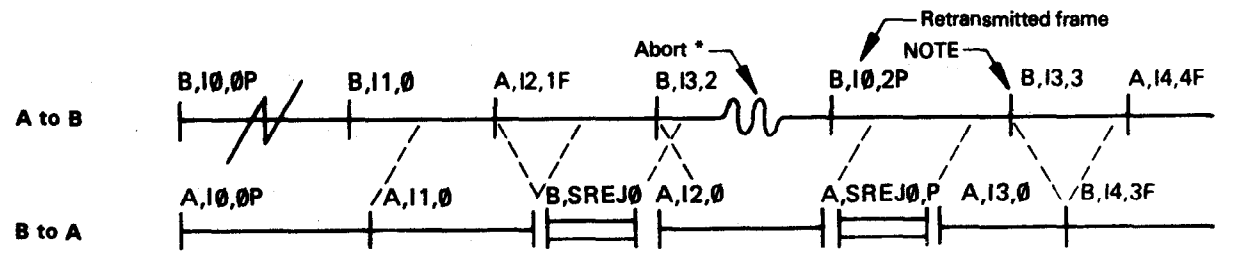



**B.9.2.7 ABM information exchange — System extended by use of REJ, P/F checkpoint inhibited**




NOTE — Receipt of B I6,2 F normally would have resulted in retransmission of I2 but inhibited due action following B,REJ2.

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

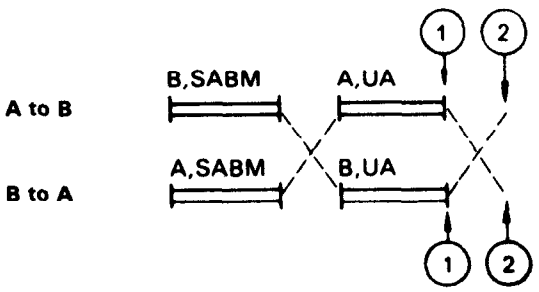



NOTE — A, SREJO, P not actioned due to previous action taken on B, SREJO.

* Optional : Frame may be completed or aborted.

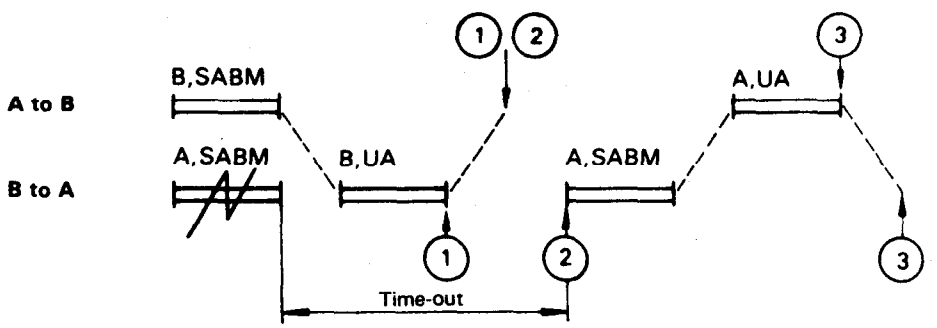
### B.9.3 Asynchronous balanced mode (ABM) contention situations

#### B.9.3.1 ABM contention — SABM and SABM



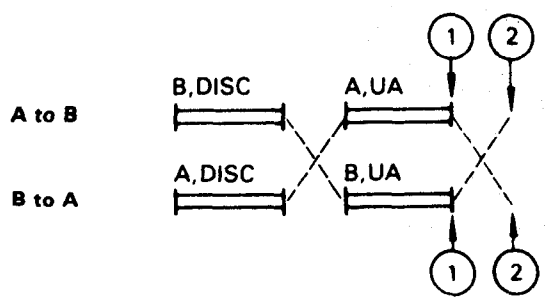

Procedure may be completed at either (1) or (2) with link available for information information transfer

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



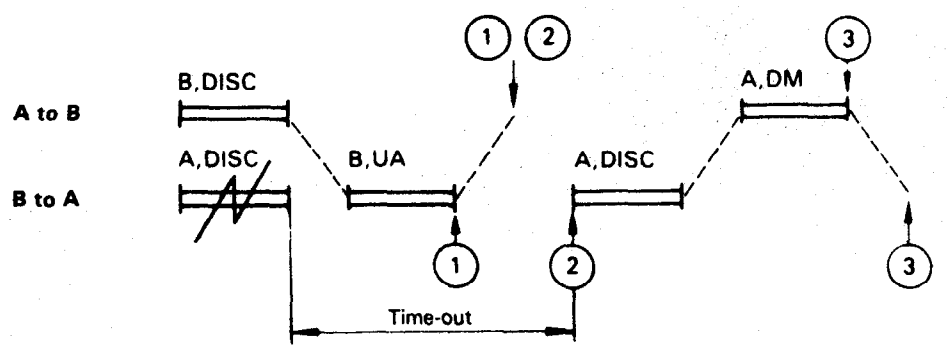

Procedure may be completed at either (1), (2) or (3) with link available for information transfer.

#### B.9.3.3 ABM contention — DISC and DISC



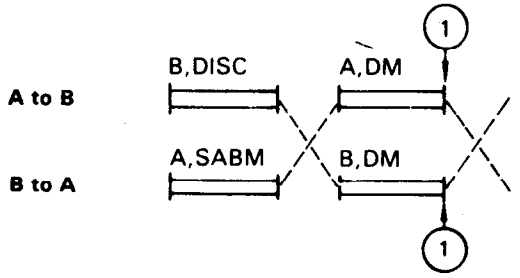

Procedure may be completed at either (1) or (2) with link in disconnected mode.

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



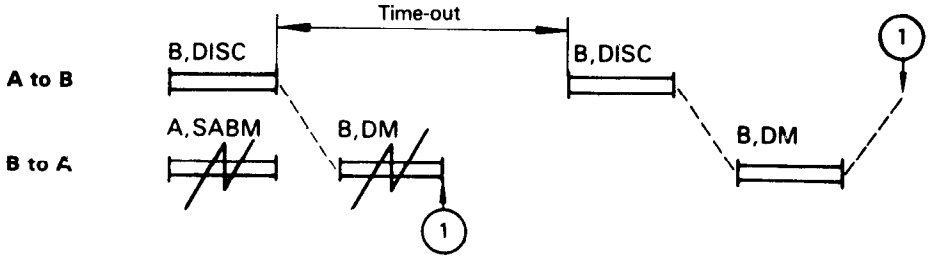

Procedure may be completed at either (1), (2) or (3) with link in disconnected mode.

### B.9.3.5 ABM contention — DISC and SABM

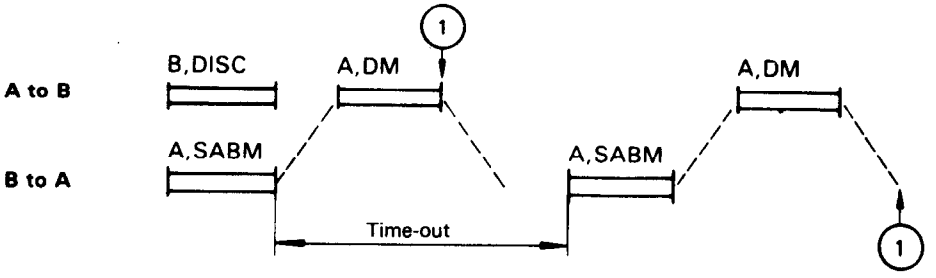



Procedure is completed at (1) with link in disconnected mode.

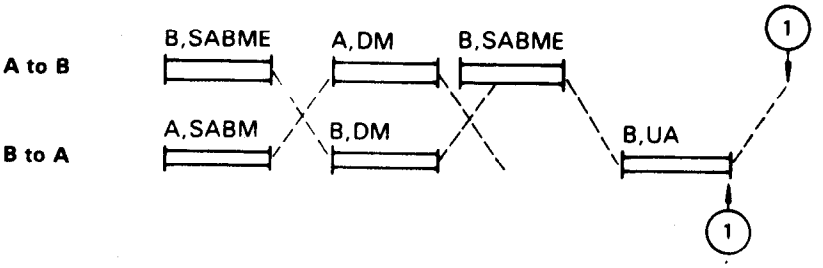
### B.9.3.6 ABM contention — DISC and SABM, with transmission errors




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

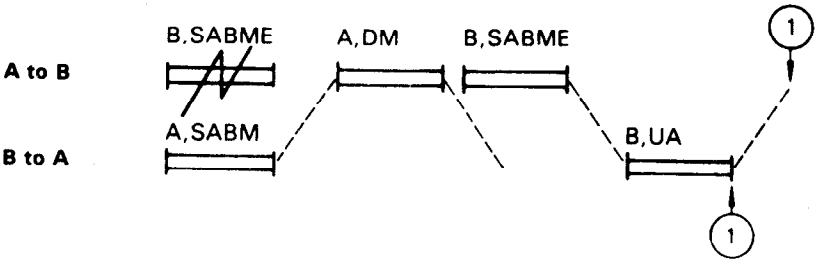



### B.9.3.7 ABM contention — SABME and SABM

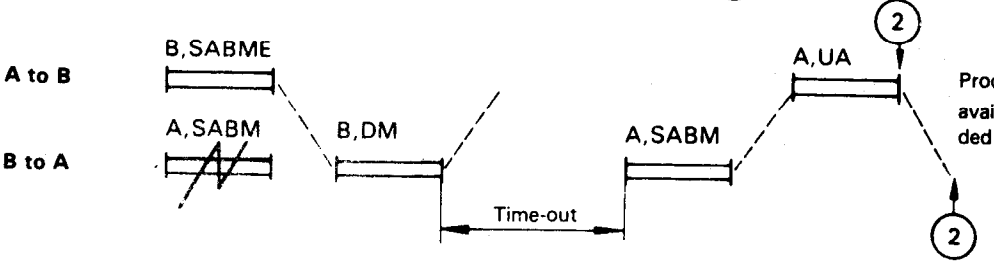



Procedure is completed at (1) with link available for information transfer in extended mode.

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




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




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