ATIS STANDARD

ATIS-1000612.1992(R2013)

Integrated Services Digital Network (ISDN) – Terminal Adaption Using Statistical Multiplexing

AMERICAN NATIONAL STANDARD FOR TELECOMMUNICATIONS

ATIS-1000612.1992(R2013), *Integrated Services Digital Network (ISDN) – Terminal Adaption Using Statistical Multiplexing*

Is an American National Standard developed by the **Signaling, Architecture, and Control (SAC)** Subcommittee under the **ATIS Packet Technologies and Systems Committee (PTSC)**.

Published by

Alliance for Telecommunications Industry Solutions
1200 G Street, NW, Suite 500
Washington, DC 20005

Printed in the United States of America.

ANSI®
T1.612-1992 (R2013)

American National Standard
for Telecommunications –

Integrated Services Digital Network (ISDN) – Terminal Adaption Using Statistical Multiplexing

Secretariat

Exchange Carriers Standards Association

Approved September 15, 1992

American National Standards Institute, Inc.

Abstract

This standard describes a protocol for use in ISDN point to point 64 kbit/s, H0, H10, H11 or D (for Frame Relay) connections to accommodate lower speed devices conforming to other standards. It does not define the specific mapping between those standards and the protocol defined as this is viewed as an implementation matter and does not require standardization.

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Published by

American National Standards Institute
11 West 42nd Street, New York, New York 10036

Printed in the United States of America

APS3C593/42

Contents

Foreword (This foreword is not part of American National Standard T1.612-1992.)

The project to revise American National Standard T1.612 was initiated under the auspices of the Accredited Standards Committee on Telecommunications, T1, as an effort in the Terminal Adaption Subworking Group of T1S1.2.

This standard is intended to provide a terminal adaption protocol for use between data terminal equipment over a public or private ISDN. This revision to T1.612 extends the use of this protocol for Frame Relay connections as well as Circuit Mode connections. It is desirable to provide a standardized protocol to allow widely implemented non-ISDN protocols to access public and private ISDN services. Asynchronous, synchronous HDLC framed, and bit transparent synchronous protocols are all supported by this standard. The standard has been written to help define the interface between different customer terminal elements and assure the interworking of these elements.

This standard contains four informative annexes. These annexes are for information only and are not considered to be part of the standard.

Suggestions for the improvement of this standard are welcome. They should be sent to the Exchange Carriers Standards Association, 1200 G Street NW, Suite 500, Washington, DC, 20005.

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American National Standard
for Telecommunications –

Integrated Services Digital Network (ISDN) – Terminal Adaption Using Statistical Multiplexing

1 Scope

This standard, based on CCITT Recommendation V.120, describes a protocol intended to be used between two terminal adaptor (TA) functional groups, between two ISDN Terminal (TE1) functional groups, between a TA and a TE1, or between either a TA or TE1 and an Interworking Function (IWF) inside a public or private ISDN. It provides for operation:

– over either Circuit mode or Frame Relay connections;

– using either demand or semi-permanent establishment of communications; and

– over any of the following types of access channel: B, H_0, H_{10}, H_{11} or, additionally, for Frame Relay bearer connections, D. It may also be used with the Multirate Circuit Mode Bearer Service.

This standard also describes how this protocol is related to synchronous and asynchronous interface specifications using the interchange circuits such as defined in Recommendation V.24, EIA/TIA 232-E or EIA/TIA 530-A. It is not intended to be a functional specification for an implementation of any system containing a TE1 or TA functional group. Except as explicitly noted, it is restricted to the definition of the protocol at the user-network interface (reference points S, T or U) and the ISDN-side interface of an interworking function (IWF).

The terminal adaption protocol in this standard may be used in support of three classes of non-ISDN-terminal protocols. These are:

a) Asynchronous (Start/Stop) Protocols, supported using the Protocol Sensitive Asynchronous Mode;

b) Synchronous Protocols using HDLC Frame Format, supported using the Protocol Sensitive Synchronous Mode;

c) Synchronous Protocols, supported using the Bit Transparent mode.

However, the Bit Transparent mode is not suitable for use with Frame Relay connections.

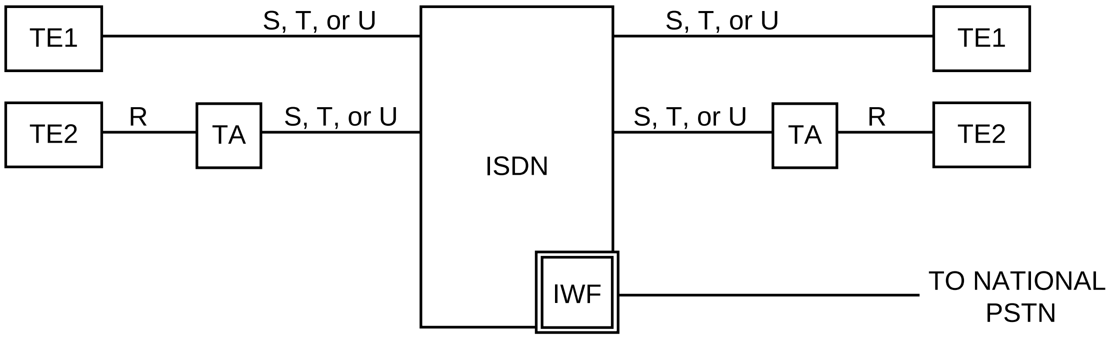
2 Normative references

The following American National Standards and CCITT recommendations contain provisions which, through reference in this text, constitiute provisions of this American National Standard. At the time of publication, the editions indicated were valid. When later editions of American National Standards are published, those later editions apply.

ANSI T1.408-1990, *Telecommunications – Integrated Services Digital Network (ISDN) – Primary Rate – Customer installation metallic interfaces layer 1 specification*

ANSI T1.601-1988, *Basic access inteface for use on metallic loops for application on the network side of the NT1 (layer 1 specification)*

ANSI T1.602-1989, *Telecommunications – Integrated Services Digital Network (ISDN) – Data-Link layer signalling specification for application at the user–network interface*



TE1	ISDN data terminal
TE2	data terminal (DTE) with non-ISDN interfaces
TA	V.120 terminal adapter
IWF	Interworking function
S, T, or U	S, T, or U are architectural reference points at which the physical interface of concern may be implemented.

Figure 1 – ISDN connection scenarios

ANSI T1.607-1990, *Telecommunications – Integrated Services Digital Network (ISDN) – Layer 3 signaling specification for circuit-switched bearer service for Digital Subscriber Signaling System Number 1 DSS1*

ANSI T1.617-1991, *Telecommunications – Integrated Services Digital Network (ISDN) – Signaling Specification for Frame Relay Bearer Service for Digital Subscriber Signaling System number 1 (DSS1)*

ANSI T1.618-1991, *Telecommunications – Integrated Services Digital Network (ISDN) – Core aspects of frame protocol for use with frame relay bearer service*

CCITT Recommendation I.233.1 (1991), *ISDN Frame Relaying Bearer Service* [1), 2)]

CCITT Recommendation I.464 (1991), *Multiplexing, Rate Adaption, and Support of Existing Interfaces for Restricted 64 kbit/s Transfer Capability* [1), 2)]

CCITT Recommendation Q.922 (1991), *ISDN Data link layer specification for Frame Mode Bearer Service* [1), 2)]

CCITT Recommendation X.212 (1988), *Data link service definition for OSI interconnection* [1), 3)]

3 Application

3.1 General

The protocols described in this standard may be used by a TE1, TA or IWF, as illustrated in figure 1. The formats and procedures contained in this standard are defined in terms of their operation across interfaces at reference points S, T or U, or (in the case of an IWF) across interfaces that may be internal network interfaces. Where necessary to promote compatibility, the relationship between the Terminal Adaption protocol and existing protocols at the interface at Reference Point R (where present) are also described.

3.2 Connectivity

Two or more Terminal Adaption connections may be multiplexed across a circuit switched bearer connection or Frame Relay access connection. These connections are referred to in this Standard as “Logical Links”. Logical Links supporting different modes of the Terminal Adaption protocol may be multiplexed across the same circuit switched bearer connection or Frame Relay access connection. Constraints on the number of Logical Links (up to the maximum number that can be

1) Available from the American National Standards Institute, 11 West 42nd St., New York, NY 10036.

2) Published in the 1991 CCITT Blue Books.

3) Published in the 1988 CCITT Blue Books.

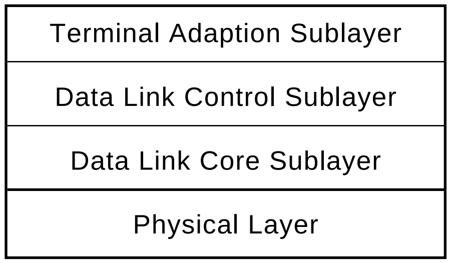


Figure 2 – Protocol Layers used in this standard

coded in the Address field) and the combinations of Modes supported by a circuit switched bearer connection or Frame Relay access connection are implementation dependent and not subject to standardization.

The Protocol Sensitive modes (a and b in clause 1) of this standard may be used to support dissimilar rates (i.e., when used between two TAs, the data rates at the interfaces at Reference Point R may be different). The use of buffering, application of the flow control protocol in this standard, use of flow control procedures at the R reference point, use of discarding and other strategies for support of dissimilar rates are implementation dependent.

Parameter exchange procedures may be defined to allow interworking between terminal adaptors (TAs) in an environment where multiple different TA protocols are used without requiring interworking functions within the network. Interworking between different types of TAs can be accomplished with Multiprotocol Terminal Adaptors (MTAs) that are capable of supporting more than one protocol. However, interworking functions may be used when TAs are not capable of supporting more than one protocol.

3.3 Protocol Architecture

Figure 2 shows the protocol architecture of the User-Plane, defined for the purposes of this standard. The protocol defined in this standard may be viewed as having the Physical layer and a Data Link Layer having three sublayers: the Core Sublayer, the Data Link Control Sublayer and the Terminal Adaption Sublayer. The Data Link Core Sublayer and the Data Link Control Sublayer are subdivisions of the Data Link Layer (see Recommendation X.212). This layering is in alignment with CCITT Recommendation I.233.1, "ISDN Frame Relaying Bearer Services." The Terminal Adaption Sublayer may also be considered a subdivision of the Data Link Layer (though it may alternatively be viewed as a thin Layer 3).

Figure 3 shows how the layering of figure 2 maps to the frame formats of this standard.

3.3.1 Terminal Adaption sublayer

The Terminal Adaption sublayer provides for transfer of data, provision for the detection of errors, and reassembly of segmented data between peer systems. It also may provide the following additional functions:

a) Segmentation;

b) Transport of notification of error conditions detected in external protocols (i.e., at the interface at Reference Point R);

c) Transport of information related to the normal operation of external protocols (e.g., Break for the Protocol Sensitive Asynchronous Mode or HDLC Idle for the Protocol Sensitive Synchronous Mode);

d) Support for operation with a Network Independent Clock;

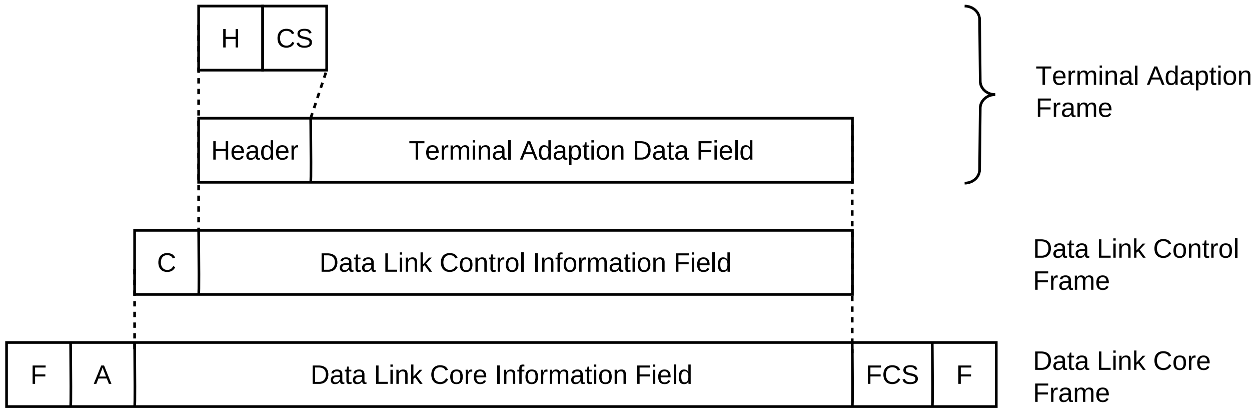
e) Flow control;

f) Transport of status information (which may be mapped to interchange circuits at the interface at Reference Point R; however, see annex B).

3.3.2 Data Link Control sublayer

The Data Link Control sublayer provides the procedures and formats of fields for Data Link Layer peer-to-peer communication. The elements of procedures define the Commands and Responses that are used for peer-to-peer communication.

For formats and the elements of procedures, see CCITT Recommendation Q.922.



F	HDLC Flag
A	Address
FCS	Frame Check Sequence
C	Control (HDLC format)
H	Header octet (Optional for bit transparent mode)
CS	Optional header extension for control state information

Figure 3 – Relationship between layering and frame formats

3.3.3 Data Link Core sublayer

The Data Link Core sublayer allows for the statistical multiplexing of Core information flows:

The major Core functions include:

- framing;
- transparency;
- multiplexing using the address field; and
- error detection.

The data link core protocol is defined in ANSI T1.618 and annex A/Q.922 for operation over a Frame Relay Bearer service and in 7.2 for operation over a Circuit Switched Bearer service. The Data Link Core service is defined in CCITT Recommendation I.233.1.

3.4 Operation over 56 kbit/s transport capabilities

Where a terminal adapter is used on an ISDN user interface for adaption to a 64 kbit/s B channel and the bearer capability provided by the ISDN is 56 kbit/s rate adapted to unrestricted 64 kbit/s, or the connection involves interworking with a 56 kbit/s network, the TA shall rate adapt to 56 kbit/s rate by using the first 7 bits of each B channel octet and shall insert a binary ONE in the eighth bit of each B channel octet. The reverse process shall be used at a receiver. All of the procedures in this document are applicable to these transport capabilities as well as 64 kbit/s capabilities. See CCITT Recommendation I.464.

NOTE – In frame relay applications, the limitation, if it exists, will be in the access connection only.

4 Terminal Adaption protocol

This clause describes the Terminal Adaption protocol. This protocol depends on the services of the Data Link Control sublayer and, for the bit transparent mode, it also depends upon the services of the Physical layer.

There are two categories of terminal adaption defined in this standard. Protocol sensitive operation requires that the TE1, TA or IWF be able to delimit the beginning and end of characters (for Asynchronous Mode) or HDLC frames (for Synchronous Mode), removing any idle time fill. Bit transparent operation provides for the transport of isochronous data (R reference point) transparently without alignment (above the bit level) of information from

8	7	6	5	4	3	2	1	BIT
E	BR	res	res	C2	C1	B	F	

E	Extension bit
BR	Break/mark hold bit
C1, C2	Error control bits
B, F	Segmentation bits
res	Reserved for future standardization

Figure 4 – Header octet format

the interface at the R reference point within the frame transport in the bearer channel. It is particularly suited to the adaption of protocols that are not covered by the protocol sensitive modes.

Two protocol sensitive modes are defined for the Terminal Adaption protocol. The Asynchronous mode is intended to transport Start/Stop mode data. The Synchronous mode is for the transport HDLC framed data.

4.1 Formats

The Terminal Adaption header may contain one or two octets. The two are labeled the Header (H) octet and the Control State (CS) octet.

4.1.1 H-Header octet

The H Octet is required for the Protocol Sensitive modes of operation, and is optional for the Bit Transparent Mode.[4)] The format of the H octet is shown in figure 4.

4.1.1.1 E-extension bit (bit 8)

The E bit is the header extension bit. It allows the extension of the header to provide additional control state information. A ‘0’ bit indicates that a control state information octet follows (see 4.1.2).

4.1.1.2 BR-break/HDLC idle bit (bit 7)

In asynchronous applications, the BR bit indicates the invocation of the BREAK function by the TE2. A ‘1’ in this bit position indicates BREAK (see 4.2.1.1 and 8.2).

In protocol sensitive operation for synchronous HDLC applications the BR bit is used to indicate whether an HDLC idle condition exists at the R reference point. A ‘1’ in this position indicates that an HDLC idle condition exists. In bit transparent mode this bit is reserved and set to ‘0’ on transmission and ignored on reception.

4.1.1.3 Bits 5 and 6

Bits 5 and 6 of the header octet are reserved and set to ‘0’.

4.1.1.4 C1, C2-error control bits (bits 3 and 4)

Bit 3 and bit 4 of the header octet are defined as control 1 and control 2, respectively, and are used for TA error detection and transmission.

The meanings of the C1 and C2 bits are encoded as shown in table 1.

4.1.1.5 B, F-segmentation bits (bit 2 and bit 1)

The B and F bits are used for segmenting and reassembly of messages in synchronous mode applications. Setting the B bit to ‘1’ indicates that the frame contains an information portion beginning a message. Setting the F bit to ‘1’ indicates the frame contains the final portion of the message. If the entire message is contained within a single frame then both B and F bits shall be set to ‘1’. A frame which is neither first nor last is termed a middle frame. For the asynchronous mode and the bit transparent mode these bits are set to ‘1’. The meaning of the B and F bits is summarized in table 2.

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4) If the H octet is not present in the Protocol Sensitive mode, or if it is not present but its use has been agreed (i.e., by the signaling protocol or by configuration management) for the Bit Transparent mode, the first octet of user data in the frame may be treated as if it were the H octet, resulting in misoperation of the protocol.

Table 1 – Coding of C1 and C2 bits

C1	C2	Synchronous	Asynchronous	Bit Transparent
0	0	No error detected	No error detected	No error detected
0	1	FCS error (interface at R)	Stop-bit error	Not applicable
1	0	Abort	Parity error on the last character in frame	Not applicable
1	1	TA overrun (from interface at the R reference point)	Both Stop-bit and parity error	Not applicable

Table 2 – Coding of B and F bits

B	F	Synchronous	Asynchronous	Bit Transparent
1	0	Begin Frame	Not applicable	Not applicable
0	0	Middle Frame	Not applicable	Not applicable
0	1	Final Frame	Not applicable	Not applicable
1	1	Single Frame	Required	Required

4.1.2 Control State Information

The control state information is contained in the second octet of the header when present. The format of the control state information octet is shown in figure 5. For TAs, this field may serve as a physical interface control field (see 4.2.3). For procedures when UI frames are used for data transfer, this field may be used to provide for flow control (see 4.2.4.1). When the H field is present and the extension bit is set, the CS octet follows the H octet. The following shows the format of the control state information octet. For an example of the mapping of the V.24 leads, see annex B. See 4.2.3 for the procedures and see 4.2.4.1 for the use of the RR bit for flow control.

4.1.2.1 E-extension bit (bit 8)

Because the control state information octet is the second and last octet in the Header, the E bit shall be set to '1'. The E bit is provided for extension of the header in future issues of this standard. Should a receiver receive a control state information octet with the E bit set to '0', it shall ignore such extension octets.

4.1.2.2 DR – data ready (bit 7)

This bit set to '1' indicates that the interface at the R reference point is activated.

4.1.2.3 SR – send ready (bit 6)

This bit set to '1' indicates that the TE is ready to send data.

4.1.2.4 RR – receive ready (bit 5)

This bit set to '1' indicates that the TE is ready to receive data.

4.1.2.5 Bits 4, 3, 2, 1

Bits 4, 3, 2, and 1 of the control state information octet are reserved and set to '0'.

4.1.3 Interframe Time Fill

Interframe time fill should normally be HDLC flags. For special non-D-channel applications it may be all '1s'. For D-channel frame relay from a basic access, transmitted interframe time fill shall be all ones (see ANSI T1.618).

8	7	6	5	4	3	2	1	BIT
E	DR	SR	RR	res	res	res	res	

E	Extension bit
DR	Data ready
SR	Send ready
RR	Receive ready
res	Reserved for future standardization

Figure 5 – Control state information octet

4.2 Procedures

4.2.1 Operating Modes – General

4.2.1.1 Protocol Sensitive Operation in the Asynchronous Mode

To send data to a peer Terminal Adaption protocol entity, characters shall be encapsulated in an HDLC frame. The Parity bit, if present, may be encapsulated or omitted (except as noted in 8.2). The start and stop bits shall not be encapsulated. More than one character may be encapsulated in a frame. The decision to forward a frame is implementation dependent. The setting of either bits C1 or C2 or both to ‘1’ shall indicate that the TA (or IWF) has detected a stop bit error, a parity bit error, (or both at the R reference point), respectively. If either bit is set, the frame shall be transmitted without the encapsulation of additional characters. Similarly, the BR bit set to ‘1’ by the Terminal Adaption protocol entity shall indicate a Break. The frame shall be forwarded without encapsulating further characters.

When a Terminal Adaption protocol entity receives a frame, it may disassemble it into characters or accumulate it into units appropriate for internal use. Handling of stop bit errors, parity errors and break is implementation specific (except that additional procedures are noted in clause 8 and annex A for TA functional groups and TE1s, respectively).

4.2.1.2 Protocol Sensitive Operation in the Synchronous (HDLC) Mode

HDLC frames, including the Address, Control and Information fields, shall be encapsulated in one or (if segmentation [5]) and reassembly are used) more Terminal Adaption frames and forwarded to the peer Terminal Adaption protocol entity. In addition, if the unacknowledged mode of the Data Link Control service is used, the FCS shall also be encapsulated. The C1 and/or C2 bits set according to table 3 shall indicate that the TA functional group or IWF detected an FCS error, an HDLC abort, or an overrun (at the R interface or internal interface). When the C1 and/or C2 bits are set, the frame shall be forwarded. To indicate an HDLC idle condition (i.e. continuous marking), the Terminal Adaption protocol entity shall send a frame containing the BR bit set to ‘1’. To indicate the end of an HDLC idle condition (i.e., resumption of sending of flags), the Terminal Adaption protocol entity shall send a frame containing the BR bit set to ‘0’.

When a Terminal Adaption protocol entity receives a frame, reassembly of segments may be necessary. If either or both of the C1 and C2 bits is set to ‘1’, the Terminal Adaption protocol entity may:

a) Discard the frame and all previously received segments;

b) Abort the HDLC frame being sent across the R interface; or

c) Generate an incorrect FCS in the HDLC frame being sent across the R interface or internal interface.

NOTES

1 Support of non-octet-aligned frames is for further study.

2 Alternatives (b) and (c) are not meaningful if the terminal adaption protocol entity is in a TE1.

[5] Segmentation and reassembly may reduce assembly delay associated with terminal adaption.

3 When adapting 56 kbit/s HDLC terminals to 64 kbit/s B channels, using unacknowledged data transfer, the value of N2xx should not exceed 64 bytes. A high probability of overflow at the transmit side of a TA may occur if a large proportion of the frames are shorter than 64 bytes and there is no idle period between them. In such cases, restrictions, such as flow control of the TE2, may be necessary.

4.2.1.3 Bit Transparent Operation

Bits shall be encapsulated in frames and forwarded without modification. The maximum length of individual frames shall not be greater than N201, but otherwise is implementation dependent [6]. Longer frames will increase transit delay attributable to terminal adaption.

When a frame is received, the content of the data field is handled as a bit stream. A TA functional group or IWF shall not modify the bit stream.

Use of the unacknowledged mode of the Data Link Control service is preferred for bit transparent operation, as delay variance due to retransmission may result in underrun. Bit transparent operation is not recommended over a Frame Relay bearer connection; it is for circuit-mode applications only.

4.2.2 Data Field Length

The maximum number of octets in a data field (N2xx) is a system parameter. Its value must be less than or equal to N201 (see CCITT Recommendation Q.922) minus the length of the header. Negotiation procedures for N201 are discussed in CCITT Recommendation Q.922.

4.2.3 Control State Information Processing

This subclause describes the use of the control state variables and the processing of the control state information field, when present, defined in 4.1.2. Use of the control state information field is optional (see octet 5b, bit 7 of low layer compatibility 7.3.2.4.5). The procedures described in this clause and in its subclauses only apply if the control state information field is used.

The terminal adaption protocol provides for six control state variables (to be maintained by the TA protocol entity) that are related to the DR, SR, and RR indicators as follows:

a) Send variables DR(S), SR(S), and RR(S) – when a frame with DR, SR, and RR is transmitted, their transmitted values shall be equal to the current values of DR(S), SR(S), and RR(S), respectively;

b) Receive variables DR(R), SR(R), and RR(R) – when a frame with DR, SR, and RR is received, the receive variables are set to the values of these indicators, respectively.

When the control state information field is used with I or UI frames, the control state information field may be included even if control state variables are not changed. The use of the control state information field with UI frames is not recommended.

4.2.3.1 Control state information initialization

The first I or UI frames sent by each peer shall contain the control state information octet. If the first frame does not contain the control state, the values of DR(R), RR(R), and SR(R) (if implemented) shall be set to ‘1’.

4.2.3.2 Sending a control state information field

A control state information field shall be sent whenever a send control state variable changes. The control state information field shall be sent in the last frame containing any of that previously queued data (received across the interface at the R reference point) prior to the control state variable change, or in a separate frame.

The contents of the control state information octet shall be set to the state of the corresponding send control state variables. DR is set to DR(S),SR is set to SR(S), and RR to RR(S).

4.2.3.3 Receiving a control state information field

Upon receipt of a control state information field, the action taken shall depend on the received control field indicators and the control field indicators shall be compared with the current receive control state variables.

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[6] As discussed in annex C, Clock recovery at the receiver may depend upon frames being of uniform length and transmitted at uniform intervals.

If SR(R) was ‘0’ and the SR indicator bit in the received control state information field is ‘1’, then the state of RR(S) is set to ‘1’ and SR(R) shall be set to ‘1’ provided that the peer entity is not being flow controlled by use of the RR(S) state (see 4.2.4.1).

If SR(R) was ‘1’, and the SR indicator bit in the received control state information field is ‘0’, then the RR(S) state shall be set to ‘0’, and SR(R) shall be set to ‘0’.

NOTE – Where the control states variables are used for control of the interface at the R reference point, the changes in the state of RR(S) should be consistent with one of the following:

a) If received data (from peer entity) does not remain to be forwarded (no message in progress), then the control actions can occur immediately;

b) If received data (from peer entity) is incomplete (e.g., in protocol sensitive mode the final frame was not received) and DR(R) is ‘1’, then the incomplete message is forwarded (continued) until delivered on the interface at the R reference point, at which time the control actions can occur;

c) If received data (from peer entity) is complete, then the received data is forwarded until delivery on the interface at the R reference point is complete, at which time the control actions should occur.

If DR(R) was ‘0’ and the DR indicator bit in the received control state information field is ‘1’, then DR(R) shall be set to ‘1’.

If DR(R) was ‘1’ and the DR bit in the received control state information field is ‘0’, then DR(R) shall be set to ‘0’.

NOTE – Where the control states variables are used for control of the interface at the R reference point, the changes in the state of DR(R) should be consistent with the following:

a) If the received message from the peer entity is incomplete, it is discarded.

b) If the received message from the peer entity is a complete message, then it should be delivered prior to the control actions taking place.

4.2.4 Data Flow Control and Buffering

Strategies for buffering, forwarding and flow control are implementation dependent. This subclause describes the mechanisms in the Data Link Control and Terminal Adaption protocols for asserting flow control between peer Terminal Adaption protocol entities. The specific protocol mechanisms are dependent on the mode of operation.

4.2.4.1 Protocol Sensitive Asynchronous Mode

When the Multi-Frame mode of the Data Link Control protocol is used, flow control between peer Terminal Adaption protocol entities may be asserted by the Data Link Control sublayer. The applicable Data Link Control protocol mechanisms are: sending an RNR frame, or withholding the update of the sequence state variable V(R).

When the Unacknowledged mode is used, flow control between peer Terminal Adaption protocol entities may be asserted by setting the RR bit in the control state information octet (if available). Flow control is asserted by sending a control state information field with the RR bit set to ‘0’. The flow control condition is removed by sending a control state information field with the RR bit set to ‘1’. Frames containing only the H and C octets may be sent even if flow control has been asserted by the peer Terminal Adaption protocol entity. Use of the RR bit for this purpose may be mutually exclusive from its mapping to V.24 interchange circuits required for support of half duplex operation – see annex B.

NOTE – In some applications, local flow control procedures (e.g., in the protocol used at the interface at Reference Point ‘R’) may be used. The use of these procedures is implementation dependent. Examples of such procedures include signaling using V.24 interchange circuits and use of the ‘XOFF’ and ‘XON’ characters.

4.2.4.2 Protocol Sensitive Synchronous Mode

In Protocol Sensitive Synchronous mode, overrun and underrun conditions are possible in a TA functional group (i.e., at the interface at Reference Point R) or, IWF (i.e., at the interface at the non-ISDN side of the IWF). Procedures at the interface at Reference Point R are described in 8.3.

If, after transmitting one or more segments of a frame to the peer Terminal Adaption protocol entity, it becomes necessary to abort the transmission of the remainder of the frame, the ‘H’ octet of last segment to be sent shall have the B and F bits set to ‘final’ (see table 2) and the C1 and C2 bits set to ‘TA Overrun’ (see table 1). Additional segments of the frame shall be discarded. (This procedure is intended for use by a TA functional group or IWF in the case of an overrun at the interface at Reference Point R, or at the interface at the non-ISDN side of the IWF, respectively.)

An underrun condition towards the R reference point may result in the sending of an abort or by forcing an FCS error.

As flow control in HDLC involves elements of procedure not supported by the Terminal Adaption protocol, internal overflow conditions may be handled by discarding user frames. Recovery from lost frames will be between users (e.g., between TE2s).

4.2.4.3 Bit Transparent Mode

In bit transparent mode, overrun and underrun conditions may occur if buffers are inadequate and/or inappropriate clock recovery capabilities are provided. Dissimilar rates between users (e.g., TE2s) are not possible.

NOTES

1 Underrun conditions may be treated as the equivalent of the mark hold condition (e.g., by sending continuous marks across the interface at reference point ‘R’).

2 If a Terminal Adaption protocol entity is unable to process data to be sent to its peer (e.g., because of buffer overflow), it may discard as much data as it is unable to process.

4.2.5 Parameter Negotiation

Parameter negotiation, during the bearer channel establishment, is in accordance with the procedures described in ANSI T1.607 (CCITT Recommendation Q.931) for circuit mode operation and ANSI T1.617 (CCITT Recommendation Q.933) for frame relay operation. During logical link negotiation, a specific value for a parameter may be requested by including the low layer compatibility information element containing the desired parameters in the SETUP message. The receiving TA may accept the requested parameter values by responding with a CONNECT message. If the receiving TA does not accept the parameter values included in the SETUP message, it may negotiate by including the desired values in allow layer compatibility information element in the CONNECT message. The originating TA may refuse the parameters received in the CONNECT message by initiating clearing with the cause number 21 ‘call rejected’.

5 Data Link Control Protocol

The Data Link Control protocol shall be according to CCITT Recommendation Q.922 for operation over either the Frame Relay bearer service or the Circuit Mode bearer service.

For operation over the Frame Relay bearer service, use of the congestion control mechanisms of Appendix I/CCITT Q.922 are recommended.

5.1 Data Link Control Modes of service

The Data Link Control sublayer has two modes of service:

a) The Unacknowledged service is provided using UI Command Frames (see CCITT Recommendation Q.922) and, optionally preceeded by exchanging XID Command and Response frames (for the optional link verification procedures described below).

b) The Multiframe service (which supports Acknowledged and Unacknowledged transfer) is provided by exchanging SABME and UA frames, for link initialization and verification, and using I and UI Command Frames (see CCITT Recommendation Q.922).

NOTE – The use of UI frames in mode (b) is not described in this standard.

5.2 Data Link Connection Verification Procedures

This subclause describes connection or link verification procedures for the modes of service in 5.1. Connection or link verification is the procedure used by each terminal adapter (associated with a TE2 or an IWF) or TE1 to determine the existence of an end-to-end transmission path and the existence of responding equipment at the opposite end.

In this subclause, “cut-through-indication” refers to the reception of CONNECT or CONNECT ACKNOWLEDGE message. In general, to assure proper verification of a connection or link, for either multiple-frame or UI-frame-only modes, no (I or UI) frames shall be transmitted or received prior to the reception of a cut-through-indication.

To reduce the possibility of transmitting to a TA that is not yet connected:

a) A TA that receives a CONNECT message from the network should always transmit a frame to initiate the connection; and

b) A TA that receives a CONNECT ACKNOWLEDGE message from the network should wait for T200 or until it receives a frame (whichever is earlier) before transmitting a frame.

NOTE – These procedures are applicable to all LLIs.

5.2.1 Multiframe mode link verification

In multiple frame mode, the exchange of SABME/UA as defined in CCITT Recommendation Q.922 is sufficient to verify the existence of the data link.

5.2.2 Unacknowledged mode (only) link verification

In UI-frame-only mode, after receiving a cut through indication, the TA shall send an XID command and start timer TM20. A TA receiving the XID command shall respond with an XID response. Upon receiving the XID response, a TA must stop TM20 and may begin data transmission (link is established).

If TM20 expires before an XID response is received, the TA shall retransmit the XID command, increment the retransmission count NM20, and restart TM20.

If TM20 expires and the retransmission count is equal to the maximum allowable number of retransmissions, the TA may either begin data transmission or abandon the call.

The values of TM20 and NM20 should be determined by the same considerations as the values of T200 and N200, respectively (see Appendix I to CCITT Recommendation Q.922). This link verification procedure does not specify the information field of the XID frames; any coding of the information field is acceptable.

This procedure is not necessary in applications that do not require link verification.

5.2.3 Collision between Multiframe mode and Unacknowledged mode link verification

When a terminal adaptor or TE1 that has sent an SABME receives an XID command, it shall send an XID response and remain in the same state. When a terminal adaptor or TE1 that has sent an XID command receives an SABME, it shall send either a DM response or a UA response.

6 Protocol Specifications for Operation over Frame Relay Bearer Service

The Terminal Adaption protocol described in clause 4 may be supported by a Frame Relay Bearer service. Either Frame Relay Case A or Case B, as described in ANSI T1.617, may be used.

6.1 Physical Protocol

The Physical Layer protocol shall be as described ANSI T1.601, ANSI T1.605 or ANSI T1.408. Frame relay access connections may operate over B channels, H_0 channels, H_{10} channels, H_{11} channels or D channels.

6.2 Data Link Core Protocol

The Data Link Core protocol shall be as described in ANSI T1.618. Use of the congestion control procedures in Appendix I/CCITT Q.922 (1.2) are recommended.

6.3 Signaling Protocol

For demand establishment of Frame Relay bearer connections, the signaling protocol shall be according to ANSI T1.617.

In the Low Layer Compatibility Information Element (6.5.2.1 of ANSI T1.617), the User Information Layer 1 protocol (octet 5) shall be coded as “CCITT standardized rate adaption V.120”. This implies the presence of octets 5a and 5b, and, optionally, octets 5c and 5d of this information element. Coding of remaining fields and octet groups in this information element is dependent on the particular application of this standard.

Additionally, for Semi-permanent Frame Relay bearer connections, the procedures of annex B or annex D of ANSI T1.617 may be used to handle failure of the permanent connection. Use of these failure notifications is implementation specific.

7 Protocol Specifications for Operation over Circuit Mode Bearer Service

7.1 Physical Protocol

For operation over a Circuit Mode Bearer Service, the Physical Layer shall be as described in ANSI T1.601, T1.605 or T1.408-. This protocol applies for operation over B channels, H_0 channels, H_{10} channels or H_{11}

8	7	6	5	4	3	2	1	BIT
LLI0						C/R	EA0	octet 2 (ADDR octet 1)
LLI1							EA1	octet 3 (ADDR octet 2)

LLI0 high order 6 bits of LLI
LLI1 low order 7 bits of LLI
C/R command/response bit
EA0 octet 2 address extension bit – set to 0
EA1 octet 3 address extension bit – set to 1 (for a 2 octet address field)

Figure 6 – Address field format for circuit-mode applications

Table 3 – Reserved LLI values for circuit mode applications

LLI	Function
0	In-channel signaling
1-255	Reserved
256	Default LLI
257-2047	For LLI assignment
2048-8190	Reserved
8191	In-channel layer; management

Table 4 – Coding of C/R bit

C/R	Meaning
0	command
1	response

channels. Establishment of the circuit switched bearer connection may be demand or semi-permanent.

7.2 Data Link Core Protocol

7.2.1 General

The format of the Data Link Core frame is as shown in figure 3. The definition of the Flag sequence, Transparency, Frame Check Sequence and Format Conventions shall be according to ANSI T1.602-1988.

7.2.2 Address Field

7.2.2.1 LLI Field

The format of the address field is shown in figure 6. The LLI0 and LLI1 fields may be viewed as a single 13 bit “logical link identifier” (LLI) field.

The LLI is considered to be the concatenation of the LLI0 field with the LLI1 field. The LLI can take on values in the range 0 – 8191. Table 3 indicates values that are reserved.

7.2.2.2 Address field extension bit (EA bit)

The address field range is extended by using bit 1, the first transmitted bit, of the address field octets to indicate the final octet of the address field. The presence of a ‘1’ in bit 1 of an address field octet signals that it is the final octet of the address field.

7.2.2.3 C/R Bit

The C/R bit identifies a frame as either a command or a response. The C/R bit is employed symmetrically for the two directions of transmission, and is coded as shown in table 4.

7.3 Signaling Protocols

Signaling procedures are described in this subclause for the:

a) Establishment and release of the underlying Circuit-mode bearer connection, and

b) Establishment and release of logical links, multiplexed within the Circuit-mode bearer connection.

Procedures for establishment and release of Circuit-mode bearer connections are required only for Demand establishment of communication.

Procedures for establishment and release of Logical Links are used only for demand establishment of logical links. A procedure for semi-permanent establishment of logical links is also defined. Either procedure may be used over either Demand or Semi-permanent circuit mode bearer connections.

To differentiate the Logical Link establishment protocol from the protocols defined in ANSI T1.607 and ANSI T1.617, a different Protocol Discriminator is used (see 7.3.2.4.1).

7.3.1 Establishment of Underlying Circuit-Switched Bearer Connection

Demand establishment and release of Circuit Switched Bearer Connections shall be done using the formats and procedures of ANSI T1.607.

In the SETUP message, the Bearer Capability Information Element shall be coded to indicate circuit mode unrestricted digital information. For interworking with networks that offer service at 56 kbit/s, the Bearer Capability Information Element shall be coded to indicate circuit mode unrestricted digital information, with CCITT Standardized Rate Adaption V.110/X.30, synchronous, with in-band negotiation not possible and 56 kbit/s user rate. However, some existing equipment may code the information transfer capability in the Bearer Capability Information Element to indicate circuit mode restricted digital information.

The Low Layer Compatibility Information Element shall be coded to indicate circuit mode, unrestricted digital information with CCITT Standardized Rate Adaption V.120. If annex M/ANSI T1.607 is to be used, the Negotiation Indicator (octet 5a) shall be coded as “Out-band negotiation possible”. If the procedures of 7.3.2 are supported, LLI Negotiation (octet 5b) shall be coded as “LLI negotiation”; otherwise, it shall be coded as Default LLI = 256 only. The remaining fields in the LLC Information Element shall be coded to indicate the particular values to be used with the Default LLI = 256.

7.3.2 Establishment of Logical Links

When an underlying Circuit Switched Bearer Connection is established, a Logical Link identified by LLI = 256 is established at the same time. Additional DLCIs may be established by a priori agreements between peer entities.

The Logical Link establishment protocol operates over a logical link reserved for its use, identified by LLI = 0. This protocol uses either the Multiframe mode (preferred) or Unacknowledged mode of the Data Link Control service. No terminal adaption protocol header is used in support of this protocol.

Signaling protocol entities shall be designated to be either “Default Assignee” or “Default Assignor”. The Default Assignor shall normally assign LLIs. However, the default assignee may need to assume the role of assignor during negotiation. The assignor/assignee field (octet 5b) in the Low Layer Compatibility Information Element shall be used during establishment of logical links using this protocol.

7.3.2.1 Logical Link Establishment during Circuit Switched Bearer Connection establishment

The first logical link established between the two Data Link Control entities is the default LLI=256. This is done using information provided in the LLC information element.

In connections where end-to-end notification of low layer compatibility is not supported, the Data Link Control entity must rely on prior agreement to configure its options. Where no prior agreement exists, it may: reject an offered call; assume an implementation specific default LLC value and attempt to communicate with its peer; or choose to negotiate LLC values inband (i.e. on LLC=0) for LLI=256.

7.3.2.2 Logical Link Establishment on an active Circuit Switched Bearer Connection

Protocol exchanges use LLI=0 in the bearer channel.

7.3.2.2.1 LLI Assignee

If a Data Link Control entity is determined to be assignee, it must set the assignor/assignee field in LLC information element contained in any additional SETUP messages to ‘0’.

The assignee Data Link Control entities may request additional logical links by sending a SETUP message without the LLI information element. The Data Link Control entity receiving this SETUP message assigns an LLI by including the LLI information element in the CONNECT message.

7.3.2.2.2 LLI Assignor

If a Data Link Control entity is determined to be assignor, it must set the assignor/assignee field in the low layer compatibility information element contained in any additional SETUP messages to ‘1’.

The assignor Data Link Control entities set up additional logical links by sending SETUP messages that include the LLI information element. The receiving Data Link Control entity responds with a CONNECT message and sets up a logical link using the information provided in the SETUP message.

7.3.2.2.3 Resolution of Collisions when both peers are Default Assignees

The first Data Link Control entity initiating a request for a logical link other than the default shall assume the assignee role. The Data Link Control entity that receives that request shall assume the assignor role.

If both Data Link Control entities simultaneously send SETUP messages, the SETUP message containing the larger ‘call reference value’ (see ANSI T1.607) for the definition of call reference) is accepted and treated in accordance with the above procedure. The response to the SETUP message with the lower ‘call reference value’ is a RELEASE COMPLETE message. If both SETUP messages contain the same ‘call reference value’, they are both cleared with RELEASE COMPLETE messages, and the Data Link Control entities select different ‘call reference values’ and try again.

7.3.2.3 Messages used for Logical Link Control

The following messages are used for establishing logical links within a bearer channel.

Call establishment:	SETUP
	CONNECT
Call clearing:	RELEASE
	RELEASE COMPLETE

7.3.2.3.1 SETUP

This message is sent by the Signaling Protocol Entity associated with either TA to indicate that it desires to initiate a new logical link. It must contain protocol discriminator, call reference, and message type. The low layer compatibility information element can optionally be included in the SETUP message. The logical link identifier information element must be included in the SETUP message if the Signaling Protocol Entity is assigning the LLI, and not included if requesting an LLI from the other Signaling Protocol Entity. For applications where physical interface selection is desired (e.g., at the R reference point), the Called Party sub-address information element may be used. See table 5 for the information elements that are used in the SETUP message.

7.3.2.3.2 CONNECT

This message is sent by the Signaling Protocol Entity associated with the TA that has received a SETUP message indicating that the request for establishment of an additional logical link has been accepted. It must include protocol discriminator, call reference,and message type information elements. The low layer compatibility information element can optionally be included in the CONNECT message. The logical link identifier information element must be included if not included in the SETUP message, and is not included otherwise. See table 6 for the information elements that are used in the CONNECT message.

7.3.2.3.3 RELEASE

The RELEASE message is used to indicate that the Signaling Protocol Entity associated with the TA has released the call reference and the logical link. The Signaling Protocol Entity receiving this message must release the logical link and the call reference after sending a RELEASE COMPLETE. This message must contain protocol discriminator, call reference, message type, and optionally cause information elements. See table 7 for the information elements that are used in the RELEASE message.

7.3.2.3.4 RELEASE COMPLETE

The RELEASE COMPLETE message is sent to acknowledge that the Signaling Protocol Entity associated with the TA sending the message has released the logical link and call reference. This message must contain protocol discriminator, call reference, and message type and optionally cause information elements. See

Table 5 – SETUP message content

Information element	Subclause	Type	Length
Protocol discriminator	7.3.2.4.1	M	1
Call reference	7.3.2.4.3	M	2
Message type	7.3.2.4.2	M	1
Logical link identifier	7.3.2.4.6	O (Note 1)	4
Called party sub-address	7.3.2.4.7	O (Note 2)	23
Low layer compatibility	7.3.2.4.5	O (Note 3)	2-13

M – Mandatory

O – Optional

NOTES

1 Included if the calling user assigns the LLI for that connection.-

2 Included if the calling user wishes to select a specific physical interface (e.g., at the R reference point) associated with the terminal adapter.

3 Included when the calling user wants to pass low layer compatibility information to the called user.

Table 6 – CONNECT message content

Information element	Subclause	Type	Length
Protocol discriminator	7.3.2.4.1	M	1
Call reference	7.3.2.4.3	M	2
Message type	7.3.2.4.2	M	1
Logical link identifier	7.3.2.4.6	O (Note 1)	4
Low layer compatibility	7.3.2.4.5	O (Note 2)	2-13

M – Mandatory

O – Optional

NOTES

1 Included if the called user is assigning LLI.

2 Included to allow the called user to negotiate low layer compatibility information with the calling user.

Table 7 – RELEASE message content

Information element	Subclause	Type	Length
Protocol discriminator	7.3.4.2.1	M	1
Call reference	7.3.2.4.3	M	2
Message type	7.3.2.4.2	M	1
Cause	7.3.2.4.4	O	2-4
M – Mandatory O – Optional			

Table 8 – RELEASE COMPLETE message contents

Information element	Subclause	Type	Length
Protocol discriminator	7.3.2.4.1	M	1
Call reference	7.3.2.4.3	M	2
Message type	7.3.2.4.2	M	1
Cause	7.3.2.4.4	O	2 - 4
M – Mandatory O – Optional			

table 8 for the information elements that are used in the RELEASE COMPLETE message.

7.3.2.4 Information elements

This subclause provides the format of the information elements used by the logical link negotiation procedure, and it specifies the coding of particular octets within those information elements. All other octets shown in the format of these information elements should be coded in accordance with ANSI T1.607.

7.3.2.4.1 Protocol Discriminator

The Protocol Discriminator is defined in 4.2 of ANSI T1.607. It shall be coded as follows:

Bits 8 7 6 5 4 3 2 1	
0 0 0 0 0 1 1 1	CCITT Recommendation V.120 rate adaption

This coding is in alignment with 4.5 of ANSI T1.607.

7.3.2.4.2 Message Type

The content of the message type shall be as defined in 4.4 of ANSI T1.607.

7.3.2.4.3 Call Reference

The Call Reference shall be as defined in 4.3 of ANSI T1.607. The length of the Call Reference shall be two octets; i.e., the length of the call reference value shall be one octet. The Dummy and Global Call References shall not be used.

7.3.2.4.4 Cause

The Cause Information Element shall be as defined in 4.5.11 of ANSI T1.607. The format of the cause information element is shown in figure 7. Only the following Cause Values shall be used:

#16 Normal Call Clearing
#21 Call Rejected

All other values are reserved. The optional diagnostic field may or may not be included.

7.3.2.4.5 Low Layer Compatibility

The low layer compatibility information element is used within the SETUP and CONNECT message to negotiate parameters. See figure 8 for definition of the low layer compatibility information element.

Bits

8	7	6	5	4	3	2	1	Octet
0	Cause 0	0	0	1	0	0	0 Information element identifier	1
Length of cause of contents								2
1 ext	0	0	0	0	0	0	0	3
1 ext	Cause value							4

Cause Values

16 Normal clearing
21 Call rejected

Figure 7 – Cause information element

Bits

8	7	6	5	4	3	2	1	Octet
0	Lower Layer compatability 1	1	1	1	1	0	0 Information element identifier	1
Length of low layer compatability contents								2
1 ext	Coding Standard		Information transfer capability					3
0/1 ext	Transfer Mode		Information transfer rate					4
0/1 ext	0 Layer 1	1 Ident.	User information Layer 1 protocol					5*
1 ext	Synch./ Asynch.	Negot.	User rate					5a*), 1)
0/1 ext	Hdr/ No Hdr	Multi Frame	Mode	LLI Negot	Assignor Assignee	In-band/ Out-band	0 Spare	5b*), 1)
0/1 ext	Number of Stop bits		Number of Data bits		Parity			5c*), 1)
1 ext	Duplex Mode	Modem type						5d*), 1)
1 ext	1 Layer 2 Ident.	0	User information Layer 2 protocol					6*)
1 ext	1 Layer 3 Ident.	1	User information Layer 3 protocol					7*)

*) This field is optional.

1) This octet is present only if octet 5 indicates rate adaption.

Figure 8 – Low layer compatibility information element

The coding of the fields in the octets of the LLC information element is as follows:

Coding standard (octet 3)

Bits 76	
00	CCITT standardized coding as described below

Information transfer capability (octet 3)

Bits 54321	
01000	unrestricted digital information
01001	restricted digital information

Transfer mode (octet 4)

Bits 76	
00	reserved

Information transfer rate (octet 4)

Bits 54321	
00000	reserved

User information layer 1 protocol (octet 5)

Bits 54321	
01000	terminal adaption (this standard)

This implies the presence of octets 5a, 5b, as defined below, and optionally octets 5c and 5d.

Synchronous/asynchronous (octet 5a)

Bit 7	
0	synchronous
1	asynchronous

NOTE – Octets 5c & 5d may be omitted in case of synchronous user rate except for half duplex operation.

Negotiation (octet 5a)

NOTE – This field should be treated as reserved. It should be set ‘0’ on transmission and ignored on receipt.

User rate (octet 5a)

Bit 54321	
00000	unspecified
00001	0.6 kbit/s
00010	1.2 kbit/s
00011	2.4 kbit/s
00100	3.5 kbit/s
00101	4.8 kbit/s
00110	7.2 kbit/s
00111	8.0 kbit/s
01000	9.6 kbit/s
01001	14.4 kbit/s
01010	16.0 kbit/s
01011	19.2 kbit/s
01100	32.0 kbit/s
01101	38.4 kbit/s
01110	48.0 kbit/s
01111	56.0 kbit/s
10110	0.100 kbit/s
10111	0.075/1.2 kbit/s
11000	1.2/0.075 kbit/s
11001	0.050 kbit/s
11010	0.075 kbit/s
11011	0.110 kbit/s
11100	0.150 kbit/s
11101	0.200 kbit/s
11110	0.300 kbit/s
11111	12.0 kbit/s

Rate adaption header/no header (octet 5b)

Bits 7	
0	optional portions of terminal adaption header not included
1	optional portions of terminal adaption header included

Multiple frame establishment support in logical link (octet 5b)

Bit 6	
0	multiple frame establishment not supported, only UI frames allowed
1	multiple frame establishment supported.

Mode of operation (octet 5b)

Bit 5	
0	bit transparent mode of operation.
1	protocol sensitive mode of operation

Logical link identifier negotiation (octet 5b)

Bit 4	
0	default LLI = 256 only
1	full LLI negotiation

Assignor/assignee (octet 5b)

Bit 3	
0	message originator is “default assignee”.
1	message originator is “assignor.”

In-band/out of band negotiation (octet 5b)

Bit 2	
1	negotiation is done in-band using logical link zero.

Number of stop bits (octet 5c)

Bits 76	
00	not used
01	1 bit
10	1.5 bits
11	2 bits

NOTE – If bit 7 of octet 5a is ‘0’, then these bits, when present, are set to ‘0’ on transmission and ignored on reception.

Number of data bits excluding parity bit (octet 5c)

Bits 54	
00	not used
01	5 bits
10	7 bits
11	8 bits

NOTES

1 The number of data bits refer to the number transmitted across the S, T, or U reference point between peer Terminal Adaption protocol entities.

2 The character structure that may be transported between peer Terminal Adaption protocol entities may be no more than eight bits. Therefore, if this field is coded as “8 bits”, the Parity Information field shall be coded as “None”. This implies that for 8 bit character structures with parity, the parity bit shall be stripped by the sending Terminal Adaption protocol entity and regenerated by its peer.

3 Characters that have eight data bits and no parity should be coded in the same way.

4 If bit 7 of octet 5a is ‘0’, then these bits when present are set to ‘0’ on transmission and ignored on reception.

Parity information (octet 5c)

Bits 321	
000	odd
010	even
011	none
100	forced to 0
101	forced to 1

NOTES

1 The parity information refers to the interface at the S, T or U reference point.

2 If bit 7 of octet 5a is ‘0’, then these bits, when present, are set to ‘0’ on transmission and ignored on reception.

Duplex mode (octet 5d)

Bit 7	
0	half duplex
1	full duplex

Modem type (octet 5d)

Bits 6-1 coded according to network specific rules.

User information layer 2 protocol (octet 6)

Bits 54321	
00001	basic mode ISO 1745
00010	CCITT Rec. Q.921(I.441)
00110	CCITT Rec. X.25 link level
01000	extended LAPB for half duplex operation (T.71)
01001	HDLC ARM (ISO 4335)
01010	HDLC NRM (ISO 4335)
01100	HDLC ABM (ISO 4335)
01100	LAN logical link control (ISO 8802/2)
01101	CCITT Rec. X.75, single link procedure

User information layer 3 protocol (octet 7)

Bits 54321	
00010	CCITT Rec. I.451/Q.931
00110	CCITT Rec. X.25 packet level protocol
00111	ISO 8208 (X.25 packet level protocol for DTE)
01000	ISO 8308 (OSI connection oriented network service specific subset of ISO 8208 and CCITT X.25)
01001	ISO 8473(ISO connectionless service)
01010	CCITT Rec. T.70 minimum network layer

7.3.2.4.6 Logical link identifier

The purpose of the logical link identifier information element is to identify a logical link within the bearer channel. The default length of this element is four octets. The logical link identifier information element is coded as shown in figure 9.

7.3.2.4.7 Called Party Subaddress

The optional Called Party Subaddress may be included (e.g., to select a specific TE2 behind an interface at the R reference point). This optional information element may be included in a SETUP message to select a specific TE2 or interface at the R reference point behind a terminal adapter. The Called Party Subaddress information element is coded as shown in figure 10.

Type of subaddress (octet 3)

Bits 765	
000	NSAP (X.213/ISO 8348 AD2)
010	user specified

Odd/even indicator (octet 3)

Bit 4	
0	even number of address signals
1	odd number of address signals

NOTE – The odd/even indicator is used when the type of sub-address is “user specified” and the coding is BCD.

Subaddress information (octet 4, etc.)

The NSAP (X.213/ISO 8348 AD2) address shall be formatted as specified by octet 4 which contains the Authority and Format Identifier (AFI). The encoding is made according to the “preferred binary encoding” as defined in X.213/ISO 8348 AD2.

For user specified subaddress, the field is encoded according to the user specification, subject to a maximum length of 20 octets. When interworking with X.25 networks, BCD coding should be applied.

7.3.2.5 Logical link control procedures

These optional procedures define the method for negotiating logical links other than the default (LLI=256). For setup and clearing of the bearer channel, the procedures described in ANSI T1.607 must be followed.

7.3.2.5.1 Logical link establishment

A logical link may be established by either signaling protocol entity by sending a SETUP message.

If the signaling protocol entity sending the SETUP message assigns the LLI, the SETUP message must also include the assigned LLI value for the logical link.

If the signaling protocol entity does not assign the LLI, it must not include the LLI information element in the SETUP message. In this case the LLI is assigned by the receiving TA by

Bits 8	7	6	5	4	3	2	1	Octet
	Logical link identifier							
0	0	0	1	1	0	0	1	1
	Information element identifier							
Length of logical link identifier contents								
0	0	0	0	0	0	1	0	2
0	0 Spare	Logical link identifier (high order 6 bits)						3
1 ext	Logical link identifier (low order 7 bits)							4

Figure 9 – Logical link identifier information element

Bits 8	7	6	5	4	3	2	1	Octet
	Called party subaddress							
0	1	1	1	0	0	0	1	1
	Information element identifier							
Length of called party subaddress identifier								2
1 ext	Type of subaddress			odd/ even indica	0	0 spare	0	3
Subaddress information								4

Figure 10 – Called party subaddress information element

including an LLI information element in the CONNECT message.

A signaling protocol entity may request a logical link by sending a SETUP message, setting timer T303, and entering “call initiated” state.

If no response to the SETUP message is received before the first expiry of timer T303, the SETUP message must be retransmitted and timer T303 restarted. After the second expiry of timer T303, the “null”state is entered.

A signaling protocol entity receiving the SETUP message must send a CONNECT message and enter the “active” state if it is able; otherwise, it must send a RELEASE COMPLETE message and enter the “null” state.

When the initiating signaling protocol entity receives the CONNECT message, it must stop timer T303, and enter the”active” state.

7.3.2.5.2 Logical Link Release

Either signaling protocol entity may request to clear a logical link by sending a RELEASE message, setting timer T308, and entering “release request” state.

When a signaling protocol entity receives a RELEASE message, it must release the logical link, send a RELEASE COMPLETE message release the call reference, and enter the “null” state.

When the signaling protocol entity initiating a RELEASE receives RELEASE COMPLETE message, it must stop timer T308, release the logical link, release the call reference, and enter the “null” state.

If the signaling protocol entity initiating the RELEASE does not receive a RELEASE COMPLETE message before the first expiry of timer T308, the RELEASE message must be retransmitted and timer T308 restarted. If RELEASE COMPLETE message is not received before timer T308 expires for the second time, the TA must release the logical link, release the call reference, and enter the “null” state.

If both signaling protocol entities simultaneously request to clear the same logical link by sending RELEASE messages, both must stop timer T308, release the logical link, release the call reference, and enter the “null”state.

NOTE – This procedure cannot be applied to the default Logical Link (LLI=256), as this logical link has no Call Reference associated with it.

8 Application of Terminal Adaption Protocol to Terminal Adaptor Functions

This clause provides additional information concerning application of the protocol defined in 4 to a Terminal Adaptor Functional Group. This clause provides information required for interoperation between a Terminal Adaptor and a TE1, IWF or another TA. However, specific design details are implementation dependent.

8.1 Clock Synchronization

The specific method for clock synchronization (circuit mode applications) is implementation dependent. See annex C for a discussion.

8.2 Asynchronous Mode Operation

The options to be used in this mode are specified and negotiated using octets 5b, 5c and 5d of the low layer compatibility information element. See 7.3.2.4.5.

8.2.1 Processing of characters received from the TE2

When adapting character oriented data streams, a sequence of characters without start or stop bits shall be encapsulated in accordance with the following:

a) Parity, when used, is checked;

b) The parity bit shall be removed if the code being used is an 8-bit code, otherwise passed as part of the octet;

c) When codes using less than 8 bits (including parity) are used, the octet containing a character is padded with ‘0s’ in the higher order bits. The low order bit of a character is the first bit of the octet containing it.

The resulting data is placed in data fields of frames, with the segmentation bits B and F set to ‘1’. The data is placed in frames ordered so that it is transmitted to the peer entity in the order it was received.

Frames may be sent based on a timer, after a certain frame size, after a carriage return, etc. However, the forwarding mechanism used is an implementation issue and may vary.

If a break is detected, a frame with the BR bit set in the header shall be transmitted in the same frame or after all queued characters have been sent. The C1 and C2 bits should be set to ‘0’.

If a parity error is detected on a character of data being queued for encapsulation, the C1 bit is set to ‘1’, and the frame is sent following any frames already queued for transmission. Thus, setting of the C1 bit to ‘1’ indicates that the last character in the frame in which the C1 bit is set to ‘1’ was received by the TA with a parity error. When a stop/start protocol is used at the interface at the R reference point and a stop bit error is detected on a character of data being queued for encapsulation, the C2 bit is set to ‘1’ and the frame is sent following any frames already queued for transmission. Thus, setting of the C2 bit to ‘1’ indicates that a stop bit error was detected by the TA immediately following the last character contained in the frame in which the C2 bit is set to ‘1’.

8.2.2 Processing of frames received from the peer Terminal Adaption protocol entity

The TA shall perform the following processing on frames received from the peer Terminal Adaption protocol entity:

a) If the number of data bits in the character structure is less than 8, and the parity of characters received from the peer Terminal Adaption protocol entity is the same as that expected by the TE2, characters shall be sent to the TE2 without further processing;

b) If the character structure contains 8 data bits, a parity bit shall be calculated for each character and appended before sending the TE2. Also, if parity conversion is implemented and the parity of characters received from the peer Terminal Adaption protocol entity is different from that expected by the TE2, a parity bit shall be calculated for each character and appended before sending to the TE2;

c) If a stop bit error is indicated in the H octet, the action of the TA is implementation dependent;

d) If a parity error is indicated in the H octet, the TA may force a parity error in the last character of the frame, or may take other implementation dependent action;

e) If a break is indicated in the H octet, the TA shall, after sending all of the characters in the frame to the TE2, send a Break to the TE2. Break timing may be the subject of other American National Standards;

f) Characters to be transmitted shall be framed by the number of start bits and stop bits expected by the TE2.

8.3 Protocol Sensitive Synchronous Mode Operation

8.3.1 Processing of frames received from the TE2

Service data units containing HDLC address, control, and information fields when applicable (and FCS when UI frames are used for encapsulation) are segmented, if necessary, with each segment preceeded by the header. (Service data units structured in this fashion will be referred to as “HDLC messages”.) Segmentation shall be such that no frame transmitted to the peer Terminal Adaption protocol entity (across the interface at the S, T, or U reference point) has an information field longer than N201 octets. The data is placed in frames ordered so that it is transmitted to the peer entity in the order it was received.

If only one segment is required, the Header shall indicate both beginning segment and final segment in the ‘B’ bit and the ‘F’ bit. If more than one segment is required, the Header of the first segment shall indicate “begin” segment and the last segment of the message shall indicate “final” segment. All intermediate segments shall have both “begin” and “final” segment indicators set to ‘0’.

The C1 and C2 bits shall be used as follows:

a) C1 set to ‘0’ and C2 set to ‘1’, indicates that a bit error is detected in the HDLC message being transmitted in the sequence of segments;

b) C1 set to ‘1’ and C2 set to ‘0’ indicates that the HDLC message being transmitted in the sequence of segments has been aborted;

c) C1 and C2 set to ‘1’ indicates that an overrun has occurred towards the interface at the S, T, or U reference point as described above in 4.2.4.2.

If an HDLC idle condition (i.e., continuous marking) is received from the TE2, a frame with the BR bit in the H octet set to ‘1’ shall be transmitted. The BR bit may be set to ‘1’ in the last segment of a previous frame, or in a frame containing no user data. When the end of the HDLC idle condition is received, a frame with the BR bit of the H octet set to ‘1’ shall be transmitted.

8.3.2 Processing of frames received from the peer Terminal Adaption protocol entity

The following processing shall be performed on the data received:

a) The header shall be checked as follows:

1) If the “begin” segment bit is ‘1’ and the previous segment did not have the “final” segment bit set to ‘1’, then the previous message shall be aborted;

2) If the “begin” segment bit is ‘0’ and there is no message currently in progress, the segment will be discarded;

3) If the C1 or C2 error bit is ‘1’ then the segment will be discarded and the message in progress will be invalidated (e.g., aborted or sent with an incorrect FCS).

b) In the case when UI frames are used for encapsulation, the FCS received in the data stream may be examined and the appropriate action taken. If the FCS is not examined, it shall be passed on as the FCS of their constructed message.

If an underrun occurs toward the R reference point, then the frame being sent shall be treated as described in 4.2.4.2.

If the BR bit is ‘1’, then an HDLC idle condition is generated after processing the received data. The HDLC idle condition shall be maintained until a frame is received with its BR bit set to ‘0’.

8.4 Bit transparent mode operation

A synchronous data stream shall be broken into fixed size blocks and sent to the peer Terminal Adaption protocol entity (over the interface at the S, T, or U reference point) in the same order in which it was queued. The received data is removed from the frames and processed in the same order as received.

The terminal adaption header must be used in bit transparent mode if it is necessary to transmit the control state information. When the terminal adaption header is used in this mode C1 and C2 bits must both be set to ‘0’(no error), B and F bits must both be set to ‘1’, and the reserved bits and the BR bit must be set to ‘0’.

If an underrun occurs toward the R reference point, then the procedures described in § 4.2.4.3 shall be followed.

For unique applications, the contents of a frame received with an FCS error may be processed.

Annex A
(informative)

TE1 Application

The protocols and procedures defined in this standard may be used for data transport by TE1s as well as terminal adapter (TAs). In the TE1 case, the interface at the R reference point is effectively replaced by a virtual interface within the TE1 to a higher layer entity. This clause describes some aspects of the application of this standard in TE1s.

A.1 Asynchronous Mode Operation

A.1.1 Transmission onto the ISDN channel

The B and F bits are set to ‘1’, and the C1 and C2 bits in the header are set to ‘0’. The data to be transmitted is segmented as required, and each segment is appended to the Header before transmission.

If a break is received from the next higher layer, a frame with the BR bit set to ‘1’ in the Header should be transmitted at the earliest opportunity following data queued for transmission.

A.1.2 Reception from the ISDN Channel

Processing of received data is as follows, based on the values of the C1 and C2 bits in the Header:

a) If the C1 bit and C2 bits are both set to ‘0’, the received characters are forwarded to the next higher layer without error indication;

b) If the C1 bit is set to ‘1’ then a parity error indication is forwarded to the next higher layer with the characters received; the parity error applies to the last character in the frame;

c) If the C1 bit is set to ‘1’, then a stop-bit error is forwarded to the next higher layer with the characters received; the error occurred immediately following the last character in the frame.

If the BR bit is set to ‘1’ in the Header of the received frame, then a break indication is forwarded to the next higher layer after all data queued has been forwarded.

A.2 Synchronous mode operation

In order to communicate properly with a TE2 as described in clause 4, the messages passed to and received from the higher layer should include the HDLC address and control field to be used over the remote TE2-to-TA HDLC connection, but do not include HDLC flags, FCS or inserted ‘0’s. The HDLC address and control field will be contained in the information/field of the frames received and transmitted by the TE1. The procedures described are for the case in which acknowledged data transfer is used. The procedure for unacknowledged data transfer are not described.

A.2.1 Transmission onto the ISDN channel

The message length is compared with N2xx (see 4.2.2).The message is processed depending on its length as follows:

a) If the message length is less than or equal to N2xx, then the entire message is appended behind the Header and both the B and F bits are set to ‘1’. The resulting segment is then transmitted;

b) If the message length is greater than N2xx, the first N2xx octets are appended to the Header, with the B bit set to ‘1’ and the F bit set to ‘0’. The resulting segment is then transmitted.

1) If the remaining portion of the message is greater in length than N2xx, the next N2xx octets are appended to the Header with both the B and F bits set to ‘0’. The resulting segment is then transmitted.

2) If the length of the remaining portion of the message is less than or equal to N2xx, then the remaining portion of the message is appended to the Header with the F bit set to ‘1’ and the B bit set to ‘0’. The resulting segment is then transmitted.

The C1 and C2 bits are normally set to ‘0’.

A.2.2 Reception from the ISDN channel

Any messages that were segmented at the transmit end are reassembled as indicated by the B and F Header bits.

The Header of a received frame shall be checked for error conditions as follows:

a) If the ‘begin’ segment bit is ‘1’ and the previous segment did not have the ‘final’ segment bit set to ‘1’, then the previous message shall be aborted.

b) If the ‘begin’ segment bit is ‘0’ and there is no message currently in progress, the segment shall be aborted.

c) If the C1 or C2 error bit is ‘1’ then the segment will be discarded and the message in progress will be aborted or discarded.

If a frame is received with the BR bit set to ‘1’ in the Header, then the TE1 management entity shall be notified of an HDLC idle condition sent from the far end. The TE1 management entity is not notified of termination of the HDLC idle condition until a frame is received with the BR bit in its Header set to ‘0’. When a message has been reassembled, it is passed to the next higher layer.

A.3 Bit Transparent Mode Operation

A.3.1 Transmission onto the ISDN channel

The transmitted entity accepts data from the process using its services, segments the data into segments of fixed length at most N2xx, and transmits that data within data fields of frames to its peer entity. The length of transmitted interframe time fill is adjusted so that the average data transmission rate matches the rate selected during the call establishment.

A.3.2 Reception from the ISDN Channel

The receiving entity upon receiving a frame from its peer entity, checks the FCS and if the FCS is valid, it passes any data contained in the frame to the process using its services. If the FCS is not valid, the entity may, on an application specific basis, discard the data contained in the errored frame or pass that data, with or without error indication, to the process using the services of the entity.

A.4 TE1 control state variable processing

This clause describes the use of the control state variable and the processing of the control state information field, when present, defined in 4.2.3. Use of the Control State information field is optional (see octet 5a, bit 7 of Low Layer Compatibility 7.3.2.4.5). The procedures described below in this clause and in its subclauses only apply if the Control State information field is used.

In TE1 applications, the six control state variable DR(S), SR(S), RR(S), DR(R), SR(R), and RR(R) have the following meanings:

a) For sending DR – DR(S) State Variable: Indicates that the sending TE1 is powered up and connected for communication.

b) For receiving DR – DR(R) State Variable: Indicates that the sending TE1 (far end) is powered up and connected for communication.

c) For sending SR – SR(S) State Variable: Indicates that the sending TE1 is ready to send frames.

d) For receiving SR – SR(R) State Variable: Indicates that the sending TE1 (far end) is ready to send frames.

e) For sending RR – RR(R) State Variable: Indicates that the sending TE1 is ready to receive frames.

f) For receiving RR – RR(R) State Variable: Indicates that the sending TE1 is ready to receive frames.

The following subclauses describe the procedure for control state variable processing in a TE1 using this standard. Note that the control states in a TE1 as described above are essentially analogous to those in a TA as described in 4.1.2. Thus, the TE1 control state variables processing described below is completely compatible with that described in 4.2.3 for a TA.

A.4.1 Control State Variable Initialization

The first I or UI frame sent by each peer shall contain the Control State Information Octet. This exchange shall occur immediately following link initialization.

A.4.2 Sending a Control State Information Octet

A Control State Information Octet should be sent whenever a Send Control State Variable changes. A Send Control State Variable shall change with a change to the state of the TE1 or a change to a Receive Control State Variable as described above. A frame containing the Control State Information octet shall be sent following any queued data for the interface at the S, T, or U reference point.

The Control State Information field is sent in the last frame assembled when the control state change occurs, or in a separate frame.

The contents of the Control State Information octet is set to the state of the corresponding Send State Variables. DR is set to DR(S), SR is set to SR(S) and RR is set to RR(S).

A.4.3 Receiving a Control State Information Octet

Upon receipt of a Control State Information Octet, the control field is checked with the Receive Control State Variables: DR to DR(R), SR to SR(R) and RR to RR(R) if the peer entity is not being flow controlled by the use of the RR(R) state. Notification is made to the TE1 management entity.

If SR(R) was ‘1’ and the receive Control State Information octet is ‘0’, then the RR(S) state is set to SR(R), consistent with one of the following:

a) If receive data (from the peer entity) does not remain to be forwarded (no message in progress), then the control actions can occur immediately;

b) If received data (from the peer entity) is incomplete (e.g., in protocol sensitive mode the final frame was not received) and DR is ‘1’, the incomplete message is forwarded with indication make to the TE1 management entity;

c) If received data (from the peer entity) is complete, the message is forwarded and the notification of the TE12 management entity occurs.

If RR(R) and the RR bit in the received control field differ, notification is made to the TE1 management entity.

If DR(R) was ‘0’ and the DR bit in the received control field is ‘1’, notification is made to the TE1 management entity.

If DR(R) was ‘1’ and the DR bit in the received control field is ‘’0’, then notification is made to the TE1 management entity consistent with the following:

a) If received data from the peer entity is incomplete, it is discarded.

b) If received data from the peer entity is a complete message, then it should be forwarded until completion prior to the control actions taking place.

Annex B
(informative)

Mapping of Interface at R Reference Point Circuit to Control State Information

The control of interface leads is not specified in this standard. It is only necessary that the control provided conform to the requirements of the particular interface at the R reference point supported (e.g., TIA/EIA 232-D). The following guidelines are provided to illustrate a suitable procedure.

B.1 Commonly supported interface leads

The TIA/EIA 232-D interface leads that would be expected to be commonly supported are shown in table B.1 as an example.

The leads that would be used to provide maintenance functionality are not listed in table B.1 because the associated functionality is outside the scope of this standard.

Table B.1 – Interface name abbreviation

Circuit function/name	Abbreviation
Signal ground	SG
Transmitted Data	TD
Received Data	RD
Request to Send	RTS
Clear to Send	CTS
Data Set Ready	DSR
Data Terminal Ready	DTR
Carrier Detect	CD
Transmitter Clock	TC
Receiver Clock	RC
Ring Indicator (optional)	RI

B.2 Control Procedures

For call origination, the response to DTR is a function of whether the TA is configured for manual or automatic call origination. Generally calls/links are not originated until DTR is ON. In response to DTR ON, DSR may be turned ON. However, it may be more consistent with the original intent of DSR to delay its ON condition until after a cut through indication (CONNECT or CONNECT ACKNOWLEDGEMENT) is received.

Generally calls/links are not accepted unless the called TA has at least one free port (interface at the R reference point or TE2) on which DTR has been turned ON (however, it is permissible, where RI is implemented, for DTR to be normally OFF but turned ON in response to Ring indicator (RI) ON condition). After receiving a cut through indication, the TA must turn DSR ON if it is not yet turned ON.

B.2.1 TE2 Operating in full duplex (FDX) mode

The Control State Information Octet is not used for control of interface leads with TE2s operating in the FDX mode. In full duplex, this field is used for providing flow control capability when UI frames are used to carry data as described in 4.2.4.

The TE2 may respond to DSR ON by turning ON RTS. After receiving the cut through indication and completing the link initialization, the TA may turn ON CD and unclamp RD (CTS, if implemented, may be turned on at this point or any time afterwards). When RD is unclamped, the TA shall send the appropriate idle code (continuous marks, flags, etc.) to the TE2.

B.2.2 TE2 Operating in half duplex (HDX) mode

For half duplex (HDX) operation of the TE2, the called TE2 may turn ON RTS at any time after the TA has turned ON DSR. This is analogous to the operations of half duplex modems where the called DTE turns on RTS. When a calling/called relationship cannot be established, a glare condition, due to both ends turning RTS ON, may occur. The resolution of glare in such cases is for further study.

In response to RTS ON, the TA, after completing connection or link initialization, must transmit a Control State Information octet with

SR bit set to ‘1’. After having established the link, the TA that receives SR equal to ‘1’ must activate CD, unclamp RD, send the appropriate idle code to the TE2, and send a Control State Information octet with RR bit set to ‘1’ to the far end TA. After having initialized the link, the TA that receives RR equal ‘1’, must turn CTS ON.

Once a TE2 completes transmitting data, it drops RTS. In response, the TA drops CTS and transmits a Control State Information octet with SR bit set to ‘0’. Upon receiving a Control State Information octet with SR bit set to ‘0’, a TA that has CD ON drops CD and sends a Control State octet with RR bit set to ‘0. When CD is dropped, the TE2 may turn RTS ON (see previous paragraph for the procedure that follows).

Annex C
(informative)

Clock synchronization

Figure C-1 shows two DTE/DCE configurations and their respective clock synchronization.

In the first case, the TA's are providing the clocks to the DTE at one side and to the DCE at the other side. The receive clock at the DTE is synchronized to the Transmit Clock at the DTE (or DCE) via the data or system synchronization. In the second case, the DCE provides the Receive Clock to the TA for data to the DTE and the TA at the DTE end provides the Receive Clock to the DTE for this same data. The Receive Clock at the DTE is synchronized to the DCE Receive Clock via the data.

There are three alternative strategies that can be used for clock tracking.

a) The first is to use the data buffers as clock variance buffers by having buffers absorb the accumulating clock variance. In this case, no special clock tracking is performed. If the buffer is completely depleted, an under-run occurs causing an error on the synchronous interface at the R reference point. Buffer space over-run can also happen, causing an error. However, the buffer accumulation or depletion to the point of over-run or under-run due to clock error is a slow process and is predictable in the worst case within the CCITT clock tolerance of 100 parts per million.

b) The second strategy is for the clocks at both ends to be synchronized to the network. This strategy solves the problem but is not applicable to case 2.

c) A third strategy is to monitor the buffer state as data is being received from the

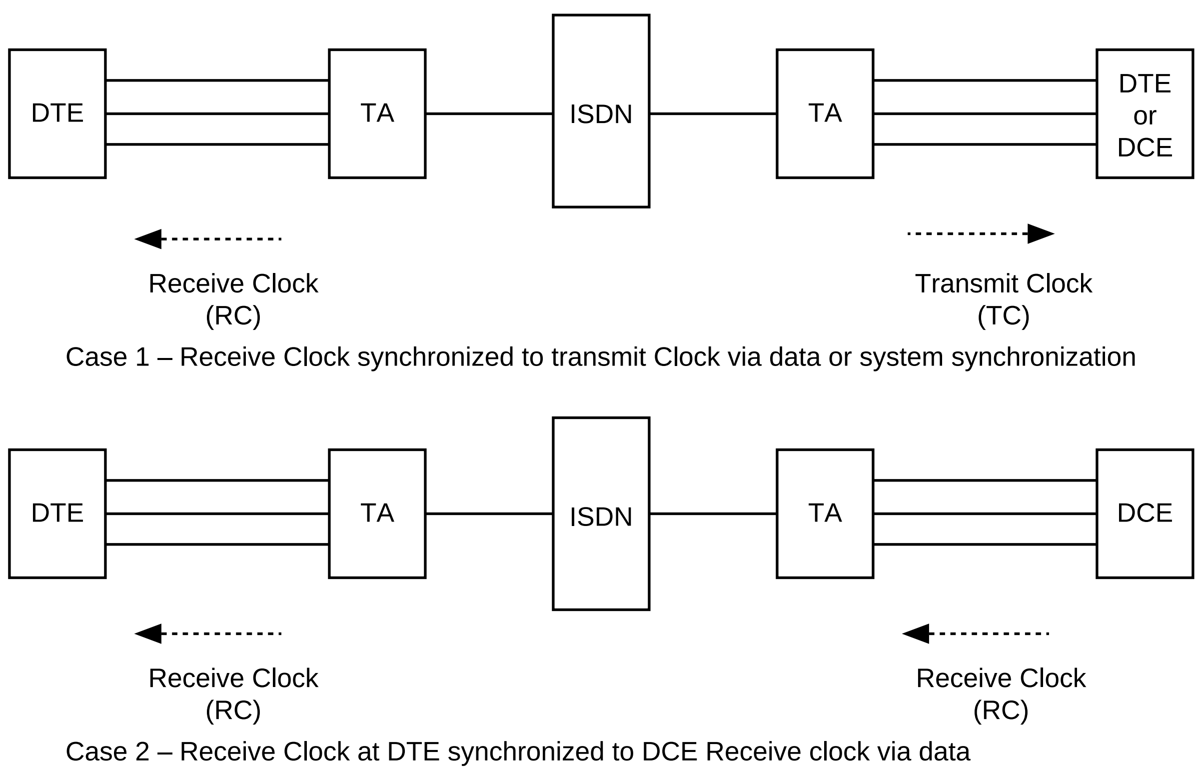

Figure C.1 – Clock tracking

interface at the S, T, or U reference point in the TA that is providing the Receive Clock to the DTE. This strategy monitors the rate of data at this interface by checking the buffer state when a new frame is received and adjusts the clock rate/phase accordingly.

For a given logical link, the nominal frame size must be kept constant for the duration of the connection. Signals at the interface at the R reference point, including timing signals, must conform to the applicable signal quality requirements (e.g., see ANSI EIA/TIA 334-B for interfaces conforming to ANSI EIA/TIA 232-E). These requirements limit the permitted jitter and the magnitude of phase adjustments steps required for clock rate adjustments.

For asynchronous application, the first strategy (no clock correction) should be sufficient. Clock tolerance is compensated for by stop-bit interval adjustment. For these applications, a clock tolerance of +1% to –2.5% is permissible. Under-run is not possible and buffering in the TA should be sufficient to avoid over-run.

For Synchronous Mode application, appropriate buffer setup and management using no clock correction should be sufficient. Any clock tolerance error should be compensated for through adjustments in interframe intervals.

For Bit Transparent Mode applications, continuous data does not allow for buffer resynchronization. For Case 2, the frames are read into a buffer at the receiving TA and are clocked out to the TE2 by a time source derived in the TA. If the data is clocked out at the rate transmitted, each frame should fill the receive buffer to precisely the same level. If the rate is low, the fill level should increase and provide an indication that the clock rate must be increased and vice versa.

In some implementations, the clock adjustments might be in the form of repeated small adjustments in the phase of the clock, which would be derived from the ISDN network clock. Where the TE2 is tolerant of large phase steps, the process may be simple.

Annex D
(informative)

Bibliography

ANSI EIA/TIA 232-E-1991, *Interface between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange*

ANSI EIA/TIA 334-B, *Signal Quality at Interface between Data Terminal Equipment and Synchronous Data Circuit-Terminating Equipment for Serial Data Transmission*

ANSI EIA/TIA 530-A-1987, *High Speed 25-Position Interface for Data Terminal Equipment and Data Circuit-Terminating Equipment* [7)]

CCITT Recommendation V.24 (1988), *List of definitions for interchange circuits between data terminal equipment (DTE) and data circuit-terminating equipment* (DCE)[1)]

CCITT Recommendation V.120 (1988), *Support by an ISDN of data terminal equipment with V-series type interfaces with provision for statistical multiplexing*[1)]

[7)] This standard is currently undergoing a revision. Contact the secretariat for more recent information.