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TELEPHONE NETWORK

Error control

Error-correcting procedures for DCEs using asynchronous-to-synchronous conversion

ITU-T Recommendation V.42

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DATA COMMUNICATION OVER THE TELEPHONE NETWORK

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ITU-T Recommendation V.42

Error-correcting procedures for DCEs using asynchronous-to-synchronous conversion

Summary

This Recommendation describes error-correcting protocols for use with V-series duplex DCEs to accept start-stop data from the DTE and transmit in synchronous mode. This Recommendation contains an HDLC-based protocol referred to as the Link Access Procedure for Modems (LAPM). This revised version of the Recommendation adds the capability for suspension and resumption of error correction in support of the V.92 modem-on-hold feature. The negotiation parameters for V.44 data compression are added for reference. This revision also gives guidance on the use of answerer detection patterns in a new Appendix VI. Annex A and Appendix V of the previous versions are now deleted in the 2002 revision. The remaining annex and appendixes have not been renumbered.

Source

ITU-T Recommendation V.42 was revised by ITU-T Study Group 16 (2001-2004) and approved under the WTSA Resolution 1 procedure on 29 March 2002.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

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ITU-T Recommendation V.42

Error-correcting procedures for DCEs using asynchronous-to-synchronous conversion

The ITU-T,

considering

- (a) that the use of high-speed DCEs for transmission of asynchronous data on the GSTN is increasing;
- (b) that there is a demand for an improved error performance on such connections by the use of an error-correcting protocol;
- (c) that there is a need to interwork with DCEs not providing such a protocol,

declares

that the error-correcting procedures to be followed by DCEs using asynchronous-to-synchronous conversion are as specified in this Recommendation.

1 Scope

1.1 General

This Recommendation describes error-correcting protocols for use with V-series duplex DCEs to accept start-stop data from the DTE and transmit in synchronous mode. Use in half-duplex DCEs is for further study.

This Recommendation contains an HDLC-based protocol referred to as the Link Access Procedure for Modems (LAPM).

The principal characteristics of the protocols are as follows:

- a) interworking in the non-error-correcting mode with V-series DCEs that include asynchronous-to-synchronous conversion according to ITU-T Rec. V.14;
- b) error detection through the use of a cyclic redundancy check;
- c) error correction through the use of automatic retransmission of data;
- d) synchronous transmission through the conversion of start-stop data;
- e) an initial handshake in start-stop format which minimizes disruption to the DTEs.

NOTE – Technical changes have been introduced since the 1988 version of this Recommendation, which make refinements to the operation of the LAPM protocol. The following clauses were affected: 7.2.1.3, 7.3, 7.4, 7.5, 7.9, 8.3, 8.4, 8.5, 8.13, 9.3, 10, 12.2.2, 12.3, A.7.2.1. Implementations conforming to the 1988 version remain fully compatible and conformant with this version.

1.2 Relationship to other international standards

The error-correcting protocol defined in the main body of this Recommendation can be specified in terms of the High-level Data Link Control (HDLC) formats and procedures. In particular, it makes use of the balanced asynchronous class (BAC) of HDLC procedures. The basic mode (i.e. without options) of this protocol makes use of HDLC "optional functions" 1, 2, 4, 6, 8 and 10. (This mode is identical to ITU-T Recs Q.920/Q.921.) When using optional procedures of this error-correcting protocol, HDLC "optional functions" 3 (for selective retransmission), 12 (for loop-back test), and 14 (for 32-bit FCS) are added.

1.3 References

The following ITU-T Recommendations and other references contain provisions, which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision: users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published.

- [1] ITU-T Recommendation Q.920 (1993), *ISDN user-network interface data link layer – General aspects*.
- [2] ITU-T Recommendation Q.921 (1997), *ISDN user-network interface – Data link layer specification*.
- [3] ITU-T Recommendation V.14 (1993), *Transmission of start-stop characters over synchronous bearer channels*.
- [4] ITU-T Recommendation V.24 (2000), *List of definitions for interchange circuits between data terminal equipment (DTE) and data circuit-terminating equipment (DCE)*.
- [5] ITU-T Recommendation X.3 (2000), *Packet Assembly/Disassembly facility (PAD) in a public data network*.
- [6] ISO/IEC 3309:1993, *Information technology – Telecommunications and information exchange between systems – High-level data link control (HDLC) procedures – Frame structure*.
- [7] ISO/IEC 4335:1993, *Information technology – Telecommunications and information exchange between systems – High-level data link control (HDLC) procedures – Elements of procedures*.
- [8] ISO/IEC 7809:1993, *Information technology – Telecommunications and information exchange between systems – High-level data link control (HDLC) procedures – Classes of procedures*.
- [9] ISO/IEC 8885:1993, *Information technology – Telecommunications and information exchange between systems – High-level data link control (HDLC) procedures – General purpose XID frame information field content and format*.

2 Definitions

An error-correcting protocol may be used with a signal converter to create an error-correcting DCE.

2.1 data circuit-terminating equipment (DCE): In this Recommendation, a DCE, when used without further qualification, consists primarily of three sections: interchange circuits for the interface to the DTE and signal converters for transmission over telephone circuits. A control function is used to provide a user interface to coordinate the operation of the interchange circuits and the signal converter. The structure of a DCE is shown in Figure 1.

- a) The DTE exchanges data with the DCE through a V.24 interface. The data is exchanged in start-stop format.
- b) The signal converter provides the modulation and demodulation of signals exchanged on the GSTN, or two-wire point-to-point leased circuits.
- c) The control function provides overall control and coordination between each of the DCE components. Further, the controller provides the specific operational configuration for the DCE selected by the user. The user interface to the controller is implementation dependent.

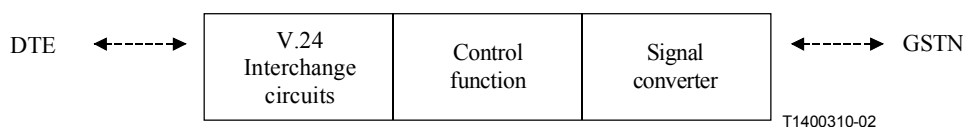


Figure 1/V.42 – DCE

2.2 error-correcting DCE: The logical structure of an error-correcting DCE is shown in Figure 2. The error control functions implement the error-correcting protocols of this Recommendation.

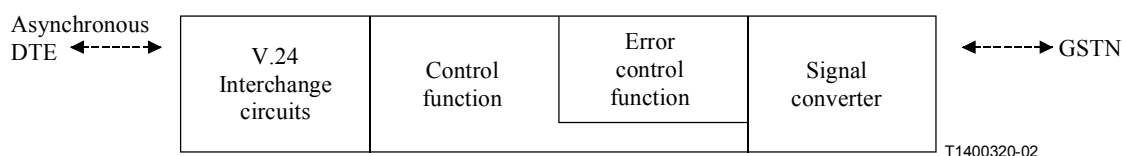


Figure 2/V.42 – Error-correcting DCE

3 Abbreviations

This Recommendation uses the following abbreviations:

ADP	Answerer Detection Pattern
C/R	Command/Response bit
CRC	Cyclic Redundancy Check
DCE	Data Circuit-terminating Equipment
DISC	Disconnect (frame)
DLCI	Data Link Connection Identifier
DM	Disconnected Mode (frame)
DTE	Data Terminal Equipment
FCS	Frame Check Sequence
FI	Format Identifier
FRMR	Frame reject (frame)
GI	Group Identifier
GL	Group Length
GSTN	General Switched Telephone Network
HDLC	High-level Data Link Control (protocol)
I	Information (frame)
LA	Link Acknowledgement (frame of the alternative error-correcting procedure)
LAPM	Link Access Procedure for Modems
LD	Link Disconnect (frame of the alternative error-correcting procedure)
LN	Link attention (frame of the alternative error-correcting procedure)
LNA	Link attention acknowledgement (frame of the alternative error-correcting procedure)
LR	Link Request (frame of the alternative error-correcting procedure)

LT	Link Transfer (frame of the alternative error-correcting procedure)
m-SREJ	Multi-Selective Reject (procedure)
ODP	Originator Detection Pattern
P/F	Poll/Final (bit)
PI	Parameter Identifier
PL	Parameter Length
PV	Parameter Value
REJ	Reject (frame)
RNR	Receive Not Ready (frame)
RR	Receive Ready (frame)
SABME	Set Asynchronous Balanced Mode Extended (frame)
SREJ	Selective Reject (frame)
s-SREJ	Single-Selective Reject (procedure)
UA	Unnumbered Acknowledgement (frame)
XID	Exchange Identification (frame)

4 Establishing an error-corrected connection

A connection over which the DCE's error-correcting protocol operates is established in two phases. Initially, a physical connection is established between the peer signal converters, as specified by the appropriate V-series Recommendations. After the physical connection has been established, the signal converter is in the data mode.

Error-correcting DCEs shall provide a mechanism for enabling or disabling establishment of the error-correcting protocol. This mechanism may be used in situations where the attempt to establish the error-correcting protocol interferes with operation of the remote DTE or when error-correction between DCEs is not desired or needed (such as when the DTEs provide higher-layer error control). The ability to initiate or terminate the error-correction protocol independent of the physical connection (i.e. while a physical connection is already in progress or retained) may optionally be provided, but coordination of protocol initiation at times other than immediately following establishment of the physical connection is not a subject of this Recommendation.

If establishment of the error-correcting protocol is enabled, then after the signal converter is in the data mode, the peer error control functions will establish the error-corrected connection.

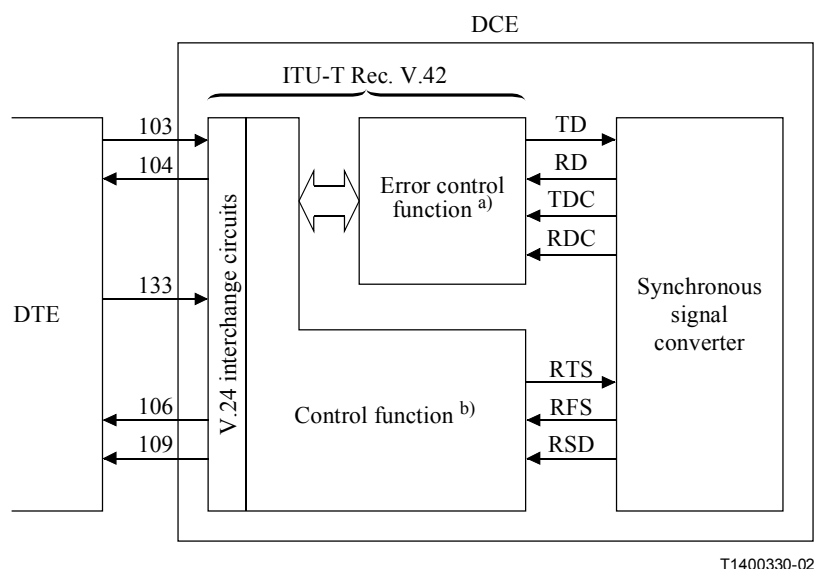
5 Interchange circuits affected by error correction

The affected circuits are listed in Table 1.

The interconnection of the functional elements of an error-correcting DCE is shown in Figure 3.

Table 1/V.42 – Interchange circuits affected by error control

No.	Description
103	Transmitted data
104	Received data
106	Ready for sending
109	Data channel received line signal detector
133	Ready for receiving



a) See clause 8 and Annex A.

b) See clause 7.

Figure 3/V.42 – Circuits affected by error control

6 Overview of error-correcting DCE operation

6.1 General

An error-correcting DCE, as depicted in Figure 2, contains four components:

- V.24 interchange circuits;
- a signal converter;
- a control function;
- an error control function.

While the first three components are also found in the DCE depicted in Figure 1, the control function in an error-correcting DCE is enhanced beyond the functionality of a control function in a DCE. For example, the control function in an error-correcting DCE shall be capable of determining whether the remote DCE is an error-correcting DCE or a non-error-correcting DCE. The error control function is unique to an error-correcting DCE.

Clause 7 provides a detailed description of the control function. Clause 8 provides detailed descriptions of the error-correcting protocols and their interactions with the control function.

NOTE – The decomposition of the functionality of an error-correcting DCE into a control function and an error control function, as well as the description of their interaction, is not meant to imply a particular method of implementation.

The remainder of this clause gives an overview of the control function and the error control function.

6.2 Overview of the control function

The control function shall be responsible for the overall coordination of functions within a DCE. When realized in an error-correcting DCE, the control function shall be responsible for the following additional aspects of operation:

- a) conducting an initial handshake to determine whether the remote DCE is also a V.42 error-correcting DCE;
- b) falling back to a non-error-correcting mode to interwork with V-series DCEs that include asynchronous-to-synchronous conversion according to ITU-T Rec. V.14;
- c) coordinating the negotiation and/or indication of any necessary parameters;
- d) coordinating the negotiation of optional procedures;
- e) coordinating the establishment of an error-corrected connection after the establishment of the physical connection with a peer error-correcting DCE;
- f) coordinating the delivery of data between the V.24 interface and the error control function so that data loss, to the extent possible, does not occur due to congestion on the DTE/DCE or DCE/DCE interface (This includes inspection of the characters received from the V.24 interface to determine whether the DTE has invoked flow control.);
- g) converting data received on the V.24 interface with start-stop framing to a format suitable for synchronous transmission;
- h) converting data received on the DCE/DCE interface in synchronous format for delivery with start-stop framing on the V.24 interface;
- i) processing a break (spacing) signal received on the V.24 interface for synchronous transmission;
- j) processing a break indication received on the DCE/DCE interface;
- k) coordinating a loop-back test;
- l) re-negotiating parameters if conditions warrant it; and
- m) releasing the error-corrected connection in an orderly fashion.

6.3 Overview of the error control function

The error control function shall be responsible for the operation of the protocol that realizes the error-corrected connection. The protocol shall have the following functional capabilities:

- a) negotiation and/or indication of appropriate operational parameters;
- b) negotiation of optional procedures;
- c) establishment of an error-corrected connection;
- d) transmission and reception of data;
- e) error detection and correction;
- f) transmission and reception of a break signal;
- g) initiation of and responding to loop-back testing; and
- h) orderly release of an error-corrected connection.

6.4 Communication between the control function and the error control function

Communication between the control function and error control function is modelled as a set of abstract primitives, which represents the logical exchange of information and control to accomplish a task or service. In the context of this Recommendation, the control function is viewed as the "service-user" while the error control function is viewed as the "service-provider".

A primitive is of the general form:

X-NAME type

where:

X designates a particular pair of communicating entities;

NAME designates the service being invoked;

Type designates the initiator of the communication.

Table 2 shows the services expected by the control function (i.e. the values that "NAME" can take on).

Table 2/V.42 – Services expected by the control function

Service	Primitive	Clause
Establish an error-corrected connection between peer error-correcting entities	L-ESTABLISH	7.2.2
Transfer data	L-DATA	7.3
Release an error-corrected connection	L-RELEASE	7.2.2, 7.7
Transfer a break signal	L-SIGNAL	7.4, 7.5
Negotiate/indicate parameter values and optional procedures	L-SETPARM	7.6
Conduct a loop-back test between error-correcting entities	L-TEST	7.8
Suspend error correction procedure	L-SUSPEND	7.10
Resume error correction procedure	L-RESUME	7.11

There are four "types" of primitives. These are:

- a) a request primitive, which is used by the service-user to request a service;
- b) an indication primitive, which is used by the service-provider to notify the service-user of a request for a service or an action initiated by the service-provider;
- c) a response primitive, which is used by the service-user to respond to a request for a service; and
- d) a confirmation primitive, which is used to indicate that a service request has been completed.

7 Operation of the control function

Clause 6.2 provided an overview of the control function. This clause details the operation of the control function, which completely controls all phases of error control function operation.

7.1 Physical handshake

The procedures for establishing a physical connection are specified by the appropriate V-series Recommendations. After the physical connection has been established, the control function shall be aware of the following information:

- a) whether the DCE is the originating or answering DCE;
- b) various aspects concerning the transmission facility (e.g. speed); and
- c) the character format used by the DTE.

The method for determining the above information is beyond the scope of this Recommendation. This information is used to govern some aspects of error-correcting-DCE operation.

7.2 Phases of error-correcting protocol establishment

Upon receipt of an indication that the signal converter element has completed carrier handshake and that the physical connection is ready for communications, the control function initiates error-correcting protocol operation. This process has been divided into two phases:

- a) the detection phase determines whether the remote DCE is also an error-correcting DCE; and
- b) the protocol establishment phase determines parameter values and optional procedures to be used, as necessary, and establishes the error-corrected connection.

The detection phase has been designed to avoid the potential disruption to the called DTE that could occur if the control function immediately entered the protocol establishment phase and the remote DCE was not an error-correcting DCE. However, the detection phase may optionally be disabled by the user if, for example, the answering DCE is known to be of a compatible type. The error-correcting DCE does not transmit any data received on the V.24 interface to the remote DCE in error-correcting mode until the successful establishment of the error-corrected connection. At that time, the control function adjusts the V.24 interface to inform the DTE that DTE-to-DTE data transfer may commence.

7.2.1 Detection phase

This phase allows the control function to verify the presence of a remote error-correcting DCE.

Considerations for interworking between an error-correcting DCE and a non-error-correcting DCE are given in Appendix I.

7.2.1.1 Determination of role

The success of the detection phase depends on both control functions knowing their roles as originating DCE (hereinafter called the originator) or answering DCE (answerer). The role is determined by the frequencies used for communication or the role assumed during carrier handshake as assigned in the particular modulation Recommendations. In the situation where no phone call is placed (such as in a "leased line" connection) or where, because of the nature of the modulation, there is no clear differentiation between originator and answerer, the roles must be determined by parameterization (stopping options or other user indication of desired role to the control function).

7.2.1.2 Originator actions

The detection phase actions by the originator may be disabled by the user. In this case, the originator moves directly to the protocol establishment phase (see 7.2.2).

If the detection phase is enabled, when circuits RFS and RSD go ON, indicating a successful connection between the signal converters, the originator shall then send the Originator Detection Pattern (ODP). The ODP is defined as the following pattern of bits (listed left to right in order of transmission):

0 1000 1000 1 11...11 0 1000 1001 1 11...11

This pattern represents DC1 with even parity, followed by 8 to 16 ones, followed by DC1 with odd parity, followed by 8 to 16 ones. The ODP is transmitted for the period of the detection phase timer, T400 (see 9.1.1) or until the Answerer Detection Pattern (ADP), which is defined in 7.2.1.3, is received.

All transmissions are sent using the scrambling function of the signal converter (if any) and in synchronization with the derived carrier clock signal (i.e. without use of any inherent asynchronous speed-matching capability of the signal converter that would otherwise be used in an asynchronous non-error-correcting DCE).

The originator shall examine the incoming bit stream from the receiver signal element for the presence of the ADP. Correct receipt of the characters from at least two adjacent ADPs shall be required for the originator to determine that the pattern is being observed.

If the ADP is not observed within the period of T400 (see 9.1.1), following completion of the transmission of the last repetition of the ODP the originator shall decide that the answerer does not possess V.42 error-correcting capability. In this case, the originator may fall back to non-error-correcting mode or may attempt to detect the presence of an alternative error-correcting capability.

If the ADP is observed within the period of T400, the originator stops transmission of the ODP and takes the appropriate action based upon the ADP received (e.g. if "EC" is received, initiate LAPM).

7.2.1.3 Answerer actions

Upon indication of successful establishment of a connection between the signal converters, the control function of the answerer shall transmit 1-bits (mark) until termination of the detection phase, receipt of the ODP, or detection of the start of the protocol phase (the start of the protocol phase is indicated by receipt of continuous flags, or of an LAPM or alternative procedure protocol frame).

The answerer shall examine the incoming bit stream from the signal converter for the presence of the ODP, which is defined in 7.2.1.2. Correct receipt of at least four DC1s of alternating parity shall be required for the answerer to determine that the ODP is being observed.

If, after establishment of the physical connection, the ODP is not observed within the period of T400 (see 9.1.1) and the start of the protocol establishment phase is not observed within the same period, then the answerer shall decide that the originator is not capable of V.42 error-correcting operation and shall fall back to non-error-correcting operation.

If the ODP is observed, the answerer interprets this as an indication from the originator that the originator is capable of error-correcting operation and desires to continue into the protocol establishment phase. The answerer shall immediately send one of the Answerer Detection Patterns (ADPs) defined in Table 3 at least ten times.

All transmissions are sent using the scrambling function of the signal converter and in synchronization with the derived carrier clock signal.

Table 3/V.42 – Answerer detection patterns

Type	Meaning
0 1010 0010 1 11...11 0 1100 0010 1 11...11 (E) and (C) separated by 8 to 16 ones	V.42 supported
0 1010 0010 1 11...11 0 0000 0000 1 11...11 (E) and (Null) separated by 8 to 16 ones	No error-correcting protocol desired
0 1010 0010 1 11...11 0 0000 XXXX 1 11...11	The remaining 15-code points are reserved for future study and assignment
NOTE – The above bit patterns are listed left to right in order of transmission (i.e. low-order bit transmitted first).	

7.2.2 Protocol establishment phase

The protocol establishment phase is initiated by the originating DCE upon successful completion of the detection phase if enabled. The purpose of this phase is to:

- negotiate and/or indicate the parameters and any optional procedures that govern the subsequent operation of the DCE; and
- establish the error-corrected connection.

Negotiation/indication may be omitted if default parameter values and procedures are satisfactory. When needed, the control function shall follow the procedures in 7.6 for the negotiation/indication of parameter values and optional procedures.

After the negotiation/indication process has been completed, the originating DCE initiates establishment of the error-corrected connection. The control function in the originating DCE instructs its error control function to initiate connection establishment by issuing an L-ESTABLISH request primitive.

Upon receiving an L-ESTABLISH indication primitive from its error control function, a control function must determine whether it wishes to accept the request for error-corrected connection establishment. If it wishes to accept the request, it issues an L-ESTABLISH response primitive; data may now be transmitted over the error-corrected connection. Otherwise, the control function issues an L-RELEASE request primitive to the error control function. The control function may fall back to operation in a non-error-control mode or it may release the physical connection.

After having issued an L-ESTABLISH request primitive, the control function, upon receipt of an L-ESTABLISH confirmation primitive, considers the establishment of the error-corrected connection to be completed and may transmit data over it. If the control function receives an L-RELEASE indication primitive (e.g. as a result of a failure to set up the error-corrected connection or the remote control function refusing to accept error-corrected connection setup), then it may fall back to operation in a non-error-correcting mode or it may release the physical connection.

7.3 Data transfer

Upon completion of the protocol establishment phase, the control function shall request transmission by the error control function of data received on the V.24 interface. Regardless of the character format used, each character received on the V.24 interface shall be transmitted as an 8-bit character (without start and stop bits) across the DCE/DCE interface.

Annex B provides the mapping of various character formats to an 8-bit character format.

NOTE – It is beyond the scope of this Recommendation to specify how the control function determines when to request the error control function to transmit data. Some considerations are given in Appendix II.

To transmit data, the control function shall issue an L-DATA request primitive to the error control function. This primitive shall indicate the data to be transmitted.

Upon receipt of an L-DATA indication primitive, the control function shall deliver the received data to the V.24 interface. Each character shall contain the proper start-stop framing.

7.3.1 Flow control across the DTE/DCE interface

The control function will be capable of indicating to the DTE a temporary inability to accept data on circuit 103 (DCE not-ready condition), and of recognizing a corresponding indication from the DTE (DTE not-ready condition). Upon receiving such an indication, the DCE shall and the DTE should complete transmission of any partially transmitted character and then cease transmitting data on circuit 104 (103) and clamp circuit 104 (103) to binary 1. When the not-ready condition is cleared, the DCE (DTE) may resume the transmission of data on circuit 104 (103).

The flow control indication may be performed in one of two ways:

- a) using circuits 133 and 106:
 - a DCE not-ready condition may be indicated by turning circuit 106 OFF and cleared by turning circuit 106 ON;
 - a DTE not-ready condition may be recognized by an ON-to-OFF transition and cleared by an OFF-to-ON transition of circuit 133;
- b) using DC1/DC3 characters (XON/XOFF functions):
 - a DCE not-ready condition may be indicated by transmitting a DC3 character and cleared by transmitting a DC1 character on circuit 104;
 - a DTE not-ready condition may be recognized by the reception of a DC3 character and the condition cleared by the reception of a DC1 character on circuit 103.

Optionally, DC1 and DC3 characters received from the DTE may remain in the data stream.

Both techniques a) and b) shall be provided; however, the choice of technique is a user-configurable option.

The response times to the DCE of indication of a DTE not-ready condition and of the DTE to indication of a DCE not-ready condition are for further study. These times should be kept as short as practical. DCEs should accommodate latency in DTE recognition of the DCE not-ready indication by accepting several characters on circuit 103 after the indication is given.

If a break signal is the next item to be delivered across the DCE/DTE interface, it shall be delivered regardless of the flow control state. In the case of a non-expedited/non-destructive break, data to be delivered prior to the break remains subject to flow control.

7.4 Transfer of break signal

Upon receipt of a break signal on the V.24 interface, the control function shall determine:

- a) how to handle data (discard or deliver) not yet transmitted across the V.24 interface or to the remote DCE; and
- b) in what sequence (in sequence or preceding) the break signal shall be delivered to the remote V.24 interface with respect to data delivery.

The control function shall issue an L-SIGNAL request primitive to the error control function, indicating the break-handling option corresponding to the appropriate actions. The break-handling option and the actions to be followed are given in Table 4. The L-SIGNAL request primitive may also indicate the length of the break. If break lengths are not so indicated, the L-SIGNAL request primitive shall be issued at the earliest opportunity following detection of the break condition on the DTE/DCE interface. If break lengths are being indicated, the L-SIGNAL request primitive shall be issued at the earliest opportunity following the detection of the end of the break condition. Should the break condition continue for more than 2.54 seconds, however, the L-SIGNAL request primitive

indicating a break exceeding 2.54 seconds (break length field value equal to 255) shall be issued at the earliest opportunity following determination that the break has exceeded 2.54 seconds.

Table 4/V.42 – Transmitting DCE actions on receipt of break signal on the V.24 interface

Break handling option	With respect to data			
	Going to remote DCE	Going to local DTE	Coming from remote DCE	Coming from local DTE
Destructive/Expedited ^{a)}	– Complete data transmission in progress, then transmit break – Discard data not yet transmitted	– Discard data not yet delivered	– Discard data until receive acknowledgement	– Hold data until receive acknowledgement
Non-destructive/Expedited	– Complete data transmission in progress, then transmit break – Hold data until receive acknowledgement	– Continue delivering data	– Continue receiving data	– Continue receiving data
Non-destructive/Non-expedited	– Wait for acknowledgement of data previously transmitted, and then transmit break – Hold data until receive acknowledgement	– Continue delivering data	– Continue receiving data	– Continue receiving data
a) All state variables pertaining to control function and error control function operation, except those pertaining to break transfer, are reset to their initial values.				

The control function shall not issue a subsequent L-SIGNAL request primitive before a prior one has been acknowledged by an L-SIGNAL confirmation primitive from the error control function. If Destructive/Expedited or Non-destructive/Expedited breaks are being used, and a subsequent break is detected on the DTE interface prior to receipt of the L-SIGNAL confirmation primitive associated with a previous break, the DCE may discard and ignore the subsequent break. If Non-destructive/Non-expedited breaks are being used, however, subsequent breaks must remain pending and signalled following receipt of the L-SIGNAL confirmation primitive associated with any previous break.

NOTE – Because break signals are not subject to flow control, the buffer capacity of the DCE may be exceeded by the receipt of multiple consecutive breaks, resulting in subsequent breaks being discarded. The maximum number of pending non-expedited non-destructive breaks which can be accommodated is manufacturer-specific.

7.5 Receipt of break

The control function is informed of a break upon receipt of an L-SIGNAL indication primitive. It shall acknowledge this primitive with an L-SIGNAL response primitive as soon as possible. Actions to be taken on receipt of the break depend on the break-handling option, as shown in Table 5. If a break length is not indicated or contains a zero value, a break of default length is delivered to the DTE.

Table 5/V.42 – Receiving DCE actions on receipt of break from the remote DCE

Break handling option	With respect to data	
	Going to remote DCE	Going to local DTE
Destructive/Expedited ^{a) b)}	– Discard data not yet transmitted	– Discard data not yet delivered – Deliver break signal
Destructive/Expedited	– No effect	– Deliver break signal immediately – Resume normal data delivery
Non-destructive/Non-expedited	– No effect	– Deliver break signal in sequence with respect to data
^{a)} All state variables pertaining to control function and error control function operation, except those pertaining to break transfer, are reset to their initial values.		
^{b)} For all break options, acknowledgement should be returned as soon as possible.		

7.6 Negotiation/Indication of parameter values and optional procedures

During the protocol establishment phase (see 7.2.2), negotiation and/or indication of parameter values and optional procedures is initiated by the control function in the originating DCE if default values are not satisfactory. It may also be initiated at any time thereafter by the control function in either DCE.

NOTE 1 – The criteria by which the control function determines to change parameter values and optional procedures, once set during the protocol establishment phase, are beyond the scope of this Recommendation. Examples may include detection of changing transmission-line conditions.

The control function issues an L-SETPARM request primitive to instruct its error control function to initiate negotiation and/or indication of parameter values and optional functions.

Upon receipt of an L-SETPARM indication primitive from its error control function, the control function shall perform the necessary negotiation (see clauses 9 and 10). It shall then issue an L-SETPARM response primitive to its error control function and complete the negotiation/indication process (see below).

Upon receipt of an L-SETPARM confirmation primitive from its error control function, the control function completes the negotiation/indication process (see below).

Negotiation/indication of parameter values and optional procedures follow the procedures in clauses 9 and 10. To complete the negotiation/indication process, the control function shall set the affected parameters to their new values and activate/deactivate the affected procedures.

NOTE 2 – Some parameters are set independently of and without informing the remote DCE. In such cases, the control function sets these parameters to their new values without interacting with the error control function as described above.

7.7 Orderly release of the error-corrected connection

After prior establishment of an error-corrected connection, the control function may instruct its error control function to release the error-corrected connection in an orderly fashion by issuing an L-RELEASE request primitive. At this time, the control function considers the procedure completed. The control function also determines whether to release the physical connection.

NOTE – The stimuli by which the control function orders the error control function to release the error-corrected connection in an orderly fashion are beyond the scope of this Recommendation. The control function may disconnect the physical connection, without requesting an orderly release of the error-corrected connection, upon detection of the corresponding changes on the V.24 interface.