ECMA

EUROPEAN COMPUTER MANUFACTURERS ASSOCIATION

STANDARD ECMA-16

for

BASIC MODE CONTROL PROCEDURES FOR DATA COMMUNICATION SYSTEMS USING THE ECMA 7-BIT CODE

2nd Edition — June 1973

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INTRODUCTION

On April 30, 1965, ECMA adopted their Standard ECMA-6 for a 7-bit Coded Character Set for Information Interchange. This standard does not comprise proposals for implementation in physical media and transmission which was left as the subject on other Standards.

The 128 characters of the standard 7-bit code comprise graphic characters, general purpose control characters, and 10 Transmission Control Characters, the unique purpose of which is to control or facilitate transmission of information over telecommunication networks.

The main objective of the present Standard is to supplement the Standard ECMA-6 by giving more precise definitions of the Transmission Control Characters. Rules are also given for assembling information for remote transmission and for carrying out a dialogue between remote stations; these rules are commonly called "Communication Control Procedures". It should be noted that a number of technical parameters must be defined before compatibility can be achieved between equipments made by different manufacturers.

The rules are based on the assumption that one of the Stations in each connection would either be a computer or a device capable of handling automatically an exchange of information. The rules are designed to allow the complexity of operation to be increased from a basic level by adding options. These options are designed so that any number of Stations can still communicate even though they normally operate at different levels of complexity. The rules may be difficult to implement in very simple systems involving low cost devices and human control, and the existence of this Standard does not preclude the use of simpler control procedures in such cases. On the other hand, in computer to computer links, the rules may seriously restrict the throughput of information. These two cases are regarded as the upper and lower fringes of the present Standard and may be the subject of future recommendations.

This Second Edition, which supersedes the First Edition, dated May 1968, has been prepared in order to incorporate in the Standard a change incorporated in the corresponding ISO R 1745, following an ECMA suggestion.

TABLE OF CONTENTS

1. SCOPE AND FIELD OF APPLICATION

1.1 General

This document describes the standard implementation of the ECMA 7-bit input/output character code on Data Transmission Channels with provision for using other codes. It also defines the standard:

- structure of the coded characters,
- formats of the transmitted messages,
- exchange of Information Messages and Supervision Sequences,
- error protection method.

This Standard covers the majority of existing Data Transmission Systems and network configurations used in conjunction with Data Processing systems. These control procedures deal with transmission over one Link at a time and do not necessarily describe the operation of Data Links in "tandem". They relate to the class of control procedures which is known as the Basic Mode.

1.2 System Concepts

A Data Communication System may be considered as the ensemble of the Terminal Installations and the interconnecting network that permits information to be exchanged.

A Data Link concept is identifiable when considering Terminal Installations connected to the same network, operating at the same speed, in the same code. Any "store and forward" delay or intermediate Data Processing really separates Data Links and any system is constituted of one or several Data Links.

The Information Transfer in a Data Link is monitored by Data Link Control Procedures where some characters, selected within a code set, are given particular meanings according to the transmission phase and are used for various purposes such as to delineate information, to reverse the direction of transmission, to ask questions, to answer, etc.

The Data Link Control Procedures are categorized in classes which are referred to as modes of operation. The present considerations relate to one class called "Basic Mode" which is defined as follows:

In the Basic Mode all the necessary transmission control information (e.g. message framing and Supervisory Instructions) passing from one station to another is carried over the Link by discrete Control Characters selected from the ten Transmission Control Characters which are described in Section 3.1. The control of the Data Link is not affected by any characters other than the ten Transmission Control Characters. Other codes than the ISO/ECMA/CCITT code may therefore be transmitted provided that they do not contain any of the ten Transmission Control Characters in either a Heading or a Text. The use of

DLE is not permitted, with the one exception DLE EOT which is defined as Disconnect.

1.3 Assumptions

- The information to be transmitted shall normally be coded in accordance with the ECMA 7-bit code.

- All transmission control functions shall be performed by the use of ten specific Transmission Control Characters which are defined in this code as TC 1 to TC 10.

- No recommendation is made regarding :
  - the technique used (hardware or software);
  - the part of the Terminal Installation, where the Information Messages and Supervisory Sequences are generated and recognized;
  - checking of Supervisory Sequences.

- Transmission may be at any data transfer rate, either serial or parallel form, and either start/stop or synchronous.

- Responses to an Information Message or a Supervisory Sequence may be either by turn around of the Channel or by using another channel.

- The Basic Mode control procedures are applicable to systems of varied complexity based on either way transmission using:
  - One-way transfer of information with alternate supervision on the same channel

  - One-way transfer of information with alternate supervision on a separate channel

  - Alternate two-way transfer of information with alternate supervision on the same channel

  - Alternate two-way transfer of information with alternate supervision on a separate channel

Other cases may be the subject of further study.

2. REFERENCES

ECMA-6	7-Bit Input Output Coded Character Set
ECMA-24	Code Independent Information Transfer
ECMA-26	Recovery Procedures
ECMA-27	Abort and Interrupt Procedures
ECMA-28	Multiple Station Selection Procedures
ECMA-29	Conversational Information Transfer
ECMA-37	Supplementary Transmission Control Functions

Standards ECMA-24, 26, 27, 28, 29 and 37 are extensions of this Standard ECMA-16.

3. CONTROL PROCEDURES

3.1 Description of Use of the Transmission Control Characters

In the following, the definition of the ten Transmission Control Characters (TC 1 to TC 10) is given and the functional description of their use is summarized (See also Section 3.2).

3.1.1 SOH - Start of Heading - TC 1

A Transmission Control Character used as the first character of a Heading of an Information Message.

Description of Use

- SOH is transmitted by a Master Station
- If a Heading is used it must be preceded by SOH.
- If a Heading is sub-divided into blocks, each block must be preceded again by SOH.
- If Block Checking is used, see Section 5.
- SOH is not permitted in Text.

3.1.2 STX - Start of Text - TC 2

A Transmission Control Character which precedes a Text and which is used to terminate a Heading.

Description of Use

- STX is transmitted by the Master Station
- A Text must be preceded by STX.
- If a Heading is used, STX in the message indicates the end of the Heading.
- If the Text is sub-divided into blocks, each block must be preceded again by STX.
- If Block Checking is used, see Section 5.
- STX is not permitted in the Heading.

3.1.3 ETX - End of Text - TC 3

A Transmission Control Character which terminates a Text.

Description of Use

- ETX is only transmitted by the Master Station.
- ETX indicates the end of the Text of each Information Message.
- If an Information Message is sub-divided into transmission blocks, ETX is used to terminate the last block.
- ETX calls for a reply from the Slave Station.
- If Block Checking is used, ETX signals that the next following character is a Block Check Character. See Section 5.
- ETX is not permitted in Text or Heading.

3.1.4 EOT - End of Transmission - TC 4

A Transmission Control Character used to indicate the conclusion of the transmission of one or more Texts.

Description of Use

- EOT may be transmitted by a Control, Master or Slave Station.
- The Control Station transmits EOT to condition all Tributary Stations in view of the reception of a Forward Supervisory Sequence.
- The Master Station in a system with Control Station, transmits EOT to relinquish its right to transmit in favour of the Control Station.
- The Master Station in a system without Control Station, transmits EOT to indicate either the end or the aborting of a transmission and resets the Master and Slave Stations to the Neutral State.

- The Slave Station transmits EOT to indicate its inability to receive further Information Messages. This is an abnormal reply or Interruption and leads into Termination Phase.
- EOT is not permitted in Text or Heading.

NOTE - Depending upon the system characteristics and configuration EOT transmitted by a Tributary Station (Master or Slave) may reset some or all Tributary Stations.

3.1.5 ENQ - Enquiry - TC 5

A Transmission Control Character used as a request for a response from a remote station - the response may include station identification and/or Station status. When a "Who are you" function is required on the general switched transmission network, the first use of ENQ after the connection is established shall have the meaning "Who are you" (station identification). Subsequent use of ENQ may, or may not, include the function "Who are you", as determined by agreement.

Description of Use

- ENQ is transmitted by the Control Station during Polling and by the Master Station during Selecting.
- In the Polling Sub-phase, ENQ is used to indicate the end of a Polling Address.
- In the Selecting Sub-phase, ENQ is used to indicate the end of a Selecting Address or Prefix when a reply is required from the Slave Station.

  More specifically ENQ can in this Sub-phase :

  - Terminate a Station Selecting Sequence;
  - Request identification and/or status;
  - Turn a Data Link out of Neutral State.
- ENQ is not permitted in Text or Heading.

3.1.6 ACK - Acknowledge - TC 6

A Transmission Control Character transmitted by a receiver as an affirmative response to the sender.

Description of Use

- ACK is transmitted only by a Slave Station as an affirmative reply to a Master Station.
- When supplementary information is included in the reply (e.g.station identification or status information) it is prefixed to ACK.

- In the Selecting Sub-phase, ACK is transmitted as a reply to a Selecting Supervisory Sequence to indicate that the Slave Station is ready to receive.
- In the Information Transfer Phase, ACK indicates that the last transmitted Information Message or Block was received correctly, and that the Slave Station is ready to receive the next one.
- If numbering of positive acknowledgement is used it must follow the rules in ECMA-37 (see section 2).
- ACK is not permitted in Text or Heading.

3.1.7 DLE - Data Link Escape - TC 7

A Transmission Control Character which will change the meaning of a limited number of contiguously following characters. It is used exclusively to provide supplementary data transmission control functions. Only graphics and Transmission Control Characters can be used in DLE sequences.

Description of Use

- DLE immediately followed by EOT is transmitted by a Master or a Slave Station to "disconnect", that is to initiate the clearing of the connection over private and/or general switched network.
- Other use of DLE are defined in Standard ECMA-37 (see section 2).

3.1.8 NAK - Negative Acknowledge - TC 8

A Transmission Control Character transmitted by a receiver as a negative response to the sender.

Description of Use

- NAK is transmitted only by a Slave Station as a negative reply to the Master Station.
- When supplementary information is included in the reply (e.g. station identification or status information) it is prefixed to NAK.
- The Slave Station transmits NAK after receipt of a Selecting Supervisory Sequence to indicate its inability to receive an Information Message.
- In the Information Transfer Phase, NAK indicates that the last transmitted Information Message or Block was not received correctly, and the Slave Station is ready to receive the same one.
- NAK is not permitted in Text or Heading.

3.1.9 SYN - Synchronous Idle - TC 9

A Transmission Control Character used by a synchronous trans-

mission system in the absence of any other character (idle condition) to provide a signal from which synchronism may be achieved or retained between terminal equipments.

Description of Use

- SYN may be transmitted by a Control, Master or Slave Station.
- SYN is used to achieve character synchronization in synchronous Data Communication Systems. At least two SYN characters must be transmitted prior to the transmission of any Information Message or Supervisory Sequence.

NOTE - It is assumed that the receiving station requires two consecutive SYN characters to reliably achieve character synchronization. The data terminal equipment may be required to achieve bit synchronization. (This may be a subject for future study.)

- SYN can be used as "time-fill" to maintain, for instance, synchronization during periods when no other characters are available for transmission. When used as "time-fill", SYN may be added at any point in a character sequence, except:
  - between ETX or ETB and the Block Check Character when Block Checking is implemented,
  - within DLE sequences.
- SYN is generally removed at the receiving Terminal Installation.
- If Block Checking is used, see Section 5.

3.1.10 ETB - End of Transmission Block - TC 10

A Transmission Control Character used to indicate the end of a transmission block of data where data is divided into such blocks for transmission purposes.

Description of Use

- ETB is transmitted only by the Master Station.
- If an Information Message is sub-divided into Blocks, ETB is used to terminate each Block, with the exception of the final one.
- ETB calls for a reply from the Slave Station.
- If Block Checking is used, ETB indicates that the next following character is a Block Check Character (BCC). See Section 5.

3.2 Message Formats

The various possible messages are categorized as follows:

- Information Messages
- Forward Supervisory Sequences
- Backward Supervisory Sequences

Every transferred sequence of characters contains at least one Transmission Control Character. These are used either to define the nature of the information contained in a sequence of data or to convey supervisory functions:

- they must not be considered as information and therefore must not be transmitted as part of the Text or Heading of an Information Message. An exception is SYN which may be inserted as required;

- when used singly or at the end of a message or sequence they invite the station receiving them to take action.

3.2.1 Information Messages

Information Messages are made of a Text which can be preceded by a Heading; the Heading is delivered with the Text. Routing indication, for intermediate point in particular, must be in the Heading. Other auxiliary information may be either in the Heading or in the Text.

SOH, STX, ETB and ETX are used as Information Framing Characters. They cannot be sent singly.

Information Messages, or Information Blocks may be accompanied by a Block Checking Character in accordance with Section 5. The use of this Block Checking Character, shown in parenthesis, is optional and therefore subject to prior agreement.

3.2.1.1 Information Message Formats

a
```
STX -- TEXT -- ETX (BCC)
```

b
```
STX -- TEXT -- ETB (BCC)
```
(Note 2)

c
```
SOH -- HEADING -- STX -- TEXT -- ETX (BCC)
```

d
```
SOH -- HEADING -- STX -- TEXT -- ETB (BCC)
```
(Note 2)

e SOH -- HEADING -- ETB (BCC) (Note 2)

NOTE 1 Fillers may be inserted in the Heading and the Text (e.g. SYN).

NOTE 2 In formats (b), (d) and (e) above which end with ETB, some continuation is required.

NOTE 3 All the above messages can be aborted by terminating them at any point with EOT.

3.2.2 Supervisory Sequences

All Supervisory Sequences except DLE EOT are composed of either a single Transmission Control Character or a single Transmission Control Character preceded by one or several graphics.

In some of the following Supervisory Sequences the meaning of the character or characters which precede the Transmission Control Character is defined (e.g. Polling Address). In others it is simply shown as a prefix which may include one or more of the following:

- identity information,
- address information,
- status information,
- any other qualifier as necessary.

The use of these prefixes and their description is subject to prior agreement. They may be standardized at a later date.

EOT, ENQ, ACK and NAK are used for supervision. They can never appear consecutively.

3.2.2.1 Forward Supervisory Sequence Formats

a Polling — Polling address — ENQ (Note 4)

b Selecting (Note 4)

b.a Station Selection — Selecting address — ENQ

If a reply is not required ENQ is not used and the selecting sequence is immediately followed by the Information Message.

b.b Identification and Status (Prefix) ENQ

b.c Out of Neutral (Prefix) ENQ

c Return to Control Station - Return to Neutral State (Note 4)

(Prefix) EOT

d Disconnect DLE EOT

NOTE 4 Polling Sequences are always preceded by EOT and so may some Selecting Sequences.

Some systems may not be able to tolerate a Polling or Selecting Sequence immediately following EOT. In such cases it may be necessary to assure a delay between the EOT character and the Polling and Selecting Sequence using for example a number of "filler" characters.

3.2.2.2 Backward Supervisory Sequence Formats (Note 5)

a Positive reply to :

- an information message
- selecting

ACK (Note 6)

b Negative reply to :

- an information message (Prefix) NAK

c Negative reply to :

- a Polling Supervisory Sequence (Prefix) EOT

d Negative reply to :

- a Selecting Supervisory Sequence

(Prefix) NAK

e Request for :

- an interruption
- a return of responsibility to the Control Station
- return to Neutral State

EOT

f Disconnect

D E
L O
E T

NOTE 5 The procedures for the cases of "no reply" are covered in Section 3.3.3 "Recovery Procedures".

NOTE 6 If numbering of positive acknowledgement is used it must follow the rules in ECMA-37 (see section 2).

3.3 Description of Phases

The operational procedures of a complete system can be constructed from the following separate phases and sub-phases :

Phase 1 Establishment of Connection over the General Network

a - Switching
b - Identification

Phase 2 Establishment of Data Link

a - Switching
b - Polling
c - Selecting or Out of Neutral State

Phase 3 Information Transfer

Phase 4 Termination

a - Return to Neutral State
b - Return to Control Station
c - Disconnect

Phase 5 Clearing of Connection

NOTE - Phase 1 and phase 5 are under the responsibility of CCITT.

3.3.1 Phase Linkage

The attached diagram represents the various phases of a Communication which are linked (thick lines) to achieve one Transmission, or Information Transfer, in the most general case encompassed by the Basic Mode Control Procedures.

3.3.1.1 The sequence of events for such a Communication would be as follows:

Phase 1 (a, b) Establishment of Connection over the General Switched Network

Here the Connection is established by the

Administration and this is likely to be divided into two sub-phases: Switching and Identification. They will both be under the responsibility of the Administration.

Unless otherwise stipulated by the Administration, once this Phase is achieved, the Calling Station takes the responsibility of the Communication and acts as Master Station or Control Station.

Phase 2 (a,b,c) Establishment of Data Link

After establishing the Connection on the general Network it is required to establish the Data Link. This procedure may involve some private Switching before Polling and Selecting.

The Polling procedure, carried out by the Control Station, invites a Tributary Station to transmit any message it may have.

This procedure transfers the responsibility of the Communication to the polled station whic takes the Status of Master Station.

The Selecting procedure, carried out by the so designated Master Station, invites in turn another station to get ready to receive in Information Message.

This procedure gives to the selected station the Status of Slave Station.

Phase 3 Information Transfer

Assuming the Slave Station(s) has accepted to receive the Information Message, the Master Station commences its transmission. During this Phase there are no changes of Station Status or responsibility.

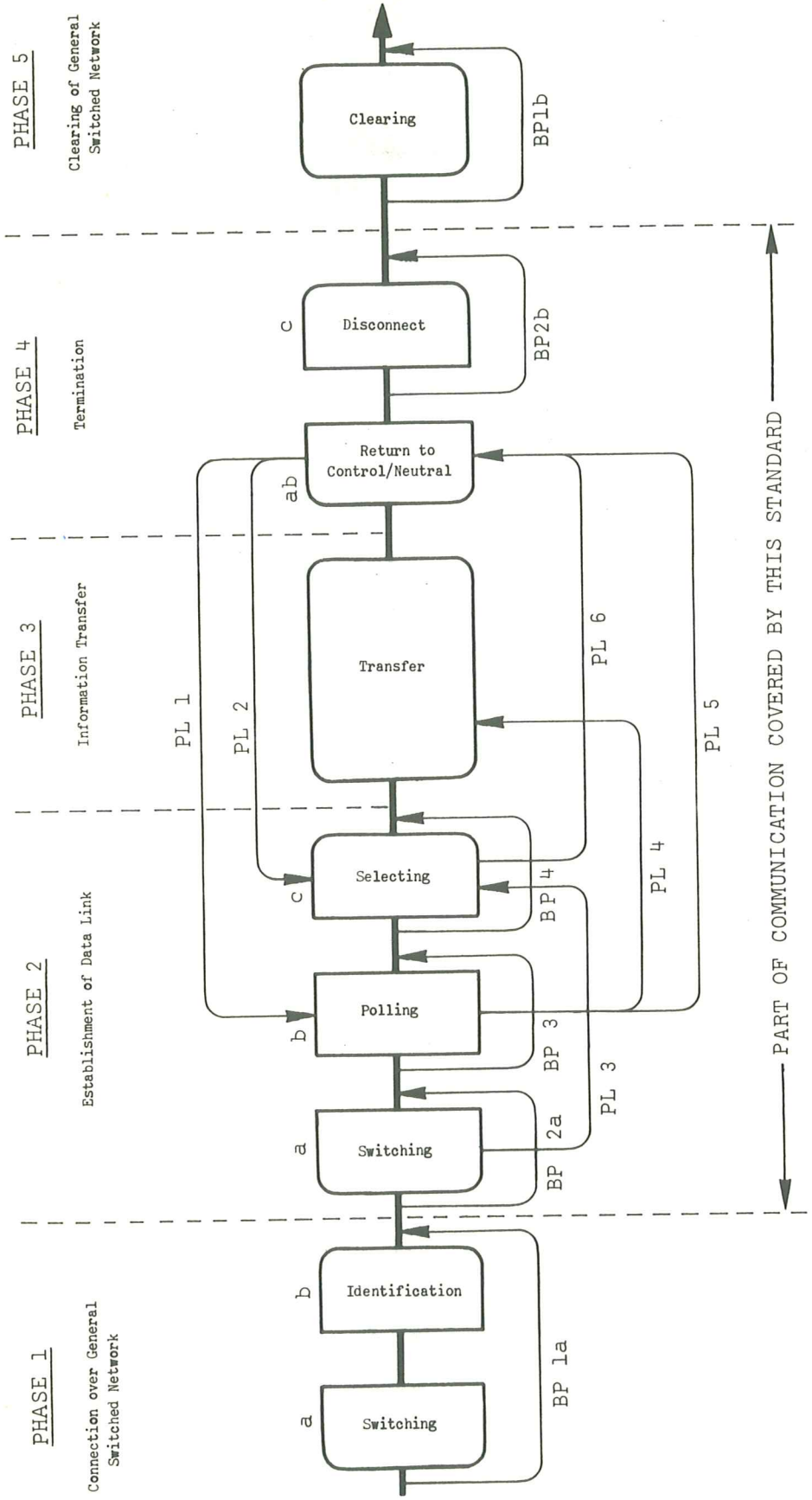
Phase 4 (a,b,c) Termination

When the Information Message has been transmitted and satisfactorily received by the Slave Station(s), the Master Station sends EOT to announce to the Control Station that its transmission requirement has temporarily ceased. By doing so the Master Station relinquishes its Master Status and returns the responsibility of the Communication to the Control Station.

If there are no further transmission requirements, the Control Station, by sending DLE.EOT, releases the possibly involved private switching equipment.

Phase 5 — Clearing of Connection (General Network

The Disconnect function (DLE.EOT) of the Termination phase will initiate the Clearing of the Connection over the General Switched Network. The procedure for so doing is under the responsibility of the PTT Administrations.



PHASE LINKAGE DIAGRAM

3.3.1.2 Multiple Information Transfer (Phase Linkage-PL)

In most systems, several Data Link Establishment and several Information Transfers shall take place in sequence within a Communication.

This is illustrated by the phase linkage arrows PL1, 2 ... 6. An example of the sequence of phases for multiple transfer could be :

Phase 1 a,b - The Control Station reaches a multistation link through the General Network;

Phase 2 c - The Control Station tries to select station X;

Phase 4 a - Station X refuses to receive;

Phase 2 b - The Control Station polls station Y;

Phase 3 - Station Y transmits information to Control Station;

Phase 4 - Station Y terminates its transmission;

Phase 4c - The Control Station decides to disconnect;

Phase 5 - The General Network is cleared.

All the permitted phase linkages are shown on the phase diagrams, section 3.3.1, along with more detailed descriptions of the phases and sub-phases.

3.3.1.3 Phase Linkage (By-pass-BP)

In some systems, not all the phases or sub-phases shown on the phase linkage diagram will be required. They are illustrated by by-passes, which are :

- By-pass 1 (BP1 a,b)

This by-pass applies to systems composed entirely of leased or private circuits not connected to the general switched network.

- By-pass 2 (BP2 a,b)

This by-pass applies to systems which do not involve private line switching.

- By-pass 3 (BP3)

In systems with Control Station the suppression of the Polling sub-phase allows only the sending of Information from the Control Station to the others.

In point-to-point systems without Control Station, each station can still select the other in order to transfer information but cannot poll in order to provoke the transmission from the other end.

- By-pass 4 (BP4)

This by-pass applies to systems with Control Station in which only the transfer of information from the Tributary Stations to the Control Station is required.

3.3.2 Phase Diagrams

The detailed procedures for the phases 2 to 4 are given in the following text and illustrated by flow diagrams.

3.3.2.1 Establishment of Data Link (Phase 2)

(a) Switching

A private switching process may be used. This, however, is not described in this standard.

(b) Polling

Polling is the process of inviting stations, one at a time in an orderly fashion, to transmit messages. The basic function of Polling is to prevent contention by insuring that only one station transmits at a time.

The Polling process can only be performed by a Control Station, following EOT.

When a station receives its appropriate Polling Supervisory Sequence, it becomes the Master Station.

Each Polling Supervisory Sequence must uniquely identify one station on the Data Link. However, a given station may be assigned more than one Address (for example, to distinguish between different precedences of originating traffic).

If no response or a non-valid response is received after transmission of a Polling Supervisory Sequence, the Control Station must clear the possibly established Data Link by sending a Termination Supervisory Sequence (EOT, see Termination Phase, Section 3.3.2.3 and Recovery Procedures, Section 3.3.3).

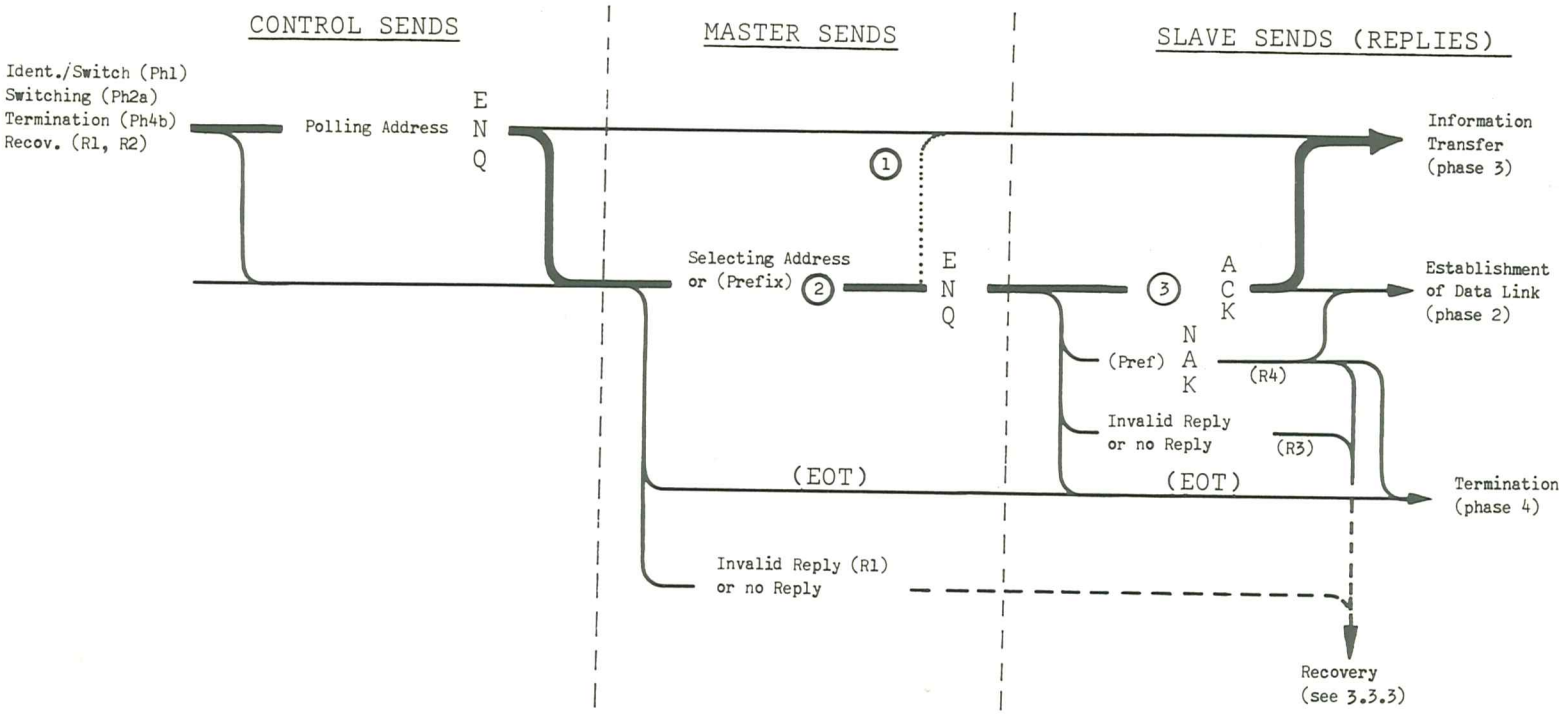
(c) Selecting

Selecting is the normal process for inviting one or more stations to receive an Information Message.

However, it can be used for the only purpose of checking the Identification of a station and/or of obtaining its Status.

The Selecting process can only be performed by a Master Station.

When used on a multistation Data Link, the Selecting Supervisory Sequence uniquely identifies, by means of its Address, one or several stations. This function is called station selection. The Address may include information other than that indicating the address of the desired station, e.g. priority-device selections, etc. The Address of the Selecting Supervisory Sequence may identify either a single station on the link or a group of stations on the link.



(1) For those systems, where the Information Message follows the Selecting Address (Fast Select path), ENQ is not used.

(2) This is used for the Out-of-Neutral state.

(3) If numbering of Positive Acknowledgement is used it must follow the rule in ECMA-37 (see Section 2).

PHASE 2 DIAGRAM

The station selection sequence may be sent either by the Control Station taking the Master status or by a station previously polled.

When used on a point-to-point Data Link the Selecting Supervisory Sequence, which may be limited to the character ENQ, essentially turns the Data Link out of its Neutral State.

In all cases, the Selecting Supervisory Sequence calls for a Status reply from the selected or opposed station. If no response or a non-valid response is received, the Master Station must take action to recover the communication (see Recovery Procedures, Section 3.3.3).

NOTE - An exception to the above is the use of the so-called "Fast Select" method in which the Information Message follows immediately the Selecting Address (ENQ is not used). The use of this method requires special agreement between sender and recipient.

3.3.2.2. Information Transfer (Phase 3)

(a) Heading

The Heading of an Information Message is a sequence of characters sent by a Master Station which constitutes the auxiliary information pertinent to the communication of a Text. Such auxiliary information may include, for instance, characters representing routing, priority, security, message numbering, and associated characters. The definition of specific portions of a Heading is not within the scope of this standard.

The sequence of characters which constitutes the Heading is prefixed by the Start of Heading (SOH) character and is terminated only with the Start of Text (STX) character.

The Heading is not a "stand alone" message but must always be immediately followed by a Text and is applicable only to that Text. Any arrangement for association of one Heading with more than one text can only be made by prior agreement between the affected parties and is not within the scope of this standard.

The Heading may be sub-divided into more than one Transmission Block by terminating each such Block with the End of Transmission Block (ETB) character and by prefixing the next following portion of the Heading with the SOH character. The Block Check Character, if used, immediately follows the ETB character (see Section 5).

(b) Text

The Text portion of an Information Message contains the information that is to be transmitt as an entity from the sender to the recipient(s). A Text is always embodied between the STX and ETX characters, and is always transmitted by a Master Station.

The Text may be sub-divided into more than one Transmission Block. Each of the Blocks is terminated by an End of Block control character (ETB or ETX if it is the last Block of Text). The following portion of the Text must be prefixed with the STX character.

If Block Checking is employed, the Block Check Character immediately follows the ETB or ETX character.

The Master Station stops sending after each Text or Block has been sent, and normally does not resume transmission until the reply has been received.

(c) Replies

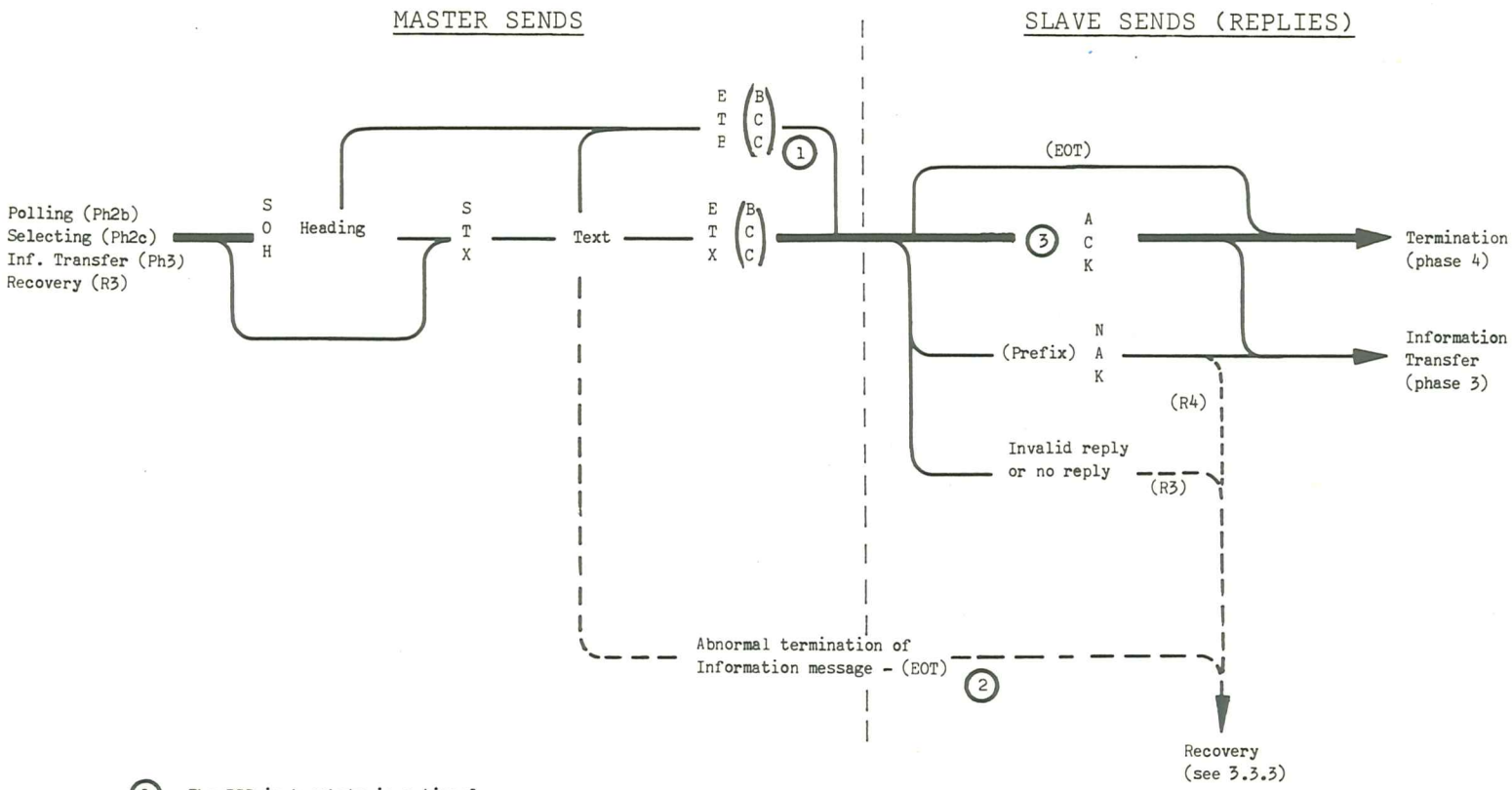
Replies are used by the Slave Station to inform the Master Station of the Status of the Slave Station and of the validity of the received message.

If the Information Message, or Block, was acceptable, and the Slave Station is ready to receive, the Slave Station replies by transmitting the Acknowledge character (ACK). The positive acknowledgment indicates to the Master Station that the data was acceptable and that the Slave Station is ready to continue to receive (see Note). The Master Station then transmits the next Information Message or Block. If the Master Station has no more to transmit, it passes to Termination Phase.

If the Information Message or Block is unacceptable, the Slave Station responds with the Negative Acknowledge character (NAK). This negative acknowledgment indicates to the Master Station that the data was unacceptable and also that the Slave Station is ready to receive. The next block of data transmitted is normally a retransmission of the previous Information Message or Block.

NOTE - If numbering of positive acknowledgment is used it must follow the rules in ECMA-37 (see section 2). First acknowledgment is DLE1, then DLE0.

If during the Information Transfer the Slave Station becomes unable to receive further, this station waits for the end of the transmitted Information Message or Block and then responds by EOT. This EOT shall be interpreted by the other station(s) as a request for interruption and, according to the type of system used, either return the responsibility or Communication to the Control Station or return the Data Link to the Neutral State (see Termination Phase, Section 3.3.2.3).



(1) The BCC in brackets is optional.

(2) EOT can abort the transfer at any point in the transfer phase.

(3) If numbering of Positive Ackonwledgement is used it must follow the rule in ECMA-37 (see section 2).

PHASE 3 DIAGRAM

Any number of characters may precede the final character of the reply sequence to convey information of a qualifying nature. The nature of this information is not a subject for this standard (see Supervisory Sequences Format, Section 3.2.3).

3.3.2.3 Termination (Phase 4)

There are essentially three situations when a station may elect to terminate the transmission in progress :

(a) When a station refuses the establishment of a Data Link, either because it has nothing to transmit (negative reply to Polling), or because it is unable to transmit (negative reply to Polling), or because it is unable to receive (negative reply to Selecting).

(b) When the Master Station has successfully transmitted all of the data it desires to send :

The Master Station then transmits the End of Transmission control character (EOT), indicating to the Slave Station that the Master Station has no more data to transmit. The Master Station thus relinquishes its right to transmit (unless it is also the Control Station).

(c) When an unusual situation arises where either the Master or the Slave Station desires to stop the transmission in progress :

If a Master Station sends EOT at any time other than after a terminated transmission, the transmission in progress is said to be aborted.

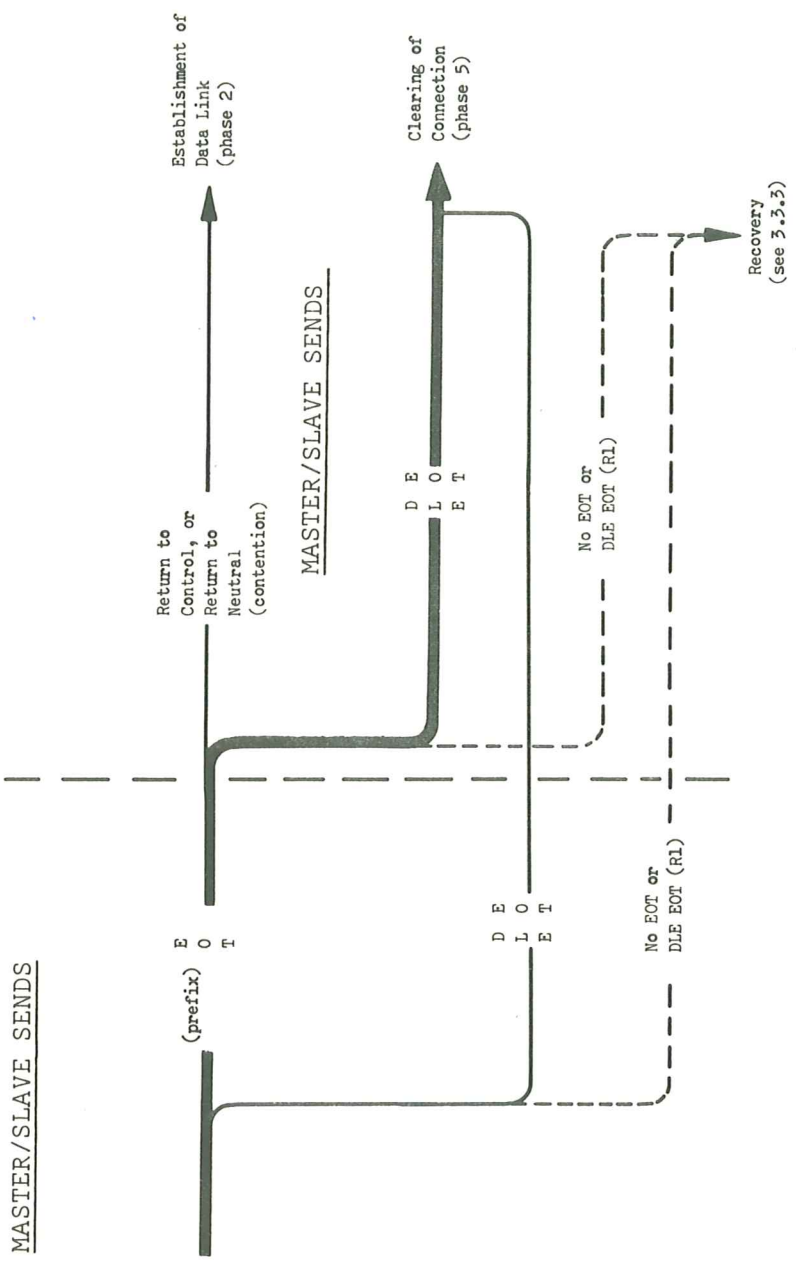
If a Slave Station sends EOT instead of a normal reply (ACK, NAK), the transmission in progress is said to be interrupted.

In all circumstances, such as (a), (b), (c), the sending of EOT by any of the stations is terminating the transmission, that is to say :

- in systems comprising a Control Station, returns the responsibility and the control of the Communication to that Control Station; this function is called Return to Control;

- in point-to-point systems, without Control Station, returns the Data Link to the Neutral State; this function is called Return to Neutral State.

In addition, in all cases of Termination, if the clearing of the Connection (private and/or General Network), is the intended consequence of the Termination, the Disconnect Supervisory Sequence (DLE.EOT) shall be sent either instead of EOT or as a reply to EOT.



PHASE 4 DIAGRAM

3.3.3 Recovery Procedures

It has been recognized that a number of recovery procedures are required to deal with various abnormal situations. The more usual recovery procedures are defined in the following and their linkage to the appropriate phase is outlined in the diagrams in Section 3.3.2.

In all cases, after appropriate time-out periods (subject to further study), it shall be the responsibility of either the Control Station or the Master Station (never of a Slave Station) to take action.

3.3.3.1. Recovery Procedures by Control Station

R1 - In the case of :

- No reply or invalid reply to a Polling Supervisory Sequence, or
- Invalid or absence of Termination Supervisory Sequence,

the Control Station must transmit EOT.

R2 - In the case of :

- Repeated unsuccessful Polling of one, several or all stations, the Control Station should set an alarm or report to the operator. Subsequent manual or automatic continuation is system dependent.

3.3.3.2. Recovery Procedures by Master Station

R3 - In the case of :

- No reply or invalid reply to an Information Message, or
- No reply or invalid reply to a selecting Supervisory Sequence,

the Master Station must repeat the previous transmission.

NOTE - Such method may lead to gaining Information Messages (or Blocks). To overcome this difficulty, a numbering scheme is required which is described in ECMA-37 (see section 2).

As an alternative, in the case of no reply or invalid reply to an Information Message, the Master Station sends a request to the Slave Station by using ENQ character (possibly prefixed) for the repetition of the previous reply.

NOTE - Such method may lead to loosing Information Messages (or Blocks). To overcome this difficulty, a numbering scheme is required. Such numbering scheme and the subsequent use of ENQ are described in ECMA-37 (see section 2).

R4 - In the case of :

- Repeated unsuccessful transmission of an Information Message, or
- Repeated unsuccessful transmission of a Selecting Supervisory Sequence, or
- Repeated negative replies (NAK) to an Information Message,

the Master Station should set an alarm or report to the operator and go to the Termination phase. Subsequent manual or automatic continuation is system dependent.

3.3.4. Table of Phases

The following table shows the various possible phases and sub-phases of a data communication.

Phases 1 and 5 which relate to the establishment and clearing of connections over the general switched network are under the responsibility of the CCITT and are therefore not covered by this standard.

In each phase, one of the stations directs the operation and is responsible for the continuity of the communication. The other station or stations only react to the actions of the responsible station.

The control characters which are shown alongside the various sub-phases are those which are involved in the Basic Mode of operation.

EOT is shown in parenthesis in Phases 2 and 3 because its use within the phases initiates a change-over to Phase 4.

PHASE		FUNCTION Action / Reaction	STATIONS NAME Responsible / Responsive	TRANSMISSION CONTROL CHARACTERS used in Basic Mode Forward / Backward	NOTES
1. Establishment of Connection over General Network	a. Switching b. Identification				CCITT Responsibility
2. Establishment of Data Link	a. Switching	Call / Answer	Calling / Called		Not covered at present
	b. Polling	Poll / Reply	Control / Tributary	(EOT), ENQ / (EOT)	
	c. Selecting or out of Neutral State	Select / Reply	Master / Slave	(EOT), ENQ / ACK, NAK, (EOT)	
3. Information Transfer		Transfer / Supervision	Master / Slave	SOH, STX ETB, ETX, (EOT) / ACK, NAK, (EOT)	
4. Termination	a. Return to Neutral State	Terminate / Interrupt	Master / Slave	EOT / EOT	
	b. Return to Control Station	Terminate / Interrupt	Master / Slave	EOT / EOT	
	c. Disconnect	Disconnect / Disconnect	Master / Slave	DLE EOT / DLE EOT	
5. Clearing of Connection					CCITT Responsibility

TABLE OF PHASES

4. CHARACTER STRUCTURE

4.1 Synchronous Character Structure

4.1.1 For synchronous data communication the character shall consist of eight bits comprising one 7-bit ECMA character plus one parity bit. Each bit shall occupy nominally equal time intervals.

4.1.2 The sense of the parity bit for synchronous communication shall be ODD over the eight bits, i.e. the number "1" or Marking bits per 8 bit character shall be ODD.

4.1.3. The eight data bits will be transmitted to and received from line serially, the least significant bit "b_1" leading. The parity bit will follow the most significant bit "b_7".

4.2 Asynchronous Character Structure

4.2.1 For asynchronous data communication the character shall consist of 10 signal elements, comprising one Start element of "0" or spacing polarity, seven elements defining an ECMA character, one parity element and one Stop bit of "1" or marking polarity. Each element shall occupy nominally equal time intervals.

4.2.2 The sense of the Parity shall be EVEN over the eight data elements, i.e. excluding the Start and Stop elements, the number of "1" or marking elements in the ECMA character plus the parity element shall be EVEN.

4.2.3 The 10 elements will be transmitted to and received from the line serially, beginning with the Start element followed by the least significant data bit "b_1". The parity element will follow the most significant data bit "b7" and will be followed by the Stop element.

4.2.4 The inter-character interval, i.e. the time interval between the end of a Stop element and the beginning of the next Start element may be of any duration and is of the same polarity as the Stop element. Receiving equipment must be capable of operating with zero inter-character interval.

4.2.5 Some configurations of communication facilities cannot operate satisfactorily with only one Stop element. Where this is the case two Stop elements will be necessary, by prior agreement.

5. ERROR PROTECTION

5.1 General

This method of detecting errors is applicable to transmission modes that are either asynchronous or synchronous. It is independent of message length (other than that determined by the frequency of errors) and is easily implemented in systems where end-to-end error control is of primary importance in order to achieve the most economical method of operation.

The procedure is based upon blocks of data with re-transmission of blocks received in error. The block size is based upon the formats required by the Data Source and Sink and/or the error control characteristics of the channel.

5.2 Character Parity Detection

Character parity (see Section 4) is checked. Odd parity is used for synchronous transmission, and even parity is used for asynchronous transmission.

5.3 Block Parity Detection

The following rules apply for adding the Block Checking Character (BCC) :

- The Block Check Character shall be composed of 7 bits plus a parity bit.
- Each of the first 7 bits of the Block Check Character shall be the modulo 2 binary sum of every element in the same bit 1 to bit 7 column of the successive characters of the transmitted block.
- The longitudinal parity of each column of the block, including the Block Check Character shall be even.
- The sense of the parity bit of the Block Check Character shall be the same as for the information characters (odd for synchronous transmission, even for asynchronous transmission).
- The summation to obtain the Block Check Character shall be started by the first appearance of either SOH (Start of Heading) or STX (Start of Text).
- The starting character shall not be included in the summation.

- If an STX character appears after the summation has been started by SOH, then the STX character shall be included in the summation as if it were a text character.

- With the exception of SYN (synchronous idle), all the characters which are transmitted after the start of the block check summation shall be included in the summation, including ETB (End of Transmitted Block) or ETX (End of Text) control character which signals that the next following character is the Block Check Character.

- No character, SYN or otherwise, shall be inserted between the ETB or ETX character and the Block Check Character.

APPENDIX A

ECMA 7-bit coded character set

b_7	0	0	0	0	1	1	1	1
b_6	0	0	1	1	0	0	1	1
b_5	0	1	0	1	0	1	0	1
b_4 b_3 b_2 b_1	0	1	2	3	4	5	6	7
0 0 0 0	0	NUL	TC_7 (DLE)	SP	0	③	P	` ④	p
0 0 0 1	1	TC_1 (SOH)	DC_1	!	1	A	Q	a	q
0 0 1 0	2	TC_2 (STX)	DC_2	" ⑥	2	B	R	b	r
0 0 1 1	3	TC_3 (ETX)	DC_3	£(#) ②	3	C	S	c	s
0 1 0 0	4	TC_4 (EOT)	DC_4	$(¤) ②	4	D	T	d	t
0 1 0 1	5	TC_5 (ENQ)	TC_8 (NAK)	%	5	E	U	e	u
0 1 1 0	6	TC_6 (ACK)	TC_9 (SYN)	&	6	F	V	f	v
0 1 1 1	7	BEL	TC_{10} (ETB)	' ⑥	7	G	W	g	w
1 0 0 0	8	FE_0 (BS)	CAN	(	8	H	X	h	x
1 0 0 1	9	FE_1 (HT)	EM	)	9	I	Y	i	y
1 0 1 0	10	FE_2 (LF)①	SUB	*	:	J	Z	j	z
1 0 1 1	11	FE_3 (VT)①	ESC	+	;	K	③	k	③
1 1 0 0	12	FE_4 (FF)①	IS_4 (FS)	, ⑥	<	L	③	l	③
1 1 0 1	13	FE_5 (CR)①	IS_3 (GS)	-	=	M	③	m	③
1 1 1 0	14	SO	IS_2 (RS)	.	>	N	^ ④⑥	n	- ④⑥
1 1 1 1	15	SI	IS_1 (US)	/	?	O	_	o	DEL

APPENDIX B

TERMINOLOGY

This set of definitions is not complete and will be extended as the need arises. Definitions marked * have been taken from the CCITT List of Definitions ("Yellow Book").

ADDRESS

A Sequence of characters to select or poll another station.

ASYNCHRONOUS TRANSMISSION *

A Transmission process such that between any two significant instants in the same group (block or character) there is always an integral number of unit intervals. Between two significant intervals located in different groups there is not always an integral number of unit intervals.

BACKWARD SUPERVISION

The use of supervisory sequences sent from the Slave to the Master Station.

BLOCK *

A group of bits, or digits, transmitted as a unit over which an encoding procedure is generally applied for error control purposes.

BLOCK CHECK *

A system of error control based on the check that some preset rules for the formation of blocks are observed.

BOTH-WAY

This is a mode of operation of two channels so that transmission may occur simultaneously. One of the channels is equipped for transmission in one direction while the other is equipped for transmission in the opposite direction.

CHANNEL *

A means of one way transmission. Several channels may share a common path as in carrier systems; in this case each channel is allotted a particular frequency band which is reserved to it.

CODED CHARACTER SET

A finite set of characters arranged in a specified order according to given rules and conventions.

CODE TRANSPARENT TRANSMISSION

A transmission process which is capable of handling any character set or binary arrangement.

CONNECTION

The established path between two or more terminal installations. It is a permanent connection when it is established without using switching facilities, and a temporary connection when it is established by using switched facilities. It may consist of one or more channels in tandem.

CONTENTION

A condition arising on a communication channel when two or more stations try to transmit at the same time.

CONTROL STATION

The station on a network which supervises the procedures such as polling, selecting and recovery. It is also responsible for establishing order on the line in the event of contention, or any other abnormal situation, arising between any stations on the network.

DATA COMMUNICATION SYSTEM

One or more data links each of which may be operating in the same or a different mode.

DATA LINK

This is an ensemble of Terminal Installations and the interconnecting network operating in a particular mode that permits information to be exchanged between Terminal Installations.

DATA TERMINAL EQUIPMENT *

Equipment comprising the data source, the data sink or both.

EITHER-WAY

This is a mode of operation of a channel to permit the transmission of signals in either direction. These transmissions cannot take place simultaneously.

ERROR

Any received character or sequence of characters that does not conform to those transmitted.

ERROR CONTROL OR ERROR PROTECTION

A procedure for detecting and reducing the effects of errors generated during the process of data transmission.

FILLER

A character that is used as a time or space fill when a block of specified size is required and there are insufficient Heading and/or Text characters for this purpose.

FORWARD SUPERVISION

Use of supervisory sequences sent from the Master to the Slave Station.

FRAMING CHARACTERS

The characters used to frame and subdivide both information messages and supervisory sequences for data transmission purposes.

FULL-DUPLEX (CIRCUIT)

Circuit permitting the simultaneous exchange of signals in both directions.

HALF-DUPLEX (CIRCUIT) *

A circuit designed for duplex operation, but which, on account of the nature of the terminal equipment, can be operated alternately only.

HEADING

A sequence of characters preceding the text of a message. It enables the receiving station to handle the text(s).

IDENTITY

A sequence of one or more characters transmitted by a station in order to identify itself.

INFORMATION BLOCK

A sequence of characters of fixed or variable length which is a subdivision of an information message formed for the purpose of meeting transmission requirements.

INFORMATION MESSAGE

A sequence of characters conveying the text. It may also convey supplementary information forming a Heading.

INVALID RECEPTION

A character or sequence of characters that has not been recognized in accordance with the expected character or sequence.

MASTER STATION

The station which, at a given instant, has the right to select

and to transmit an information message to a Slave Station and the responsibility of ensuring the information transfer. There should be only one Master Station on a data link at one time.

MULTI-POINT NETWORK

A configuration in which a connection is established between more than two Terminal Installations. The connection may include switching facilities.

NETWORK

This is the ensemble of equipment through which connections are made between Terminal Installations. These equipments operate in real time and do not introduce store and forward delays.

ONE-WAY

This is a mode of operation of a channel for one way transmission of signals in a preassigned direction.

PARITY BIT

A bit associated with a character or block for the purpose of checking the absence of error within that character or block. This is chosen to make the modulo 2 sum of the bits (including the parity bit) in the character or block a '0' or a '1' as required.

PARALLEL TRANSMISSION *

The simultaneous transmission of a certain number of signal elements constituting the same telegraph of data signal.

POINT-TO-POINT CONNECTION

A configuration in which a connection is established between two, and only two, Terminal Installations. The connection may include switching facilities.

POLLING

The process of inviting another station to become a Master Station.

QUALIFIER

A character, or sequence of characters, that add to the meaning of the transmission control character with which it is associated.

QUERY

The process by which a Master Station asks a Slave Station to identify itself and to give its status.

RECOVERY PROCEDURE

A process by which a responsible station within the network attempt to resolve either conflicting, or erroneous, conditions

arising in the communication process. The Control or Master Station is responsible for this procedure.

ROUTE

The selected path between Master Station and Slave Station for the purpose of information transfer.

SELECTION

The process of inviting a station to receive.

SERIAL TRANSMISSION *

Transmission, at successive intervals, of signal elements constituting the same telegraph or data signal. The sequential elements may be transmitted with or without interruption provided that they are not transmitted simultaneously.

SIGNAL-CONVERSION EQUIPMENT *

That part of the Terminal Installation belonging to the data channel, comprising at least one modulator or one demodulator and providing :

- modulation according to the signals to be transmitted
- and/or demodulation of the signals received.

Note: The signal-conversion is used for transmission of data, including information, service signals, repetition, etc; it may for example comprise clocks and signal regenerators but not error-control equipment.

SIMPLEX (CIRCUIT) *

Permitting the transmission of signals in either direction, but not simultaneously.

SLAVE STATION

A station which at a given instant is intended to receive an information message from a Master Station.

START ELEMENT (IN A START-STOP SYSTEM)

Binary element serving to prepare the Terminal Installation for the reception of a character.

START/STOP TRANSMISSION *

Asynchronous transmission in which a group of code elements corresponding to a character signal is preceded by a start signal which serves to prepare the receiving mechanism for the reception and registration of a character and is followed by a stop signal which serves to bring the receiving mechanism to rest in preparation for the reception of the next character.

STATION

See Terminal Installation.

STATUS

The capability at a given instant of a station to receive or transmit. It is indicated by a sequence of one or more characters which may be an acknowledgement of the previous data exchange.

STOP ELEMENT (IN A START-STOP SYSTEM)

Binary element serving to bring the Terminal Installation to rest.

SUPERVISORY SEQUENCE

A sequence of one or more characters used for transmission control, whose structure does not follow the formatting rules applied to the information message.

SWITCHING *

Operations involved in interconnecting circuits in order to establish a temporary communication between two or more stations.

SYNCHRONOUS TRANSMISSION *

A transmission process such that between any two significant instants there is always in integral number of unit intervals.

TERMINAL INSTALLATION (FOR DATA TRANSMISSION) OR STATION *

Installation comprising the :

data terminal equipment,
signal conversion equipment,
and any intermediate equipment.

Note : In some instances the data terminal equipment may be connected directly to a data processing machine or may be a part of it.

TEXT

A sequence of characters forming part of a transmission, which is transmitted as an entity to the ultimate destination and which contains the information to be conveyed.

TRANSMISSION CONTROL CHARACTERS (TCC)

Characters used either to define the nature of the information contained in a sequence of data characters or to convey supervisory instructions. They must not be transmitted as part of the text or heading.

TRIBUTARY STATION

All stations on a non-switched multipoint network other than the control station, are called Tributary Stations.