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МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ

Industrial asynchronous data link and physical layer —

Part 1: Physical interconnection and two-way alternate communication

Liaison de données industrielle, asynchrone et couche physique —
Partie 1: Liaison physique et transmission deux voies à l'alternat

Reference number
ISO 8867-1 : 1988 (E)

Contents

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 8867-1 was prepared by Technical Committee ISO/TC 184, *Industrial automation systems.*

ISO 8867 consists of the following parts, under the general title *Industrial asynchronous data link and physical layer*:

- *Part 1: Physical interconnection and two-way alternate communication*
- *Part 2: Two-way simultaneous communication*
- *Part 3: HDLC based asynchronous transmission*

Annexes A and B of this part of ISO 8867 are for information only.

Introduction

The ISO Reference model of Open Systems Interconnection (ISO 7498) gives a framework for the exchange of information among systems with a layered architecture. This concept is used in the specification of the connection between a host computer and NC machines or other equipment for workshop automation.

ISO 8867, which consists of the following three parts, provides three classes of point-to-point communications:

Part 1 — Physical interconnection and two-way alternate communication

Part 2 — Two-way simultaneous communication

Part 3 — HDLC based asynchronous transmission

Parts 1, 2 and 3 have the same physical layer.

Industrial asynchronous data link and physical layer —

Part 1: Physical interconnection and two-way alternate communication

1 Scope

This part of ISO 8867 describes physical interfaces and protocols to link computer controlled devices in an automated workshop, such as NC machines, industrial robots, programmable controllers, measuring equipment or other equipment for workshop automation, with a host computer via point-to-point connection. The communication protocol used ensures secure data transmission. Data is transmitted bit-serially and asynchronous. This part of ISO 8867 corresponds to functions as described in layer 1 (physical) and 2 (data link) of ISO 7498.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 8867. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 8867 are encouraged to investigate the possibility of applying the most recent editions of the standards listed below. Members of IEC and ISO maintain registers of currently valid International Standards.

2.1 International Standards

ISO 646 : 1983, *Information processing — ISO 7-bit coded character set for information interchange.*

ISO 1177 : 1981, *Information processing — Character structure for start/stop and synchronous character oriented transmission.*

ISO 1745 : 1975, *Information processing — Basic mode control procedures for data communication systems.*

ISO 2110 : 1980, *Data communication — 25-pin DTE/DCE interface connector and pin assignments.*

ISO 2111 : 1985, *Data communication — Basic mode control procedures — Code independent information transfer.*

ISO 2382/9 : 1984, *Data processing — Vocabulary — Part 09: Data communication.*

ISO 2628 : 1973, *Basic mode control procedures — Complements.*

ISO 4873 : 1986, *Information processing — ISO 8-bit code for information interchange — Structure and rules for implementation.*

ISO 4902 : 1980, *Data communication — 37-pin DTE/DCE interface connectors and pin assignments.*

ISO 4903 : 1980, *Data communication — 15-pin DTE/DCE interface connector and pin assignments.*

ISO 7498 : 1984, *Information processing systems — Open Systems Interconnection — Basic Reference Model.*

ISO 8481 : 1986, *Data Communication — DTE to DTE physical connection using X.24 interchange circuits with DTE provided timing.*

2.2 CCITT Recommendations

CCITT Recommendation V.11 : 1984, *Electrical characteristics for balanced double-current interchange circuits for general use with integrated circuit equipment in the field of data communications.*

CCITT Recommendation V.24 : 1984, *List of definitions for interchange circuits between data terminal equipment (DTE) and data circuit-terminating equipment (DCE).*

CCITT Recommendation V.28 : 1984, *Electrical characteristics for unbalanced double-current interchange of circuits.*

CCITT Recommendation X.20 : 1984, *Interface between data terminal equipment (DTE) and data circuit-terminating equipment (DCE) for start-stop transmission services on public data networks (PDN).*

CCITT Recommendation X.21 : 1984, *Interface between data terminal equipment (DTE) and data circuit-terminating equipment (DCE) for synchronous operation on public data networks.*

CCITT Recommendation X.24 : 1984, *List of definitions for interchange circuits between data terminal equipment (DTE) and data circuit-terminating equipment (DCE) on public data networks.*

3 Definitions and abbreviations of the transmission control characters

For the purposes of this part of ISO 8867, the definitions given in ISO 1745, ISO 2111 and ISO 2628 and the following definitions apply.

3.1 Data Link Escape (DLE): A transmission control character which forms a transmission control function with the subsequent eight-bit-character.

Only those characters listed in 6.1 can be used in the DLE sequences.

3.2 enquiry (DLE ENQ)[1]: A transmission control character sequence used as a request for a response from a remote station and also used to solicit a retransmission of the last reply (ACK N/DLE NAK).

3.3 block abort: The sending station may send DLE ENQ at an arbitrary point of data transmission.

Transmission will be terminated and deleted. The receiving station must reply with DLE NAK. A DLE sequence may not be interrupted.

3.4 end of transmission (DLE EOT)[1]: A transmission control character issued by the sending station to indicate the conclusion of the transmission or an abnormal termination.

3.5 abort: DLE EOT is used to abort a receiving station or a sending station.

When an abort occurs, both receiving stations and both sending stations are simultaneously aborted.

3.6 negative acknowledge (DLE NAK)[1]: A transmission control character sequence transmitted by a receiving station as a negative response to a sending station, when it is not ready to receive or when the transmitted data were incorrectly received.

3.7 end of text (DLE ETX)[1]: DLE ETX indicates the end of a text.

DLE ETX specifies that the subsequent characters from the block check sequence (BCS) are used for block verification. DLE ETX is always included in the block check.

3.8 start of text (DLE STX)[1]: The transmission control character sequence DLE STX appears immediately before the text.

DLE STX is not included in the block check. DLE STX places the data link in a condition to transmit message text.

3.9 ACK N — Alternating positive responses (ACK 0 and ACK 1) (DLE 0 and DLE 1)[1]: Transmission control sequences that are used as positive responses into the text transmission phase, beginning with DLE 1 and then alternating.

DLE 0 is used as the positive response in the initialization phase.

3.10 WACK — Wait after positive acknowledgement (DLE;)[2]: A transmission control sequence issued by a receiving station as an alternative affirmative response to a sending station and also as an indication that the receiving station is temporarily unable to receive data.

It is used in lieu of DLE 0 or DLE 1.

3.11 positive acknowledgement with interrupt (DLE <)[1]: A transmission control sequence issued by the receiving station as a positive acknowledgement with an interrupt in place of the normal positive acknowledgement DLE 0 or DLE 1.

The sending station replies with DLE EOT.

3.12 double DLE (DLE DLE)[1]: A transmission character sequence that indicates that a single DLE character is being transmitted as data.

4 Data signalling rate

The interface shall permit at least the data signalling rates 600/1 200/2 400/4 800/9 600 bit/s and preferably in addition 110/300/19 200 bit/s.

NOTE — 19 200 bit/s is not a CCITT recommended speed.

5 Physical layer (Layer 1)

5.1 Mechanical interface

Two alternative mechanical interfaces may be used: the 37-pole connector of ISO 4902 or the 15-pole connector of ISO 4903.

5.2 Electrical interface

The electrical interface according to CCITT Recommendation V.11 shall be used.

5.3 Interchange circuits

The interchange circuits depend on the mechanical interface used.

1) The two character control sequences DLE ENQ and DLE NAK conform to existing installed equipment, but are defined as single Transmission Control Characters in ISO 1745. DLE ETX and DLE STX are defined in ISO 2111. DLE 0 and DLE 1 are defined in an annex to ISO 1745. DLE < is defined in ISO 2628.

2) This Transmission Control Character is not defined in ISO 1745.

NOTE — For short distance links, the unbalanced interface according to CCITT Recommendation V.28 with the 25-pole connector (for contact allocation: see ISO 2110) could be used on mutual agreement. This is based on historical precedent and is not part of this part of ISO 8867.

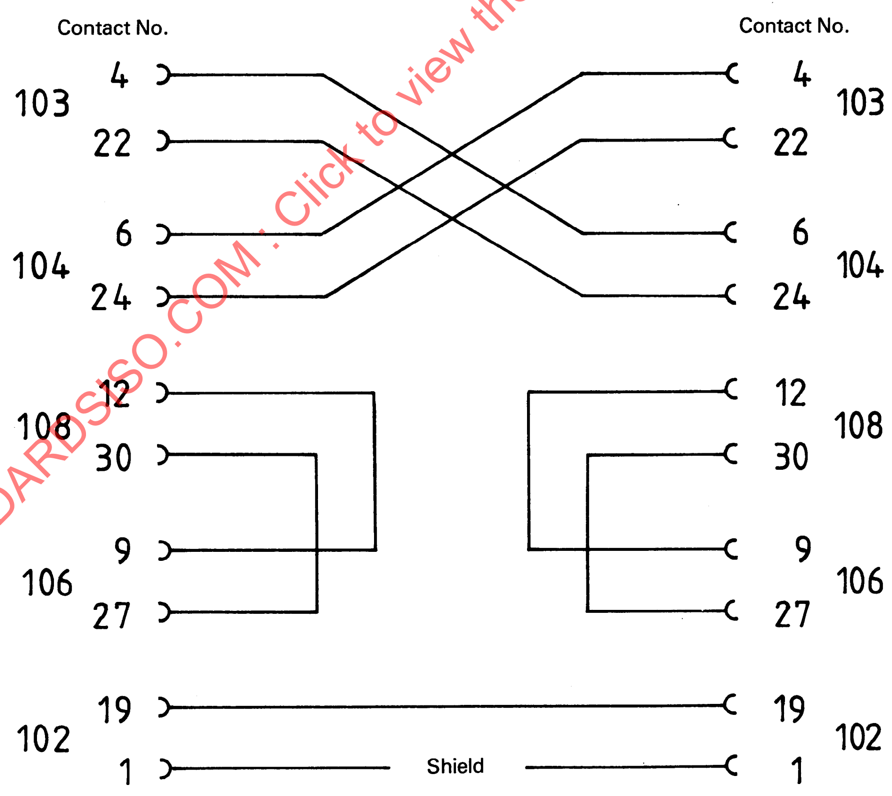
5.3.1 CCITT V.24/ISO 4902

Interchange circuits and contact assignments for a 37-pole connector are given in table 1 and shown in figure 1.

Table 1 — Use of V.24 type interchange circuits with a 37-pole connector conforming to ISO 4902 and local looping of control interchange circuits

Contact number	Interchange circuit assignment
1	Shield
19	102 Signal ground for common return
4	103 Transmitted data
22	103 Transmitted data
6	104 Received data
24	104 Received data
9	106 Ready for sending
27	106 Ready for sending
12	108 Data terminal ready
30	108 Data terminal ready

NOTE — This version cannot be used with interoperation of V. Type Modems.



NOTE — This arrangement uses a simplified version of the looping contact interchange circuits which are not covered in ISO/TR 7477.

Figure 1 — Contact arrangements

5.3.2 CCITT X.24/ISO 4903

Interchange circuits and contact assignments for a 15-pole connector for public data networks are given in table 2 and shown in figure 2.

Table 2 — Use of X.24 type interchange circuits with a 15-pole connector conforming to ISO 4903

Contact number	Interchange circuit assignment
1	Shield
8	G Signal ground or common return
2	T(A) Transmitted data
9	T(B) or Ga DTE common return
4	R(A) Received data
11	R(B) or Gb DCE common return

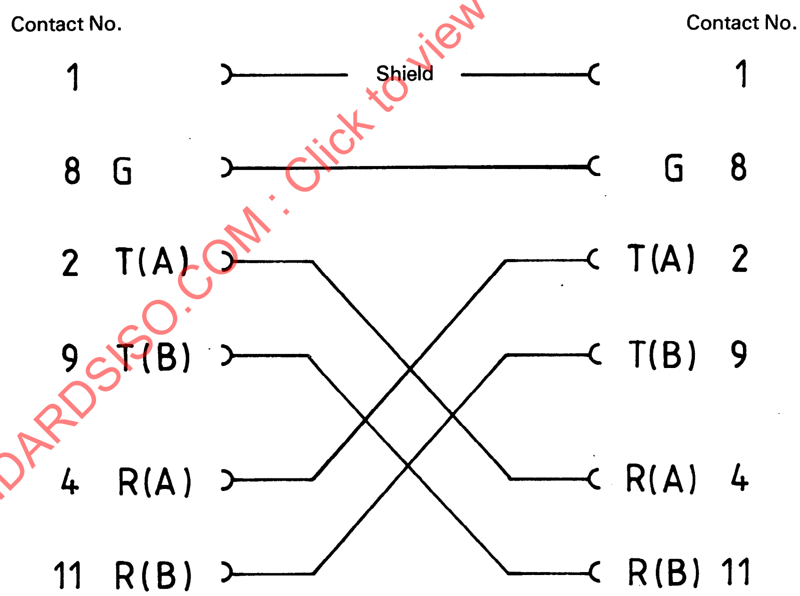
Key

Shield assigned for connecting the shields between the tandem section of the shielded interface cable.

G Signal ground or common return.

T Data supplied by the Data Terminal Equipment (DTE). This circuit shall be maintained in the binary state "1" in the idle condition.

R Data received by the Data Terminal Equipment (DTE).



NOTE — This arrangement conforms to ISO 8481 and provides for interoperation with CCITT Recommendations X.20 and X.21 interfaces on public data networks at speeds up to 9 600 bit/s.

Figure 2 — Contact arrangement

5.3.3 Interworking of CCITT V.24/ISO 4902 with CCITT X.24/ISO 4903

Interchange circuits and contact assignments for interworking of 37 poles and a 15-pole connector are shown in figure 3.

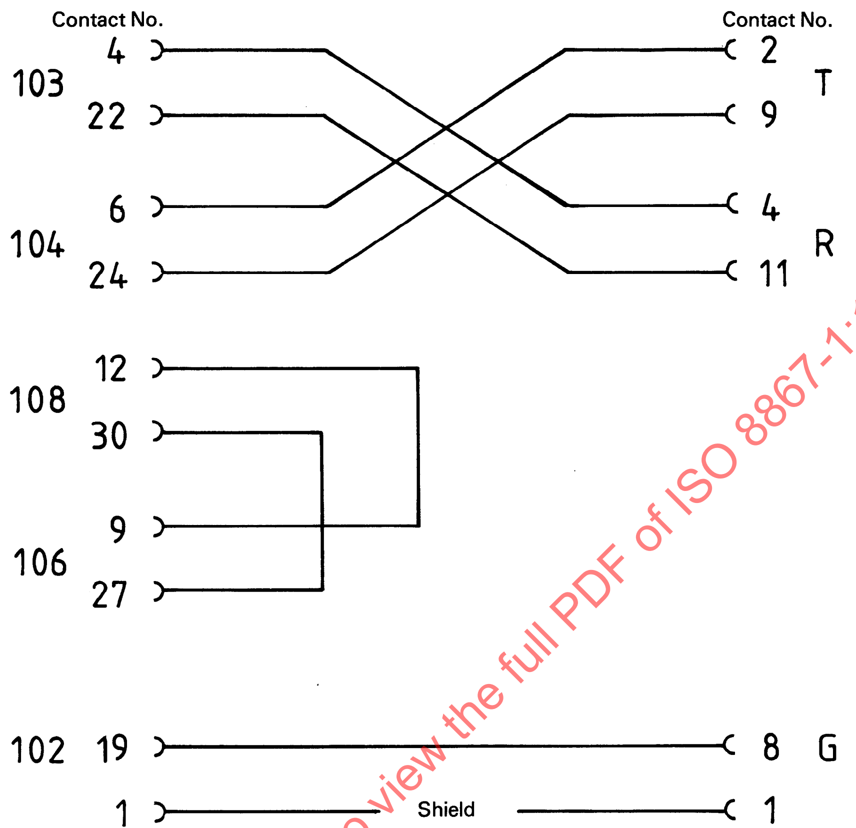


Figure 3 — Contact arrangements

5.4 Character format

The characters to be transmitted are arbitrary text-characters and defined transmission-control-characters (see figure 4).

The character format contains the following elements:

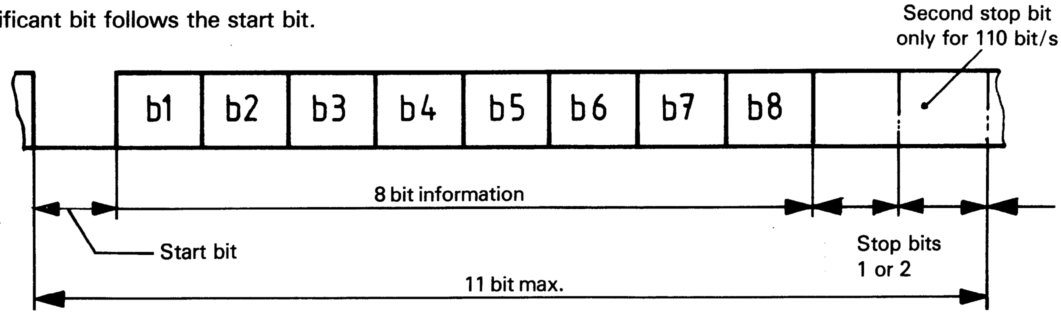
a) 1 start-bit

b) 8 information-bits

- text characters, comprising any eight-bit combination;
- transmission control characters (eight bits in accordance with ISO 1177);

c) 1 or 2 stop bits (2 stop bits only in the case of 110 bits/s).

The least significant bit follows the start bit.



NOTE — The second stop bit may be required when public network multiplexers are involved.

Figure 4 — Character format

6 Data link layer (Layer 2)

The communication protocol has been taken from ISO 1745, and ISO 2628 for code independent information transfer. Only blocks of text are used without a header. Error protection is in accordance with ISO 2111.

6.1 Transmission control and text characters

The text characters can be any octet.

A list of used transmission control characters (TCC) is given in table 3.

Table 3 — Transmission control characters

	Column/row representation	Hexidecimal representation*
DLE	1/0	X'90'
ENQ	0/5	X'05'
EOT	0/4	X'84'
ETX	0/3	X'03'
NAK	1/5	X'95'
STX	0/2	X'82'
;	3/11	X'BB'
1	3/1	X'B1'
0	3/0	X'30'
<	3/12	X'3C'

* From ISO 646 — International Reference Version (even parity is included)

6.2 Transparency

Transparency is achieved through application of ISO 2111.

6.3 Data link protocol

6.3.1 Message transfer

The protocol consists of three phases:

- Establishment of data link phase;
- Data transfer phase;
- Termination phase.

Table 4 — Message transfer

S	R	S	R	S
DLE ENQ	DLE 0	DLE STX Text DLE ETX BCS BCS (Block Check Sequence)	DLE 1	DLE EOT
Establishment of data link phase		Data transfer phase		Termination phase

S = Sending station
R = Receiving station

6.3.1.1 Establishment of data link phase

The two stations shall be in the idle state prior to the establishment of data link phase. Both stations are allowed to initiate transmission. See 6.3.4 for an example of initialization. If a station wishes to send, it shall request the opposite station (receiving station) to receive text by sending the transmission control character DLE ENQ.

If the receiving station accepts to enter the information transfer phase as slave, it shall send the control character sequence DLE 0. Upon reception of this control character sequence, the station which wishes to send can enter the information transfer phase as master.

The sequence of operations and the possible error conditions of the establishment of data link phase are shown in figure 2 of ISO 1745. The sending station shall repeat the request with the transmission control character DLE ENQ up to four times, if it receives no valid acknowledgement or if it does not receive an acknowledgement during the time out period T1 (see 6.3.2). For operation sequence and possible error conditions, see 6.3.3.2.

If the sending station receives the transmission control character DLE NAK, the receiving station is not able to receive any text. The sending station shall terminate with DLE EOT.

Priority: Due to simultaneous sending of a DLE ENQ from both stations, a collision occurs when the DLE ENQ comes in place of the expected DLE 0. In this case, the host computer shall always have the lowest priority.

The station with the higher priority shall ignore the received DLE ENQ and the other station shall retract its request and send DLE 0.

6.3.1.2 Data transfer phase

The sending station shall enter the data transfer phase by transmitting DLE STX. The receiving station shall enter the data transfer phase by receiving DLE STX.

The text has a maximum of 512 octets (arbitrary 8-bit combinations) without the transmission control characters. The block length is variable. The receiving station generally acknowledges a correctly received block beginning with DLE 1 and then alternating with DLE 0. If the sending station receives a valid acknowledgement signal, it can send the next block of text or enter the termination phase. If the receiving station wishes to terminate the transmission, it shall send the positive acknowledgement DLE< after correct reception of text. The sending station shall then enter the termination phase.

In the eventuality of the bit combinations of the character DLE appearing on the text to be transmitted, an additional DLE character shall be inserted to identify the character as text. One of the two consecutive DLE characters transmitted shall be excluded by the receiving station. The remaining DLE character forms part of the transmitted text.

If errors have been detected, the receiving station shall respond with DLE NAK and wait for a new text transmission.

6.3.1.3 Termination phase

A DLE EOT shall be used at any time to abort a receiving station or a sending station. When an abort occurs, both receiving stations and both sending stations are simultaneously aborted.

6.3.2 Timers

Time-out periods are used to avoid ambiguous states which can occur due to errors (incorrect transmission control character sequences). These times are used in order to start-up recovery procedures in the case of errors or to terminate the transmission. The time-out times shall be established following:

T0: Receiver Timer — The receiving station activates the time-out period (twice the block transmission time) when it receives DLE STX. If the character sequence DLE ETX is not received in this time, the receiving station sends no acknowledgement and waits for a reception.

T1: Response Timer — The sending station starts the time-out period T1 ($T1 < T2$) by transmitting DLE ENQ or BCS. If no valid response is received from the receiving station within this time, a maximum of four repetitions of the last transmission may be carried out.

T2: Idle Timer — The receiving station activates the time-out period T2 ($T1 < T2$) by sending an acknowledgement DLE 0, DLE 1, DLE < or DLE NAK. The receiving station reverts to the idle state, if no valid transmission (a block finished by BCS or DLE ENQ or DLE EOT) from the sending station is received within this time.

6.3.3 Error handling

6.3.3.1 Error detection

The cyclic redundancy checking method is used to generate the Block Check Sequence (BCS) in accordance with ISO 2111. The bits of a transmission character sequence correspond to the coefficients of a polynominal which is divided by the generator polynominal

$$X^{16} + X^{12} + X^{5} + 1$$

modulus 2.

The remaining 16 bits resulting from the division represent the Block Check Sequence.

The sequence of bits used as coefficients of the polynominal in the transmission character sequence begins immediately after the transmission control character sequence DLE STX.

The sequence of bits comprise the subsequent eight-bit combination and ends immediately after the control character sequence DLE ETX.

The DLE characters inserted for identification purposes are excluded from the cyclic redundancy check.

The sending station forms the block check sequence (BCS) in accordance with the above-mentioned rule and sends this sequence immediately after DLE ETX, whereby the most significant bit of the block check sequence is transmitted first.

Transmission errors using the above rule are detected by the receiving station when a remainder results from the modulus 2 division of the specified sequence of bits in the generator polynominal.

Error detection is performed in accordance with ISO 2111.

6.3.3.2 Error recovery

The control character DLE ENQ shall be repeated a maximum of four times, which makes a total of five times, by the sending station in the establishment of a data link phase. This station shall send DLE EOT and revert to idle state if no valid acknowledgement is received after the fourth repetition.

If a DLE NAK is received, a maximum of four repetitions are also possible in the data transfer phase.

If no valid acknowledgement is received on a transmitted block, the sending station shall send DLE ENQ as a request for acknowledgement. If no valid acknowledgement is received after five attempts, the sending station shall send DLE EOT and revert to idle state. When the receiving station receives DLE ENQ, it shall retransmit the last acknowledgement.

6.3.4 Initialization example

Sending station — Receiving station

Normal transmission

(DLE EOT) — — — — — — ▶ (abort message)

. . . . (data link is aborted) . . . . **

*(DLE EOT) — — — — — — ▶ (reset data link)

*(DLE ENQ) — — — — — — ▶ (establish data link)

*◀ — — — — — — — — — — (DLE 0)

. . . .

Data link established
Normal transmission begins

* During this time interval, the sending station shall ignore all messages except DLE 0 and DLE ENQ.

Moreover, the sending station may receive DLE EOT; if this situation should occur, the sending station shall ignore the DLE EOT.

** During this time interval, all transmission ceases.

Annex A
(Informative)

Timer values

This part of ISO 8867 does not define timer values; however, the following recommended equation can be used to calculate the value of the Receive Timer T0. The following equation generates a timer value which is a function of message length and data signalling rate.

Receive Timer T0 in milliseconds = N* NCD* BPC* 1 000/BR

where

NCD is the number of character time delays (518 for this part of ISO 8867);

BPC is the number of bits per character;

BP is the data signalling rate;

N is the system delay factor (N = 3 as a minimum. The system delay factor is the time the SYSTEM requires to respond to a transmission. This value is system and implementation dependent).

The worst case would be a text which would consist only of the codes equal to DLE, with insertion of DLE characters for transparency, the time to send the text would be higher than the transmission of the number of octets in the text. Together with the time to transmit the other control characters, a minimum system delay factor of 3 is recommended.

For example:

if,

BR = 9 600 bit/s

NCD = 518

BPC = 10

N = 3

then,

Receive Timer T0 = 3* 518* 10* 1 000/9 600 = 1 619 milliseconds

Similarly:

other timer in milliseconds = N* NCD* BPC* 1 000/BR

Annex B
(informative)

Flow charts

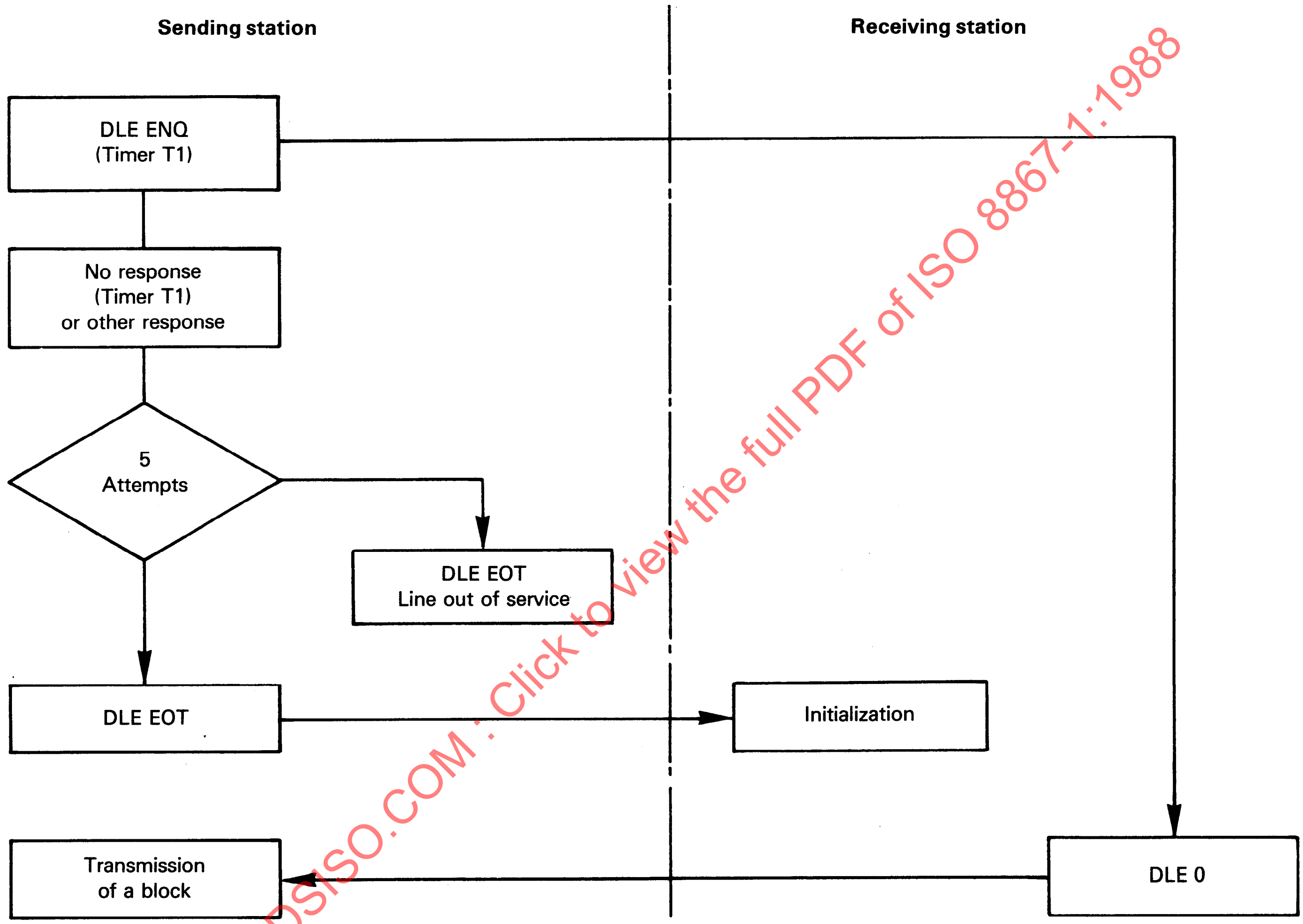


Figure 5 — Establishment of data link phase (Initialization)

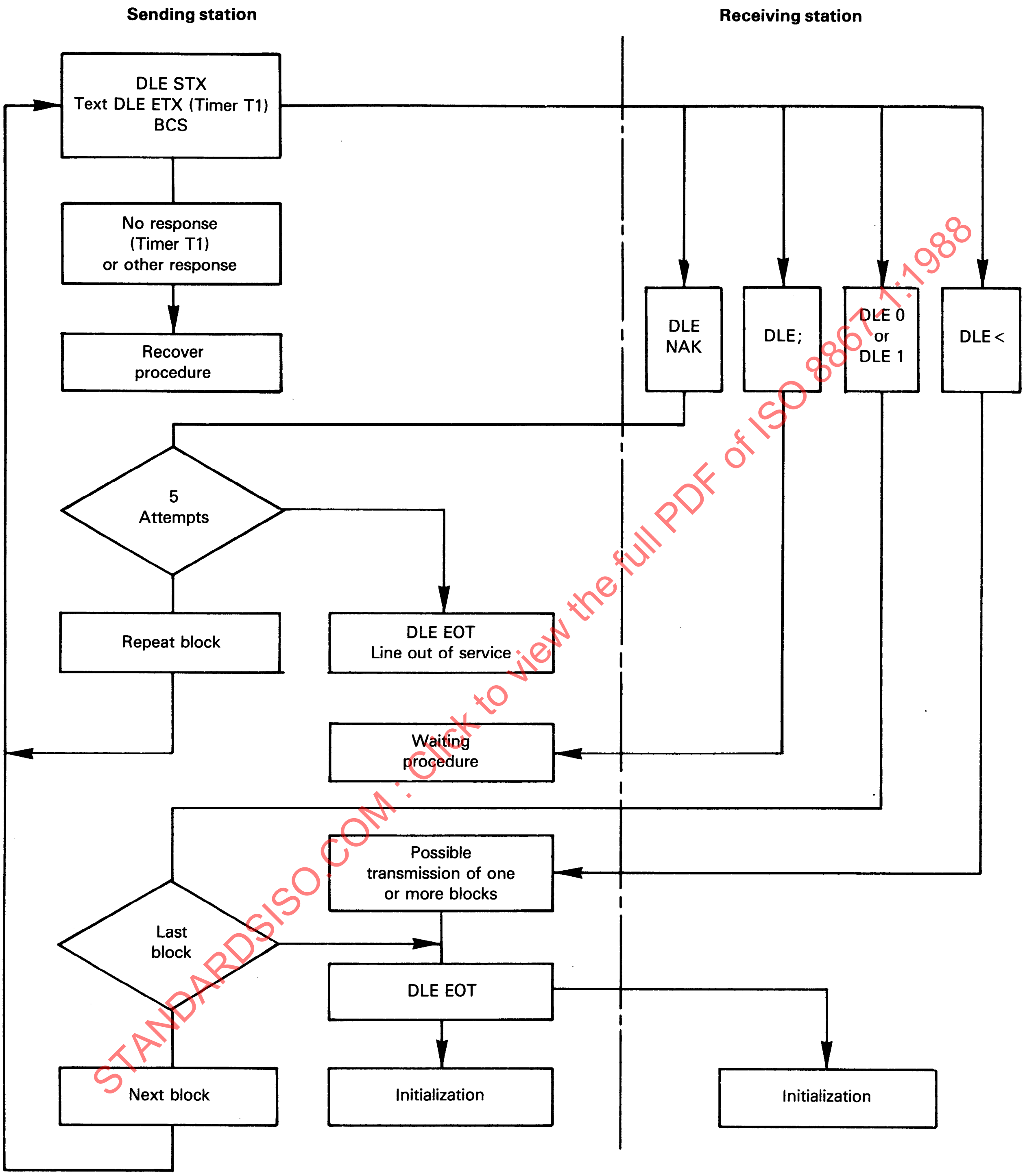


Figure 6 — Data transfer phase

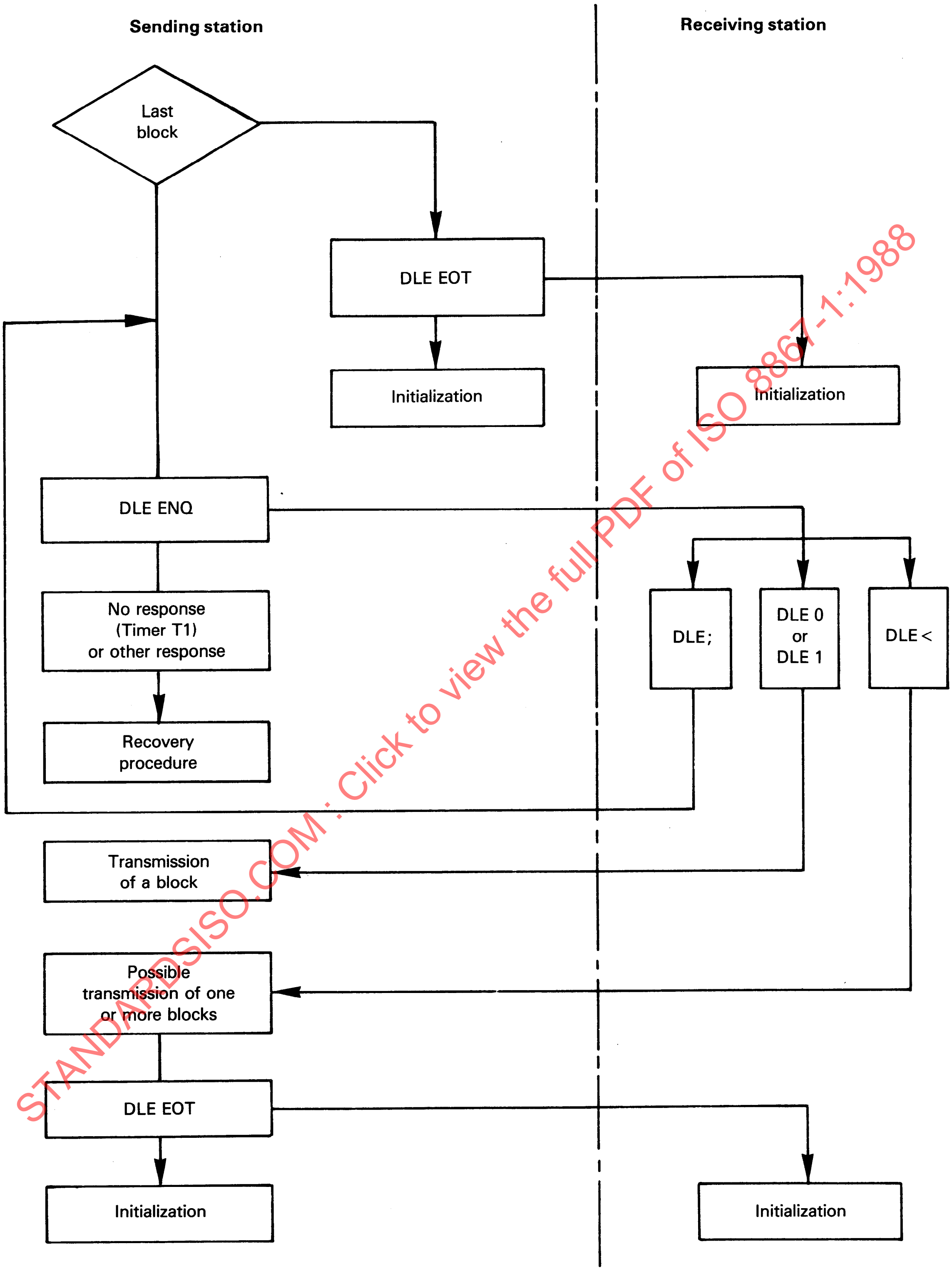


Figure 7 — Waiting procedure

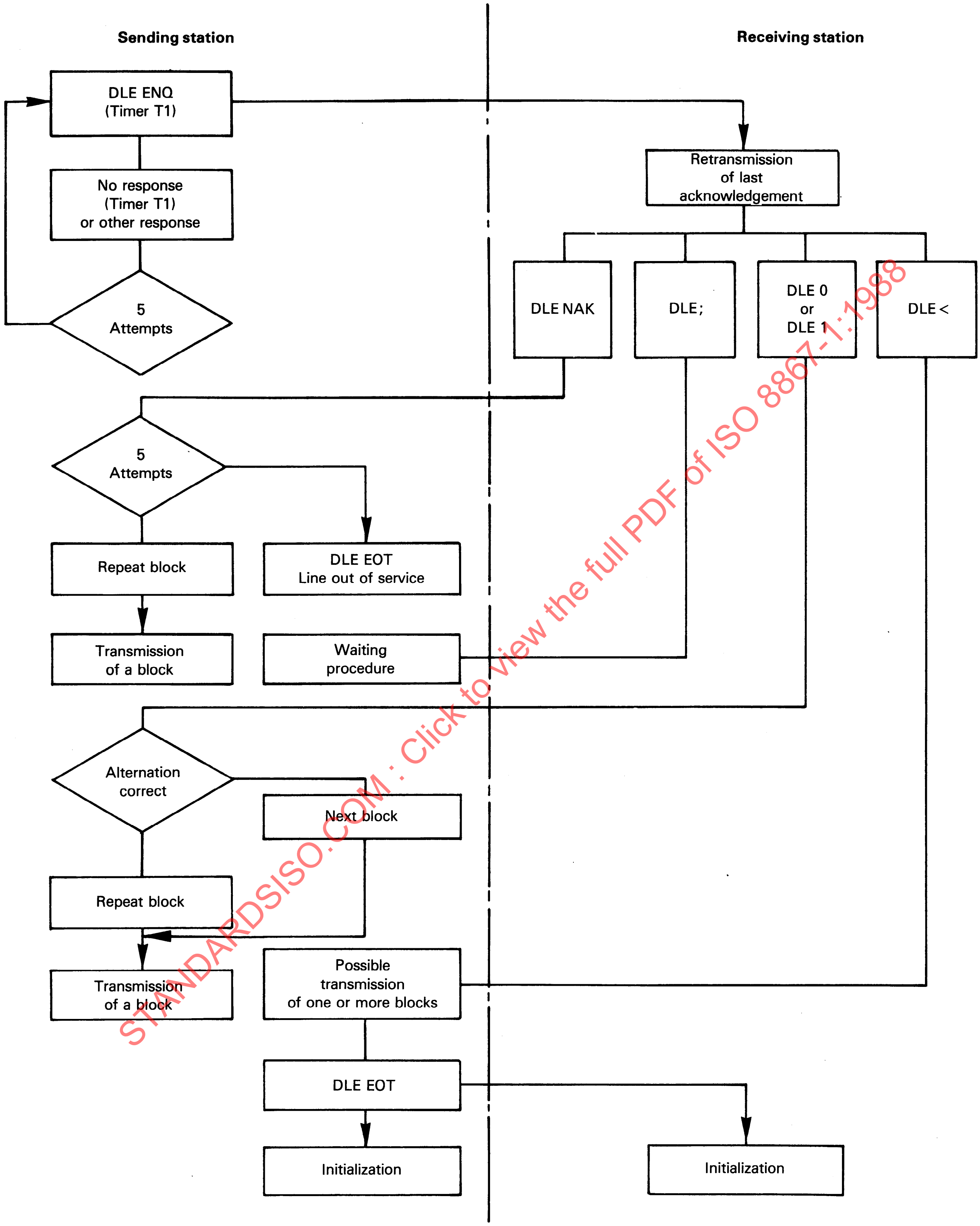


Figure 8 — Recovery procedure for transmission of a block