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ISDN USER-NETWORK INTERFACES

PRIMARY RATE USER-NETWORK INTERFACE – LAYER 1 SPECIFICATION

ITU-T Recommendation I.431

(Previously “CCITT Recommendation”)

FOREWORD

The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of the International Telecommunication Union. The 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 Conference (WTSC), which meets every four years, established the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

ITU-T Recommendation I.431 was revised by the ITU-T Study Group XVIII (1988-1993) and was approved by the WTSC (Helsinki, March 1-12, 1993).

NOTES

1 As a consequence of a reform process within the International Telecommunication Union (ITU), the CCITT ceased to exist as of 28 February 1993. In its place, the ITU Telecommunication Standardization Sector (ITU-T) was created as of 1 March 1993. Similarly, in this reform process, the CCIR and the IFRB have been replaced by the Radiocommunication Sector.

In order not to delay publication of this Recommendation, no change has been made in the text to references containing the acronyms "CCITT, CCIR or IFRB" or their associated entities such as Plenary Assembly, Secretariat, etc. Future editions of this Recommendation will contain the proper terminology related to the new ITU structure.

2 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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Recommendation I.431

PRIMARY RATE USER-NETWORK INTERFACE – LAYER 1 SPECIFICATION

(Malaga-Torremolinos, 1984; amended at Melbourne, 1988, and at Helsinki, 1993)

1 Introduction

This Recommendation is concerned with the layer 1 electrical, format and channel usage characteristics of the primary rate user-network interface at the S and T reference points. In this Recommendation, the term "NT" is used to indicate network terminating layer 1 aspects of NT1 and NT2 functional groups, and the term "TE" is used to indicate terminal terminating layer 1 aspects of TE1, TA and NT2 functional groups, unless otherwise indicated. The terminology used in this Recommendation is contained in Recommendation I.112. Interfaces for the 1544 kbit/s primary rate and for the 2048 kbit/s primary rate are described. It has been an objective that differences between the interface specifications for the two rates be kept to a minimum.

1.1 Scope and field of application

This specification is applicable to user-network interfaces at 1544 kbit/s and 2048 kbit/s primary rates for ISDN channel arrangements as defined in Recommendation I.412.

2 Type of configuration

The type of configuration applies only to the layer 1 characteristics of the interface and does not imply any constraints on modes of operation at higher layers.

2.1 Point-to-point

The primary rate access will support only the point-to-point configuration.

Point-to-point configuration at layer 1 implies that for each direction, only one source (transmitter) and one sink (receiver) are connected to the interface. The maximum reach of the interface in the point-to-point configuration is limited by the specification for the electrical characteristics of transmitted and received pulses and the type of interconnecting cable. Some of these characteristics are defined in Recommendation G.703.

2.2 Location of interfaces

The electrical characteristics for both the 1544 kbit/s case (4.1) and the 2048 kbit/s case (5.1) apply at the interfaces I_a and I_b defined in Figure 1.

Examples of functional groups corresponding to TE and NT as used here are given in 4.3/I.411.

3 Functional characteristics

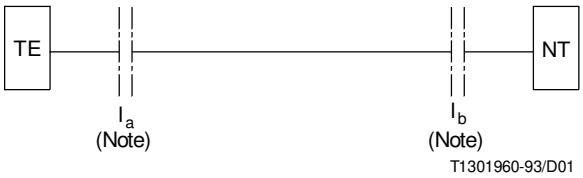
3.1 Summary of functions (layer 1) (see Figure 2)

B-channel

This function provides for the bidirectional transmission of independent B-channel signals each having a bit rate of 64 kbit/s as defined in Recommendation I.412.

H_0-channel

This function provides for the bidirectional transmission of independent H_0-channel signals each having a bit rate of 384 kbit/s as defined in Recommendation I.412.



NOTE – I_a and I_b are located at the input/output port of the TE or NT.

FIGURE 1/I.431

Location of interfaces

TE		NT
B, H_0 or H_1 channels	←– – – – – →	B, H_0 or H_1 channels
1 D-channel 64 kbit/s	←– – – – – →	1 D-channel 64 kbit/s
Bit timing	←– – – – – →	Bit timing
Octet timing	←– – – – – →	Octet timing
Frame alignment	←– – – – – →	Frame alignment
Power feeding (see Note)	– – – – – →	Power feeding (see Note)
Maintenance	←– – – – – →	Maintenance
CRC procedure	←– – – – – →	CRC procedure

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CRC Cyclic redundancy check

NOTE – This power-feeding function is optional and, if implemented, uses a separate pair of wires in the interface cable.

FIGURE 2/I.431

Functional characteristics

H_1-channels

This function provides for the bidirectional transmission of an H_1-channel signal having a bit rate of 1536 (H_{11}) or 1920 (H_{12}) kbit/s as defined in Recommendation I.412.

D-channel

This function provides for the bidirectional transmission of one D-channel signal at a bit rate of 64 kbit/s as defined in Recommendation I.412.

Bit timing

This function provides bit (signal element) timing to enable the TE or NT to recover information from the aggregate bit stream.

Octet timing

This function provides 8 kHz timing towards TE or NT for the purpose of supporting an octet structure for voice coders and for other timing purposes as required.

Frame alignment

This function provides information to enable the TE or NT to recover the time-division multiplexed channels.

Power feeding

This function provides for the capability to transfer power across the interface towards the NT1.

Maintenance

This function provides information concerning operational or failure conditions of the interface. The network reference configuration for maintenance activities on primary rate subscriber access is given in Recommendation I.604.

CRC (cyclic redundancy check) procedure

This function provides for protection against false framing and may provide for error performance monitoring of the interface.

3.2 Interchange circuits

Two interchange circuits, one for each direction, are used for the transmission of digital signals. All the functions listed above, with the exception of power feeding and possibly maintenance, are combined into two composite digital signals, one for each direction of transmission.

If power feeding via the interface is provided, an additional interchange circuit is used for power feeding.

The two wires of the pairs carrying the digital signal may be reversed if symmetrical wiring is provided.

3.3 Activation/deactivation

The interfaces for the primary rate user-network interface will be active at all times. No activation/deactivation procedures will be applied at the interface. However, to indicate the layer 1 transport capability to layer 2, the same primitive set is used as defined in Recommendation I.430. This provides for a unique application of the layer 1/layer 2 interface. The primitives PH-AR, MPH-DR, MPH-DI, and MPH-II, are not required for this application and, therefore, they are not used in this Recommendation.

3.4 Operational functions

In this subclause the term network is used to indicate either:

- NT1, LT and ET functional groups in case of an interface at the T reference point; or
- relevant parts of the NT2 functional group in case of an interface at the S reference point.

The term TE (or “user side”) is used to indicate terminal terminating layer 1 aspects of TE1, TA, and NT2 functional groups.

3.4.1 Definition of signals and signal detection at the interface

Signals exchanged between the network and user sides under normal and fault conditions are listed in Table 1. Further information on these signals is given in 4.7.3 and 5.9.1.

TABLE 1/I.431

Signals between the network and user sides under normal and fault conditions

Name	List of the signals
Normal operational frame	Operational frame with: – Active associated CRC bits – CRC error information (see Recommendation G.704 for 2048 kbit/s systems, Note 1 for 1544 kbit/s systems) – No defect indication
RAI	Operational frame with: – Active associated CRC bits – CRC error information (Note 2) – Remote alarm indication (see Table 4a/G.704 for 2048 kbit/s systems) and (16-bit sequence of eight binary ONEs and eight binary ZEROs (1111111100000000) in the m-bits for 1544 kbit/s systems
LOS	No received incoming signal (Loss of signal)
AIS	Continuous stream of binary ONEs (Recommendation M.20)
CRC error information	– E bit according to Table 4b/G.704, set to binary ZERO if CRC block is received with error (2048 kbit/s systems only) – Appropriate Gn bit (n = 1 to 6) in the performance report message (see Figure 7) set to binary ONE if one or more CRC block are received with error during the performance report period (1544 kbit/s systems).

AIS Alarm indication signal

CRC Cyclic redundancy check

LOS Loss of signal

RAI Remote alarm indication

NOTES

1 In 1544 kbit/s systems, performance report messages are conveyed by the m-bits. However, the use of the m-bits for option 2 of Recommendation I.604 is optional. (see 4.7.4.2)

2 For 1544 kbit/s systems RAI and CRC-derived error performance information cannot be sent simultaneously. (Solution for option 2 according to Recommendation I.604 is given in 3.4.1.2, RAI and continuous CRC error information.)

3.4.1.1 Definition of signals at the interface

remote alarm indication (RAI): The RAI (remote alarm indication) signal indicates loss of layer 1 capability at the user-network interface. RAI propagates towards the network if layer 1 capability is lost in the direction of the user, and RAI propagates toward the user if layer 1 capability is lost in the direction of the network.

For 1544 kbit/s systems, RAI is coded as continuously repeated 16-bit sequence of eight binary ONEs and eight binary ZEROs (1111111100000000) in the m-bits.

NOTE – HDLC flag patterns (01111110) are transmitted in the m-bits when no signal is to be sent.

For 2048 kbit/s systems, RAI is coded in bit A, i.e. bit 3 of time slot 0 of the operational frame which does not contain the frame alignment signal (see Table 4b/G.704):

RAI present: A-bit set to binary ONE

RAI not present: A-bit set to binary ZERO.

alarm indication signal (AIS): The AIS (alarm indication signal) is used to indicate loss of layer 1 capability in the ET-to-TE direction on the network side of the user-network interface. A characteristic of AIS is that its presence indicates that the timing provided to the TE may not be the network clock. AIS is non-framed and coded as all binary ONEs.

cyclic redundancy check error report (CRC): Performance report message (see Figure 7) in the m-bits for 1544 kbit/s systems, and E bit (see Table 4b/G.704) in operational frame for 2048 kbit/s systems are used.

3.4.1.2 Signal detection algorithm

Normal operational frame

The detection algorithm shall be in accordance with 2.1.2/G.706 for 1544 kbit/s systems and 4.1.2 and 4.2/G.706 for 2048 kbit/s systems.

Loss of frame alignment

The detection algorithm shall be in accordance with 2.1.1/G.706 for 1544 kbit/s systems and 4.1.1/G.706 for 2048 kbit/s systems.

Remote alarm indication (RAI)

RAI is detected when both conditions occur:

for 1544 kbit/s systems,

- frame alignment condition;
- reception of repeated 16-bit sequences of eight binary ONEs and eight binary ZEROs (1111111100000000) in the m-bits;

for 2048 kbit/s systems,

- frame alignment condition;
- reception of one bit A containing a binary ONE.

Loss of signal (LOS)

The equipment shall assume “loss of signal” when the incoming signal amplitude is, for a time duration of at least 1 ms, more than X dB below the nominal amplitude. The equipment shall react within 12 ms by issuing AIS.

The value of X is 30 for 1544 kbit/s systems, and 20 for 2048 kbit/s systems.

Alarm indication signal (AIS)

AIS is detected in 2048 kbit/s systems when both conditions occur:

- loss of frame alignment condition;
- reception of 512 bit periods containing less than three binary ZEROs.

An AIS defect is detected in 1544 kbit/s systems at the occurrence of an unframed signal with a ONEs density of at least 99.9% present for a time T, where 3 ms ≤ T ≤ 75 ms. An AIS defect is terminated in 1544 kbit/s systems within a time period T after the detection of a signal not meeting the ONEs density or the unframed signal criteria, where 3 ms ≤ T ≤ 75 ms.

CRC error information

CRC error information is conveyed in the performance report message in the m-bits for 1544 kbit/s systems, and by reception of one E bit set to binary ZERO for 2048 kbit/s systems. CRC procedures should be in accordance with Recommendations G.704 and G.706.

RAI and continuous CRC error information

This event is identified when A bit set to binary ONE and E bit set to binary ZERO are continuously received within a persistence check time period of at least 10 ms but no longer than 450 ms for 2048 kbit/s systems. RAI and CRC-derived error performance information cannot be sent simultaneously for network options 1 and 4 (see Recommendation I.604) of 1544 kbit/s systems. In only option 2, this event can be identified when the appropriate performance report messages including G6 bit set to binary ONE and SE bit set to binary ONE (see Figure 7) are received for a maximum of 100 ms per interruption while receiving RAI.

No signal

It is to be understood that the term "No signal" characterizes a range of transmitted signal which does not necessarily have a zero pulse amplitude but may be interpreted by a receiver as "Loss of signal".

Loss of power or return of power

These are equipment internal events and do not require further definition of the detection mechanism.

3.4.2 Definitions of state tables at network and user sides

The user side and network side of the interface have to inform each other of the layer 1 states in relation to the different defects that could be detected.

For the purpose, two state tables are defined, one at the user side and one at the network side. States at the user side (F states) are defined in 3.4.3 and states at the network side (G states) are defined in 3.4.4. The state tables are defined in 3.4.6.

Fault conditions FC1 to FC4 that could occur at the network side or between the network side and user side are defined in Figure 3. These fault conditions directly affect the F and G states. Information on these fault conditions is exchanged between the user and network sides in the form of signals defined in Table 1.

NOTES

1 Only stable states needed for operation and maintenance of the user and the network side of the interface (system reactions, user and network relevant information) are defined. The transient states relative to the detection of the CRC error information are not taken into account.

2 The user does not need to know where a failure is located in the network. The user must be informed on the availability and the continuity of the layer 1 service.

3 The user has all information relative to the CRC associated with each direction of its adjacent CRC section. The supervision of the quality of this section is the user's responsibility.

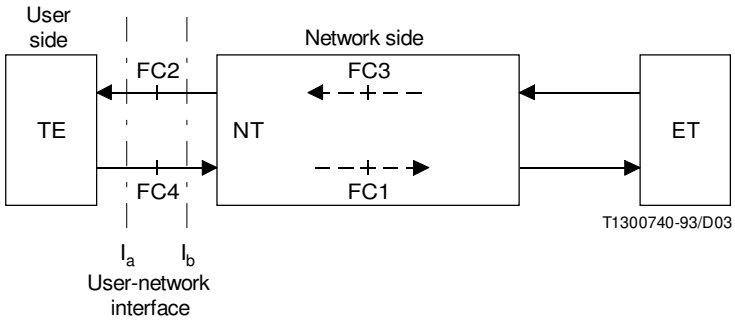


FIGURE 3/I.431

Location of fault conditions (FC) relative to interface

3.4.3 Layer 1 states on the user side of the interface

F0 state: Loss of power on the user side

– In general, the TE can neither transmit nor receive signals.

F1 state: Operational state

– Network timing and layer 1 service is available.

– The user side transmits and receives operational frames with associated CRC bits and with temporary CRC error information (Note 1).

– The user side checks the received frames and the associated CRC bits, and transmits to the network side operational frames containing the CRC error information, if a CRC error is detected.

F2 state: Fault condition No. 1

– This fault state corresponds to the fault condition FC1.

– Network timing is available at the user side.

– The user side receives operational frames with associated CRC bits and with temporary CRC error information (Note 1).

– The received frames contain RAI.

– The user side transmits operational frames with associated CRC bits.

– The user side checks the received frames and the associated CRC bits and transmits to the network side operational frames containing the CRC error information, if a CRC error is detected.

F3 state: Fault condition No. 2

– This fault state corresponds to the fault condition FC2.

– Network timing is not available at the user side.

– The user side detects loss of incoming signal (this will involve loss of frame alignment).

– The user side transmits operational frames with associated CRC bits and RAI (Note 2).

F4 state: Fault condition No. 3

– This fault state corresponds to fault condition FC3.

– Network timing is not available at the user side.

– The user side detects AIS.

– The user side transmits to the network side operational frames with associated CRC bits and RAI (Note 2).

F5 state: Fault condition No. 4

– This fault state corresponds to the fault condition FC4.

– Network timing is available at the user side.

– The user side receives operational frames with continuous CRC error information (optional) (Note 3).

– The received frames contain RAI.

– The user side transmits operational frames with associated CRC bits.

– The user side checks the received frames and the associated CRC bits. It may transmit to the network side operational frames containing the CRC error information, if a CRC error is detected.

F6 state: Power on state

– This is a transient state and the user side may change the state after detection of the signal received.

NOTES

1 The interpretation of the CRC error information depends on the option used in the network (see 5.9.2 and Recommendation I.604).

2 In 1544 kbit/s systems, RAI and CRC-derived error performance information cannot be sent simultaneously. Failure conditions may be sectionalized across the interface by obtaining additional information by means that are for further study. (Solution for option 2 is given in 3.4.1, RAI and continuous CRC error information.)

3 Only in options 2 and 3 of Annex A/I.604. The condition of "continuous CRC error information" corresponds to loss of incoming signal or loss of frame alignment on the network side.

3.4.4 Layer 1 states at the network side of the interface

G0 state: Loss of power in the NT1

– In general, the NT1 can neither transmit nor receive any signal.

G1 state: Operational state

– The network timing and layer 1 service is available.

– The network side transmits and receives operational frames with associated CRC bits and temporary CRC error information.

– The network side checks the received frames and the associated CRC bits and transmits to the user side the CRC error information if a CRC error is detected.

G2 state: Fault condition No. 1

– This fault state corresponds to the fault condition FC1.

– Network timing is provided to the user side.

– The network side receives operational frames with associated CRC bits.

– The network side transmits to the user side operational frames with associated CRC bits and RAI. The operational frames may contain CRC error information (Note 1).

G3 state: Fault condition No. 2

– This fault state corresponds to the fault condition FC2.

– Network timing is not provided to the user side.

– The network side transmits to the user side operational frames with associated CRC bits.

– The network side receives operational frames with associated CRC bits and RAI (Note 2).

G4 state: Fault condition No. 3

– This fault state corresponds to the fault condition FC3.

– Network timing is not provided to the user side.

– The network side transmits AIS.

– The network side receives operational frames with associated CRC bits and RAI (Note 2).

G5 state: Fault condition No. 4

– This fault states corresponds to the fault condition FC4.

– Network timing is provided to the user side.

– The network side detects loss of incoming signal or loss of frame alignment.

– The network side transmits to the user side operational frames with associated CRC bits and RAI and continuous CRC error information (Notes 2 and 3).

G6 state: Power on state

– This is a transient state and the network side may change the state after detection of the signal received.

NOTES

1 The interpretation of the CRC error information depends on the option used in the network (see 5.9.2 and Recommendation I.604).

2 In 1544 kbit/s systems, RAI and CRC-derived error performance information cannot be sent simultaneously. Failure conditions may be sectionalized across the interface by obtaining additional information by means that are for further study. (Solution for option 2 is given in 3.4.1, RAI and continuous CRC error information.)

3 Only in options 2 and 3 of Annex A/I.604.

3.4.5 Definition of primitives

The following primitives should be used between layers 1 and 2 (primitives PH) or between layer 1 and the management entity (primitives MPH).

PH-AI PH ACTIVATE INDICATION

PH-DI PH DEACTIVATE INDICATION

MPH-AI MPH ACTIVATE INDICATION (is used as error recovery and initialization information)

MPH-EIn MPH ERROR INDICATION with parameter "n"

n Parameter which defines the failure condition relevant to the reported error.

3.4.6 State tables

Operational functions are defined in Table 2 for the layer 1 states at the user side of the interface and in Table 3 for the network side. The exact reaction in case of double faults may depend on the type of double fault condition and the sequence in which they occur.

4 Interface at 1544 kbit/s

4.1 Electrical characteristics

4.1.1 Bit rate and synchronization

4.1.1.1 Network connection characteristics

The network shall (except as noted below) deliver a signal synchronized from a clock having a minimum accuracy of 1×10^{-11} (Stratum 1). When synchronization by a Stratum 1 clock has been interrupted, the signal delivered by the network to the interface shall have a minimum accuracy of 4.6×10^{-6} (Stratum 3).

While in normal operation, the TE1/TA/NT2 shall transmit a 1544 kbit/s signal having accuracy equal to that of the received signal by locking the frequency of its transmitted signal to the long term average of the incoming 1544 kbit/s signal, or by providing equal signal frequency accuracy from another source.

NOTE – Synchronization to an independent source may result in serious degradation where the source is not a Stratum 1 clock.

While in any maintenance states controlled by signals/messages passed over the m-bits and by AIS, TE1/TA/NT2 functional groups shall operate with received signals having a minimum bit rate accuracy of 3.2×10^{-5} (Stratum 4).

4.1.1.2 Requirements at I_a/I_b

The following requirements are specified in terms of the tolerance to received signal variations at interface I_a and the limitation on the transmitted signal at I_a from the associated equipment. Each receiver requirement implies a requirement on the transmitted signal at the interface I_b of the connected equipment or the network, as applicable. Similarly, each transmitter requirement implies a receiver requirement at the interface I_b of the connected equipment or network, as applicable. Requirements that are unique to a particular functional grouping, e.g. NT2, are specifically noted.

Equipment entities designed to operate under the conditions covered by more than one of the following sub-clauses must comply with the requirements in all of the relevant sub-clauses.

4.1.1.2.1 Receiver bit stream synchronized to a network clock

a) *Receiver requirements* – Receivers of signals across interface I_a shall operate with an average transmission rate in the range of 1544 kbit/s ± 4.6 ppm. However, operation with a received signal transmission rate in the range of 1544 kbit/s ± 32 ppm is required in any maintenance state controlled by signals/messages passed over the m-bits and by AIS.

NOTE 1 – In normal operation the bit stream is synchronized to Stratum 1.

Primary reference and the long term bit rate accuracy is 10^{-11}, but the full bit range of ± 4.6 ppm should be expected in abnormal conditions.

TABLE 2/I.431

Primary rate layer 1 state matrix at user side of the interface

	Initial state	F0	F1	F2[b)]	F3	F4	F5[b)]	F6
Definition of the states	Operational condition or failure condition	Power off at user side	Operational	FC1	FC2	FC3	FC4	Power on at user side
	Signal transmitted towards interface	No signal	Normal operational frames	Normal operational frames	Frames with RAI	Frames with RAI	Normal operational frames	No signal
New event, detected at the receiving side	Loss of TE power	/	PH-DI MPH-EI0 F0	MPH-EI0 F0	MPH-EI0 F0	MPH-EI0 F0	MPH-EI0 F0	MPH-EI0 F0
	Return of TE power	F6	/	/	/	/	/	/
	Normal operational frames from network side	/	–	PH-AI MPH-AI F1	PH-AI MPH-AI F1	PH-AI MPH-AI F1	PH-AI MPH-AI F1	/
	Reception of RAI[a)]	/	PH-DI MPH-EI1 F2	–	MPH-EI1 F2	MPH-EI1 F2	MPH-EI1 F2	MPH-EI1 F2
	Loss of signal or frame alignment	/	PH-DI MPH-EI2 F3	MPH-EI2 F3	–	MPH-EI2 F3	MPH-EI2 F3	MPH-EI2 F3
	Reception of AIS	/	PH-DI MPH-EI3 F4	MPH-EI3 F4	MPH-EI3 F4	–	MPH-EI3 F4	MPH-EI3 F4
	Reception of RAI and continuous CRC error report[a)]	/	PH-DI MPH-EI4 F5	MPH-EI4 F5	MPH-EI4 F5	MPH-EI4 F5	–	MPH-EI4 F5

Single fault conditions

–	No state change
/	Impossible situation
PH-x MPH-y Fz	Issue primitive x Issue management primitive y Go to state Fz

PH-AI PH ACTIVATE INDICATION

PH-DI PH DEACTIVATE INDICATION

MPH-EIn MPH ERROR INDICATION with parameter *n* (*n* = 0 to 4)

a) This event covers different network options. The network options 2 and 3 (see Recommendation I.604) of the 2048 kbit/s system (which include CRC processing in the digital transmission link) provide CRC error information which allows the user-side equipment to localize a fault, indicated by means of RAI, to either:

i) the network side (FC1), if frames without continuous CRC error reports are received; or

ii) the user side (FC4), if frames with continuous CRC error reports are received.

If network options other than 2 and 3 of the 2048 kbit/s system apply, the faults FC1 and FC4 are indicated identically at the interface, and therefore, the signal "RAI with continuous CRC error report" does not occur.

In 1544 kbit/s systems, the network option 2 (see Recommendation I.604) provides the performance report messages, while receiving RAI, which allows the user-equipment to localize a fault to either:

i) the network side (FC1), if frames with performance report message sent from ET, which include continuous CRC error information, are received; or

ii) the user side (FC4), if frames with performance report message sent from the user side of NT1, which include continuous CRC error information, are received.

In options 1 and 4 (see Recommendation I.604), the performance report message cannot be sent while transmitting RAI, so FC 1 and FC 4 faults are indicated identically at the interface.

b) This state covers two user options:

i) if a TE adopting the option to distinguish between F2 and F5 (given by options 2 and 3) is used, but the network does not provide the distinction (see note), then signal “RAI with continuous CRC error report” will not occur and the TE always enters state F2 on receipt of RAI;

ii) the user option of not processing CRC error information when accompanied with RAI, even if provided, merges states F2 and F5.

NOTE – The interpretation of the CRC error information depends on the option used in the network (see 5.9.2 and Recommendation I.604).

TABLE 3/I.431

Primary rate layer 1 state matrix at network side of the interface

	Initial state	G0	G1	G2	G3	G4	G5[a]	G6
Definition of the states	Operational condition or failure condition as seen from the interface	Power off at NT	Operational	FC1	FC2	FC3	FC4	Power on at NT
	Signal transmitted towards interface	No signal	Normal operational frames	RAI[b]	Normal operational frames	AIS	RAI[b]	No signal
New event detected at the receiving side	Loss of NT power	/	MPH-EI0 PH-DI G0	MPH-EI0 G0	MPH-EI0 G0	MPH-EI0 G0	MPH-EI0 G0	MPH-EI0 G0
	Return of NT power	G6	/	/	/	/	/	/
	Normal operational frames, no internal network failure	/	–	PH-AI MPH-AI G1	PH-AI MPH-AI G1	PH-AI MPH-AI G1	PH-AI MPH-AI G1	/
	Internal network failure FC1	/	PH-DI MPH-EI1 G2	–	MPH-EI1[c] G2	MPH-EI1[c] –	MPH-EI1[c] –	MPH-EI1[c] G2
					♦	G2	G2	
	Reception of RAI FC2	/	PH-DI MPH-EI2 G3	MPH-EI2[c] –	–	MPH-EI2[c] –	MPH-EI2[c] –	MPH-EI2 G3
				G3		G3	G3	
	Internal network failure FC3	/	PH-DI MPH-EI3 G4	MPH-EI3[c] G4	MPH-EI3[c] G4	–	MPH-EI3[c] G4	MPH-EI3 G4
				♦	♦		♦	
	Loss of operational frames FC4	/	PH-DI MPH-EI4 G5	MPH-EI4[c] G5	MPH-EI4[c] G5	MPH-EI4[c] –	–	MPH-EI4[c] G5
				♦	♦	G5		

Single fault conditions

–	No state change
/	Impossible situation
PH-x MPH-y Gz	Issue primitive x Issue management primitive y Go to state Gz

Double fault conditions

MPH-y Gz	Second fault is dominant. Action to be taken when second fault occurs.
♦	The disappearance of the first fault is not visible at the interface since the second fault is dominant and the state has changed already to Gz.
MPH-y	First fault is dominant, therefore the state will not change when the second fault occurs but the error indication may be given to the management if possible.
Gz	Action to be taken when first (dominant) fault disappears.

PH-AI PH ACTIVATE INDICATION
PH-DI PH DEACTIVATE INDICATION
MPH-EIn MPH ERROR INDICATION with parameter n (n = 0 to 4)

a) In the case of no CRC processing in the digital link, the state G5 is identical to state G2.

b) In options 2 and 3 of the 2048 kbit/s systems, the RAI signal must contain CRC error information of the section between TE and NT which can be used by the user to localize faults FC1 and FC4. In option 1, the faults FC1 and FC4 are indicated identically at the interface (see 5.9).

c) The issue of this primitive depends on the capability of the digital transmission system and the option used in the network.

b) *Transmitter requirements* – The average transmission rate of signals transmitted across interface I_a by the associated equipment shall be the same as the average transmission rate of the received bit stream. The possible need for a requirement applicable to TE1/TAs only, that would require a tighter coupling of the phase/bit rate of the transmitted bit stream to the received bit stream, is outside the scope of this Recommendation.

NOTE 2 – Where multiple network interfaces are involved, the transmission rate of the transmitted signal is normally determined by the signals received across only one interface but the transmission rate of all interfaces are normally synchronized to the same master source.

4.1.1.2.2 TE1/TA operating behind an NT2 that is not synchronized to a network clock

a) *Receiver requirements* – Receivers of signals across interface I_a shall operate with an average transmission rate in the range of 1544 kbit/s ± 32 ppm.

b) *Transmitter requirements* – The transmitted signal across interface I_a shall be synchronized to the received bit stream. The required coupling (relative phase) of the transmitted and received bit stream is outside the scope of this Recommendation.

4.1.1.2.3 Receive bit stream synchronized to customer provided transmitted signal clock (leased line application)

a) *Transmitter requirements* – The transmission rate of the signals transmitted across interface I_a (or I_b) shall be in the range of 1544 kbit/s ± 32 ppm. Requirements, if any, on the necessary synchronization of transmitted and received bit streams are beyond the scope of this Recommendation.

b) *Receiver requirements* – The tolerance of receivers to variations in the transmission rate of signals received across interface I_a (or I_b) is dependent upon the far end transmitter tolerance.

4.1.2 Specification of output ports

The signal specification for output ports is summarized in Table 4.

4.1.2.1 Test load

A termination of 100-ohms resistive shall be used at the interfaces (I_a and I_b) for the evaluation of signal characteristics.

4.1.2.2 Pulse characteristics

Pulses in the transmit direction through interface at points I_a and I_b shall comply with the following requirements when attenuated by a cable pair having a loss at 772 kHz in the range of 0 to 1.5 dB and having a loss vs. frequency characteristic following the $\sqrt{f}$ law in the frequency range of 200 kHz to 1.5 MHz.

a) *Pulse mask* – An isolated pulse, both positive and negative (inverted), shall have an amplitude between 2.4 and 3.6 volts, measured at the centre of the pulse, and fit a normalized template shown in Figure 6 (the pulse mask shown in Figure I.1 is an example of a pulse template sufficient but not necessary to meet the requirements of Figure 6 after transmission through a cable loss of 0 to 1.5 dB).

b) *Power levels* – For an all binary "ONEs" pattern, into a test load of 100 ohms, the power from a transmitter in a 3 kHz band centred at 772 kHz shall be in the range of 12.0 to 19.0 dBm and the power in a 3 kHz band centred at 1544 kHz shall be at least 25 dB less.

4.1.2.3 Pulse imbalance

There shall be less than 0.5 dB difference between the total power in the positive pulses and the negative pulses. In addition, in any window of 17 consecutive bits, the difference between the largest pulse amplitude and the smallest pulse amplitude shall be less than 200 mV, and the difference between the width (half amplitude) of the widest pulse and the width (half amplitude) of the narrowest pulse shall be less than 20 ns.

4.1.2.4 Voltage of binary ZERO

The voltage within a time slot containing a binary ZERO (space) shall be no greater than either the value produced in that time slot by pulses (marks) in adjacent slots that are within the mask of Figure 6 or ± 5% of the zero-to-peak pulse (mark) amplitude, whichever is greater in magnitude. An isolated pulse shall satisfy the requirements set out in Table 4.

TABLE 4/I.431

Digital interface at 1544 kbit/s

Bit rate		1544 kbit/s
Pair(s) in each direction of transmission		One symmetrical pair
Code		B8ZS (Note 1)
Test load impedance		100 ohm resistive
Nominal pulse shape		See pulse mask (Note 2)
Signal level (Notes 2 and 3)	Power at 772 kHz	+ 12 dBm to + 19 dBm
	Power at 1544 kHz	At least 25 dB below the power at 772 kHz

NOTES

1 B8ZS is modified AMI code in which eight consecutive binary ZEROs are replaced with 000 + – 0 – + if the preceding pulse was positive (+) and with 000 – + 0 + – if the preceding pulse was negative (–).

2 The pulse mask and power level requirements apply at the end of a pair having a loss at 772 kHz of 0 to 1.5 dB.

3 The signal level is the power level measured in a 3 kHz bandwidth at the output port for an all binary ONEs pattern transmitted.

4.1.3 Specifications of input ports

Receivers shall receive input data sequences under the following conditions and with signals having the following characteristics, with transmission rates over the acceptable range specified in 4.1.1, with pulse imbalance as specified in 4.1.2.3, and with superimposed jitter and wander as specified in 4.5.

In demonstrating compliance with this requirement, it shall be sufficient to demonstrate reception of data sequences (in the presence of the test conditions) with a bit error ratio of less than 10^{-7}.

4.1.3.1 Received signal characteristics

Signals delivered to receivers at interfaces I_a and I_b shall have the transmitted pulse characteristics defined in 4.1.2.2 and attenuated by a cable pair (terminated by 100-ohms resistor) with a loss in the range of 0.0 to 18.0 dB at 772 kHz between interfaces I_a and I_b.

4.1.3.2 Interference test conditions

The general requirement of 4.1.3 applies with interference described in a) and b) superimposed individually (not simultaneously).

a) *Gaussian interference* – Noise having a Gaussian amplitude distribution and a power spectral density (PSD) flat over the frequency range of 100 kHz to 1500 kHz, rolling off at 6 dB per octave to 3 MHz, and having a power measured in 100 ohms, in the frequency band of 400 kHz to 1350 kHz (see note) of –32.7 dBm. The variation, relative to the specified spectrum, in the amplitude of the noise at each frequency shall not exceed ± 1dB. The amplitude distribution of the noise shall conform to the Gaussian distribution up to a peak-to-RMS ratio of at least 14.5 dB.

b) *Single frequency* – A sinusoidal signal at 772 kHz having a power, measured into 100 ohms, of –20dBm.

NOTE – The choice of 400 kHz and 1350 kHz is arbitrary but the two frequencies determine points on the transmitted PSD at the same value, –95.6 dBm/Hz, and integration of the transmitted PSD over this range includes essentially all of the first lobe power (–30.6 dBm).

4.1.4 Interim provisions

For an interim period, equipment conforming to the following requirement shall be acceptable.

4.1.4.1 Interim I_a/I_b alternative

a) *Output Ports* – The electrical characteristics of signals at output ports shall conform to the requirements of 4.1.2.1 and 4.1.2.2, except that the requirements are applicable at I_a/I_b with a cable loss of only 0 dB, and 4.1.2.4, except that Note 2 of Table 4 is not applicable.

b) *Input Ports* – The digital signal presented at the input port shall be as defined above but modified by the characteristics of the interconnecting pair where the attenuation of the pair shall be assumed to follow the $\sqrt{f}$ law and the loss at a frequency of 772 kHz shall be in the range of 0 to 6 dB.

4.1.4.2 Interim DSX alternative

The single interface point architecture of the digital cross connect (DSX) is specified in Recommendation G.703 for the 1544 kbit/s rate.

4.2 Frame structure

The frame structure is based on 3.1.1 and 3.1.2/G.704 and is shown in Figure 4.

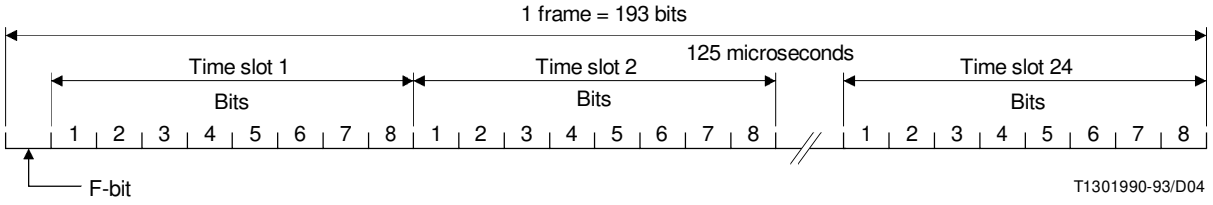


FIGURE 4/I.431

Frame structure of 1544 kbit/s interface

4.2.1 Each time slot consists of eight consecutive bits, numbered 1 to 8.

4.2.2 Each frame is 193 bits long and consists of an F-bit followed by 24 consecutive time slots, numbered 1 to 24. The frame repetition rate is 8000 frame/s.

4.2.3 Multi-frame structure

The multi-frame structure is shown in Table 5. Each multi-frame is 24 frames long and is defined by the multi-frame alignment signal (FAS) which is formed by every fourth F-bit and has the binary pattern (....001011....). The bits e_1 to e_6 in Table 5 are used for error checking, as described in 2.1.3.1.2/G.704. A valid error check by the receiver is an indication of transmission quality and of the absence of false frame alignment (see 4.6.3).

4.3 Timing considerations

This subclause describes the hierarchical synchronization method selected for synchronizing ISDNs. It is based upon consideration of satisfactory customer service, ease of maintenance, administration and minimizing cost.

The NT derives its timing from the network clock. The TE synchronizes its timing (bit, octet, framing) from the signal received from the NT and synchronizes accordingly its transmitted signal.

TABLE 5/I.431

Multi-frame structure

Multi-frame frame number	F-bits			
	Multi-frame bit number	Assignments		
		FAS	(See Note)	(See 4.2.6)
1	1	–	m	–
2	194	–	–	e_1
3	387	–	m	–
4	580	0	–	–
5	773	–	m	–
6	966	–	–	e_2
7	1159	–	m	–
8	1352	0	–	–
9	1545	–	m	–
10	1738	–	–	e_3
11	1931	–	m	–
12	2124	1	–	–
13	2317	–	m	–
14	2510	–	–	e_4
15	2703	–	m	–
16	2896	0	–	–
17	3089	–	m	–
18	3282	–	–	e_5
19	3475	–	m	–
20	3668	1	–	–
21	3861	–	m	–
22	4054	–	–	e_6
23	4247	–	m	–
24	4440	1	–	–
NOTE – The current use of the m-bits is defined in 4.7.4.				

4.4 Time slot assignment

4.4.1 D-channel

Time slot 24 is assigned to the D-channel when this channel is present.

4.4.2 B-channel and H-channels

A channel occupies an integer number of time slots and the same time slot positions in every frame. A B-channel may be assigned any time slot in the frame, an H_0-channel may be assigned any six slots in the frame, in numerical order (not necessarily consecutive), and an H_{11}-channel may be assigned slots 1 to 24 in a frame. The assignment may vary on a call by call basis (see Note). Mechanisms for the assignment of these slots for a call are specified in Recommendation I.451.

NOTE – For an interim period, a fixed time slot allocation to form channels may be required. An example of a fixed assignment of slots for the case where only H_0-channels are present at the interface is given in Annex A.

4.5 Jitter, wander and phase transients

The following is a provisional specification of jitter, wander and phase transients which are the subject of continuing study. The requirements are generally specified in terms of the tolerance of TE1/TA and NT2 functional groups to received signal variations at interface I_a and limitations on the transmitted signal at I_a from the associated functional group. Each receiver requirement implies a requirement on the transmitted signal at the interface I_b of the connected functional group. Similarly, each transmitter requirement implies a receiver requirement at the interface I_b of the connected functional group. Requirements that are unique to a particular functional grouping, e.g. NT2, are specifically noted.

4.5.1 General

Jitter is the short-term variation of the significant instants of a digital signal from their ideal positions in time; wander is long-term variations of the same instants. Phase transients are relatively short duration step functions of the same instants. The term jitter applies to variations above a frequency of 10 Hz. Wander applies to variations below a frequency of 10 Hz.

Wander is a long-term phenomenon with time constants of hours/minutes. Transient phenomena have time constants of seconds/ms. The magnitude of jitter and wander is specified in terms of unit intervals (UIs). One UI is equal to 648 ns. Transients are specified in terms of the maximum transient phase deviation and the maximum equivalent frequency off-set during the transient.

4.5.2 Jitter

Jitter is specified in two frequency bands: band 1 and band 2.

- Band 1: 10 Hz to 40 kHz
- Band 2: 8 kHz to 40 kHz

The jitter requirements given in this subclause do not apply during clock phase transient events (see 4.5.4.1).

4.5.2.1 Receive signal jitter

Satisfactory operation shall be achieved with jitter of the receive signal at interface I_a as follows:

- Band 1: 5.0 UI, peak-to-peak; and
- Band 2: 0.1 UI, peak-to-peak.

For the purpose of demonstrating compliance, it shall be sufficient to demonstrate satisfactory operation (no bit errors introduced or frame alignment lost) with sinusoidal jitter according to the amplitude/frequency characteristics of Figure 5.

4.5.2.2 Transmit signal jitter

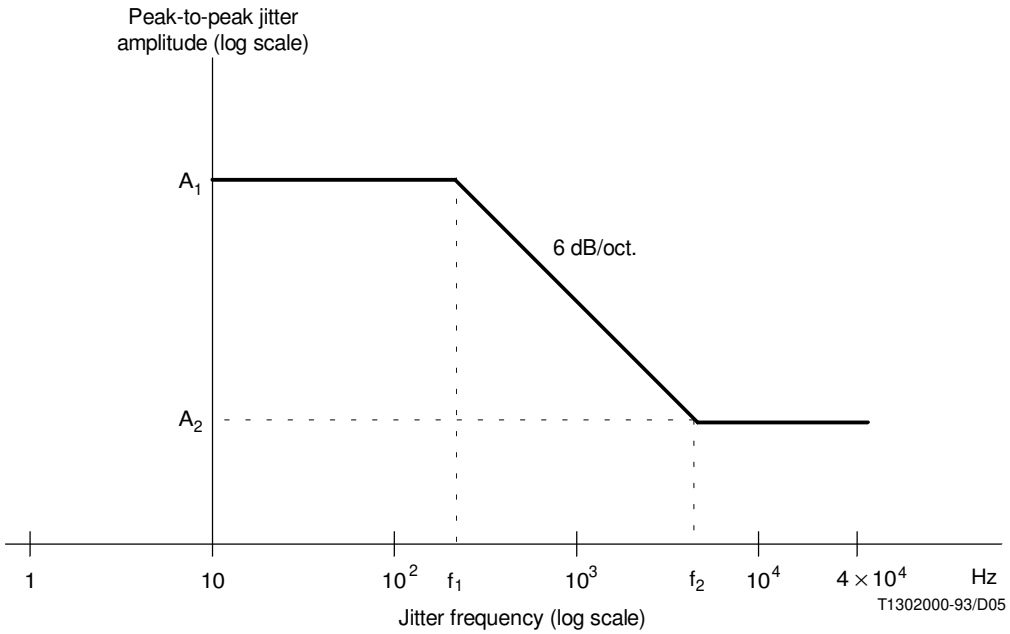
The jitter of the transmitted signal from interfaces I_a or I_b shall not exceed the following:

- Band 1: 0.5 UI, peak-to-peak; and
- Band 2: 0.07 UI, peak-to-peak.

NOTE – The transmit signal jitter shall not exceed the jitter of the received signal in band 1. In band 2, the jitter shall conform to the requirement above.

4.5.3 Wander

Wander across the entire spectrum of frequencies up to 10 Hz is significant. For the purpose of this Recommendation, wander is classified as long term (24 hours), medium term (1 hour), and short-term (15 minutes). (The short-term wander requirements are still under study.) The following limitations on wander and required tolerance to wander are specified for the condition where the bit stream is synchronized to a primary reference source (PRS). When the bit stream is not synchronized to a PRS, the clock tolerance may cause a drift in the phase of the bit stream that far exceeds the values of the wander specified below which could degrade service.



A_1 = 5.0 UI
A_2 = 0.1 UI
f_1 = 120 Hz
f_2 = 6 kHz
UI Unit interval (648 ns)

FIGURE 5/I.431
Tolerable TE input jitter characteristic

4.5.3.1 Transmit signal wander

The wander of the transmitted signal shall not exceed 28 UI (18 μs) peak-to-peak in any 24-hour period, nor exceed 23 UI (15 μs) peak-to-peak in any 1-hour interval when the received signal wander conforms to the limitations specified in 4.5.3.2.

NOTE – Control of wander during intervals shorter than one hour is important; e.g. the wander in any 15-minute interval should be limited to 13 UI (8.5 μs) peak-to-peak.

This requirement includes the accumulative effect of clock phase transient events (4.5.4.1), that occur under normal operating conditions. This requirement is applicable to an NT2. The wander in the transmitted signal of a TE1/TA shall not exceed the wander of its received signal by more than 0.5 UI.

4.5.3.2 Received bit stream wander

NT2s shall operate, as required, with wander of the received signal of up to 16.8 UI (10.8 μs) peak-to-peak over any 24 hour period and up to 15.4 UI (10 μs) peak-to-peak in any 1-hour interval.

However, TE1/TAs (assumed to be loop timed) shall operate with wander in their received signal as large as is permitted in 4.5.3.1 for the transmitted signal.

4.5.4 Phase transients

Phase transients are specified as the maximum transient phase deviation and the maximum equivalent frequency offset during the transient.

4.5.4.1 Received signal transients

Equipment shall operate with transients in the phase of signals received across interface I_a of up to 1.5 UI (1 μs). During the phase transient, the frequency of the signal appears offset from the nominal frequency by up to 61 ppm. Such transients shall be isolated in time. (Phase transients are defined as occurring at a maximum rate of 81 ns for any period of 1.326 ms.) Additionally, accommodation must be made for SDH virtual container (VC) pointer adjustments (see Recommendation G.709) in the magnitude of 13 UI (8.5 μs). Phase slope characteristics of this transient have yet to be determined but typically fall within a one second timeframe and will be no greater than 61 ppm.

NOTE – In early designs of clock synchronization circuits, synchronization may be interrupted due to bit errors in the "reference" source causing transmitted signal wander as large as 7700 UI (5 ms) peak-to-peak in any 24-hour period, and as large as 4600 UI (3 ms) peak-to-peak in any 1-hour interval. This performance includes the accumulative effect of clock phase transients (see 4.5.4.2), which accounts for the majority of this wander. However, it must be recognized that such wander may cause 42 frame slips within the network per day, which may seriously degrade service.

4.5.4.2 Transmit signal transients

In response to phase transients in the receiver signal, as specified in 4.5.4.1 phase transients in the signals transmitted across I_a shall not exceed the magnitude and phase slopes of the allowable received transients. During the phase transient, the frequency of the signal shall not appear offset from the nominal frequency by more than 61 ppm. Phase transients that are the result of customer clock rearrangement activity or VC pointer adjustments (see Recommendation G.709) shall be similarly limited.

NOTE – Due to early designs of clock synchronization circuits, phase transients that are the result of customer clock rearrangement activity may be as large as 1 ms. During the phase transient, the frequency of the signal shall not appear offset from the nominal frequency by more than 300 ppm. However, it must be recognized that such transients may cause loss of frame synchronization which may seriously degrade service.

4.6 Interface procedures

4.6.1 Codes for idle channels and idle slots

A pattern including at least three binary ONEs in an octet must be transmitted in every time slot that is not assigned to a channel (e.g. time slots awaiting channel assignment on a per-call basis, residual slots on an interface that is not fully provisioned, etc.), and in every time slot of a channel that is not allocated to a call in both directions.

4.6.2 Interframe (layer 2) time fill

Contiguous HDLC flags shall be transmitted on the D-channel when its layer 2 has no frames to send.

4.6.3 Frame alignment and CRC-6 procedure

The frame alignment and CRC-6 procedures shall be in accordance with 2/G.706.

4.7 Maintenance

4.7.1 General introduction

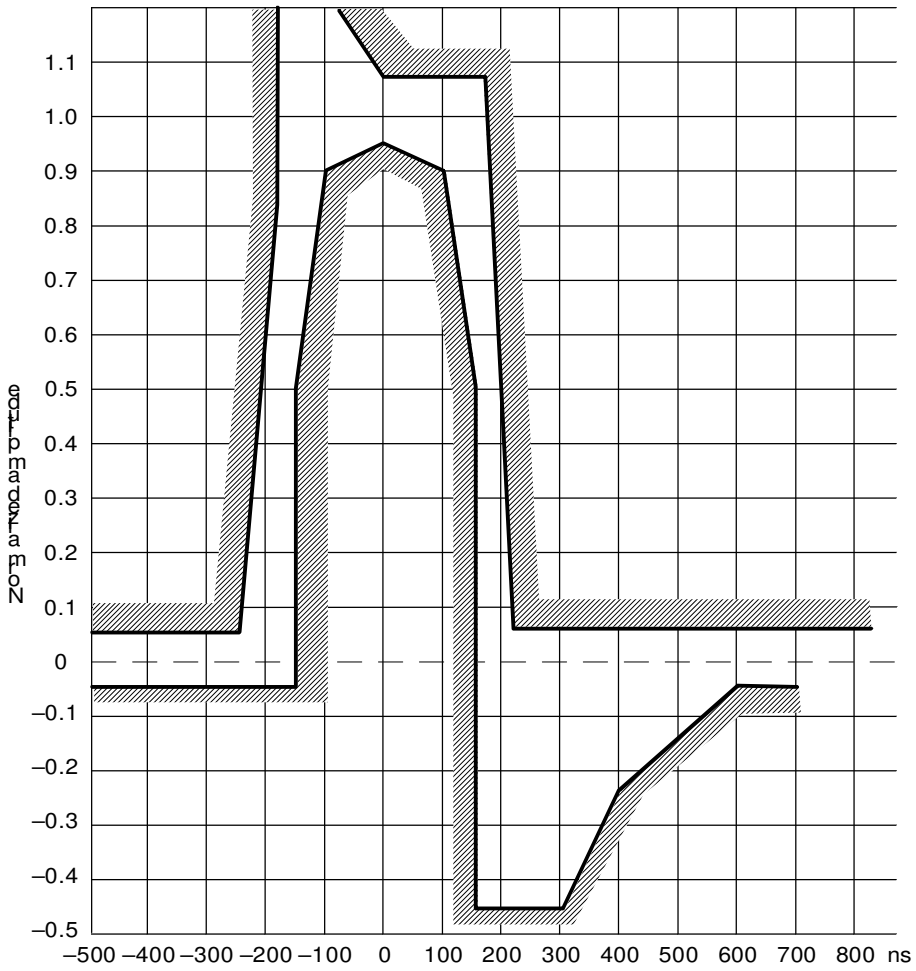
Recommendations I.604 and G.963 specify the overall approach to be employed in maintaining 1544 kbit/s ISDN primary rate access. However, since required maintenance functions are supported by the TE (Options 1, 4 and 2 according to Recommendation I.604) detailed functional requirements are provided here.

4.7.2 Maintenance functions

The interface divides maintenance responsibility between network and user sides.

Specified maintenance functions are as follows:

a) Supervision of layer 1 capability and reporting across the interface, which includes, on the user side, reporting loss of incoming signal or loss of frame alignment from the network side.



NOTE – See table below for corner points.

Maximum curve

Time	Nanoseconds	–500	–258	–175	–175	–75	0	175	228	500	750
	Unit intervals	–0.77	–0.40	–0.27	–0.27	–0.12	0	0.27	0.35	0.77	1.16
Normalized amplitude		0.05	0.05	0.8	1.20	1.20	1.05	1.05	0.05	0.05	0.05

Minimum curve

Time	Nanoseconds	–500	–150	–150	–100	0	100	150	150	300	396	600	750
	Unit intervals	–0.77	–0.23	–0.23	–0.15	0	0.15	0.23	0.23	0.46	0.61	0.93	1.16
Normalized amplitude		–0.05	–0.05	0.5	0.9	0.95	0.9	0.5	–0.45	–0.45	–0.26	–0.05	0.05

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FIGURE 6/I.431

Standard pulse template and corner points for interface at 1544 kbit/s

On the network side, reporting loss of layer 1 capability and the incoming signal or frame alignment from the user side, are included.

b) CRC performance monitoring and reporting across the interface (this function is specified in 4.7.4).

4.7.3 Maintenance signals

The following signals are defined at the T reference point:

- Remote alarm indication (RAI) which is transmitted in the m-bits;
- Alarm indication signal (AIS) which is transmitted as an all binary ONEs pattern in the entire 1544 kbit/s signal;
- Loopback signals which are transmitted in the m-bits;
- Performance report message used to convey CRC results and other layer 1 performance information.

4.7.4 The m-bits (4 kbit/s data link)

The 1544 kbit/s multiframe format provides a data channel derived from the framing overhead. These m-bits (Table 5) occur in every other 1544 kbit/s frame. This results in an available resource of 4 kbit/s. This resource is used for various purposes associated with operation and maintenance of the access digital section and the TE; including remote alarm indication (4.7.3), loopback activation and deactivation and the regular reporting of data associated with CRC check sum calculations and the occurrence of controlled slip events, etc. (4.7.4.2.2). The data link is hereafter referred to as the DL.

The DL carries two types of information: control signals and performance data. Unless otherwise indicated, the specification of these signals is the same for both directions of transmission.

The control signals are pre-emptive, i.e., when sent, they overwrite other signals on the DL. The two categories of control signals (priority and command messages) are defined in 4.7.4.1.1 and 4.7.4.1.2.

The performance data is transmitted in a simplified format similar to the Q.921/LAPD protocol, and is described in 4.7.4.2.

4.7.4.1 Control signals

Control signals are repetitive bit-oriented codewords used to convey alarm and command information. Control signals preempt all other uses of the DL. Control signals consist of multiple transmissions of bit-oriented codewords with the left-most bit transmitted first, conforming to the format:

11111111 0xxxxxx0

Table 6 defines the priority message codewords, and the command message codewords appropriate to the TE. Other bit-oriented codewords may be used on the DL to support operation and maintenance of network facilities and of NT1s. TEs shall not act upon any bit-oriented codewords other than those listed in Tables 6 and 7. TEs shall not source any messages other than those listed in Tables 6 and 7 and only under the conditions prescribed for their use.

4.7.4.1.1 Priority messages

Priority messages indicate a service-affecting condition. They shall be transmitted until the condition no longer exists, but not for less than one second. These messages may be interrupted for a maximum of 100 ms per interruption with a minimum interval of one second between the start of interruptions.

4.7.4.1.2 Command messages

Command messages are transmitted to perform loopback functions within the customer installation (NT/TE). They may also be used to support operation and maintenance of network transmission facilities. The codewords in Table 7 are available for use within the customer installation and will not be recognized within the network.

Command codewords shall be repeated at least 10 times. TEs shall act upon commands when appropriate codewords are detected at least 5 times in 10 intervals.

TABLE 6/I.431

Assigned Bit-oriented Data Link messages

Function	Codeword	
Priority messages		
RAI	11111111	00000000
Loopback retention	11111111	01010100
Command messages		
Line loopback 3 activate	11111111	01110000 (Note 3)
Line loopback 3 deactivate	11111111	00011100 (Note 3)
Payload loopback 3 activate	11111111	00101000 (Note 4)
Payload loopback 3 deactivate	11111111	01001100 (Note 4)
Universal loopback deactivate	11111111	00100100

NOTES

1 The left-most bit is transmitted first.

2 The loopbacks are defined in 4.7.5.

3 Loopback 2 as described in G.963 is implemented in NT1 using this same codeword (options 1 and 4 according to Recommendation I.604).

4 The provision of this loopback is optional.

TABLE 7/I.431

Codewords reserved for use within the customer installation

Function	Codeword	
Reserved for user	11111111	01000000
Reserved for user	11111111	01100000
Reserved for user	11111111	01010000
Reserved for user	11111111	01101100
Reserved for user	11111111	01110100
Loopback C activate	11111111	00000100 (Note 2)

NOTES

1 The left-most bit is transmitted first.

2 This loopback is located within the NT1 but controlled by the customer installation.

4.7.4.2 Performance report message (PRM)

Performance verification of the 1544 kbit/s primary rate access digital section is based on facility monitoring and calculation and comparison of check sums generated by framing sources. Framers insert a six bit check sum into the C_1 through C_6 bit positions of the 1544 kbit/s frame F-bits overhead. This CRC-6 polynomial is the check sum associated with the preceding multi-frame.

Partial verification of the performance is possible at any point in an access digital section by securing 1544 kbit/s frame reference, calculating CRC-6 check sums, and comparing them to those (received in the bit positions reserved for C_1 through C_6) calculated and inserted by the framer. Upstream performance can thus be verified from the monitoring point for both ET and NT/TE generated information. The downstream performance can be inferred from the performance reports described below.

4.7.4.2.1 Method of operation

This subclause illustrates the use of the m-bits for conveying performance information specified in 4.7.4.2.2. Performance information appearing in one direction of transmission is a quantification of the quality of transmission in the opposite direction.

A simplified version of the LAP-D protocol, utilizing only unnumbered frames, is used for this purpose. Reports are transmitted at one second intervals, and that data for each second is repeated in four messages in subsequent reporting periods. The repetitions provide robustness to the method. The specification of these signals is the same for both directions of transmission.

NOTE – As described in 4.7.4.1, the m-bits are also used for the transmission of priority messages, e.g., alarms and command and response messages. In 1544 kbit/s systems supporting options 1 and 4 (see Recommendation I.604), such messages have a priority over performance reports. In systems supporting option 2 of Recommendation I.604, the performance report message can be sent at a maximum of 100 milliseconds per interruption, while transmitting RAI, to localize a fault.

Both the received and the transmitted signals include a performance report sent each second. The one-second timing (which defines the measurement interval) may be derived from the transmitted or received signal, as applicable, or from any source with an accuracy ± 32 ppm, or better. The phase of the one-second periods with respect to the occurrence of error events is arbitrary; i.e., the one-second timing does not depend on the time of occurrence of any error event.

The performance report contains information for each of the four previous one-second intervals. This is illustrated in Figure 7, octets 5 through 12, and by an example in Figure 8.

Counts of events are accumulated in each contiguous one-second interval. At the end of each one-second interval, a modulo 4 counter is incremented, and the appropriate performance bits are set in the t_0 octets (octets 5 and 6 in Figure 7). These octets, along with octets that carry the performance bits of the preceding three one-second intervals form the performance report.

NOTE – A single performance report message occupies 15 bytes. This is transmitted once per second. A performance report message with one address should not be blocked or overwritten by one with another address. When the NT1 with CRC processing (option 2 according to Recommendation I.604) transmits three kinds of 15-byte performance report messages, the three performance report messages occupy 45 bytes per second.

4.7.4.2.2 Error performance parameters

The performance report message is used to convey specific error information between the network side and the user side.

The network side will receive the following transmission-error information to allow it to evaluate the error performance parameters defined in Recommendation G.821. The user side will receive the same information, from the network side, for the opposite direction of transmission.

Occurrences of transmission-error events indicate the quality of transmission. The occurrences that shall be detected and reported are:

- No events;
- CRC error;
- Severely-errored framing.

Octet Nº	8	7	6	5	4	3	2	1	Octet control
1	Opening flag								01111110
2	SAPI						C/R	EA	00111000 or 00111010
3	TEI							EA	00000001 or 00000011
4	Control								00000011
5	G3	LV	G4	U1	U2	G5	SL	G6	t_0
6	FE	SE	LB	G1	R	G2	Nm	N1	
7	G3	LV	G4	U1	U2	G5	SL	G6	t_{0-1}
8	FE	SE	LB	G1	R	G2	Nm	N1	One-second report
9	G3	LV	G4	U1	U2	G5	SL	G6	t_{0-2}
10	FE	SE	LB	G1	R	G2	Nm	N1	
11	G3	LV	G4	U1	U2	G5	SL	G6	t_{0-3}
12	FE	SE	LB	G1	R	G2	Nm	N1	
13	FCS								Variable
14									
15	Closing flag								

ADDRESS	INTERPRETATION
00111000	SAPI = 4, C/R = 0(NT1 networkside/TE), EA = 0
00111010	SAPI = 14, C/R = 1 (ET/NT1 userside), EA = 0
00000001	TEI = 0, EA = 1 [Performance report related to the access digital section (Note 2)]
00000011	TEI = 1, EA = 1[Performance report related to the link between NT1 and TE (Note 3)]
CONTROL	INTERPRETATION
00000011	Unacknowledged information transfer
ONE-SECOND REPORT	INTERPRETATION
G1 = 1	CRC error event = 1
G2 = 1	1< CRC error event ≤ 5
G3 = 1	5 < CRC error event ≤ 10
G4 = 1	10 < CRC error event ≤ 100
G5 = 1	100 < CRC error event ≤ 319
G6 = 1	CRC error event ≥ 320
SE = 1	Severely-errored framing bit ≥ 1 (FE shall = 0)
FE= 1	Framing synchronization bit error event ≥ 1 (SE shall = 0)
LV = 1	Line code violation event ≥ 1
SL = 1	Slip event ≥ 1
LB = 1	Payload loopback 3 activated indication
U1, U2 = 0, R = 0	Reserved for national option
NmN1 = 00,01,10,11	One-second report modulo 4 counter
FCS	CRC 16 frame check sequence

NOTES

1 The rightmost bit is transmitted first.

2 In options 1 and 4 of Recommendation I.604, this report is between the ET and TE. In option 2 of Recommendation I.604, this report is between the ET and NT1.

3 This applies only to implementations following option 2 of Recommendation I.604.

FIGURE 7/I.431

Performance Report message Structure

	$t = t_0$	$t = t_{0+1}$	$t = t_{0+2}$	$t = t_{0+3}$
FLAG	01111110	01111110	01111110	01111110
ADDRESS OCTET 1	00111000	00111000	00111000	00111000
ADDRESS OCTET 2	00000001	00000001	00000001	00000001
CONTROL	00000011	00000011	10000011	00000011
MESSAGE OCTET 1	00000001	00000000	10000000	00100000
MESSAGE OCTET 2	00000000	00000001	00000010	00000011
MESSAGE OCTET 3	00000000	00000001	00000000	10000000
MESSAGE OCTET 4	00010011	00000000	00000001	00000010
MESSAGE OCTET 5	00000000	00000000	00000001	00000000
MESSAGE OCTET 6	01000010	00010011	00000000	00000001
MESSAGE OCTET 7	00000010	00000000	00000000	00000001
MESSAGE OCTET 8	00000001	01000010	00010011	00000000
FCS OCTET 1	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx
FCS OCTET 2	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx

$t = t_{0-3}$ Slip = 1, all other parameters = 0, N(t) = 1

$t = t_{0-2}$ Severely errored framing event = 1, all other parameters = 0, N(t) = 2

$t = t_{0-1}$ CRC error events = 1, all other parameters = 0, N(t) = 3

$t = t_0$ CRC error events = 320, all other parameters = 0, N(t) = 0

$t = t_{0+1}$ CRC error events = 0, all other parameters = 0, N(t) = 1

$t = t_{0+2}$ CRC error events = 6, all other parameters = 0, N(t) = 2

$t = t_{0+3}$ CRC error events = 40, all other parameters = 0, N(t) = 3

NOTE – This example describes the C/R = 0/TEI = 0 case only.

FIGURE 8/I.431

Performance report messages – Example

The occurrences that should be detected and reported are:

- Frame synchronization bit error;
- Line code violation;
- Controlled slip.

These are defined in the following subclause.

4.7.4.2.2.1 CRC error event: A CRC error event is the occurrence of a received CRC code that is not identical to the corresponding locally-calculated code.

4.7.4.2.2.2 severely-errored framing event: A Severely-errored framing event is the occurrence of two or more framing-bit errors within a 3 ms period. Contiguous 3 ms intervals shall be examined. The 3 ms period may coincide with the multi-frame defined in Table 5.

NOTE – The use of existing 2 of 4, 2 of 5, 3 of 5, etc. framing error detection criteria may be substituted for this criterion.

4.7.4.2.2.3 frame synchronization bit error event: A frame synchronization bit error event is the occurrence of a received framing-bit-pattern error.

4.7.4.2.2.4 line code violation event: A line code violation event is the occurrence of a received violation that is not part of a line code substitution rule.

4.7.4.2.2.5 controlled slip event: A controlled slip event is the occurrence of a replication, or deletion, of a frame by the receiving terminal. A controlled slip may occur when there is a difference between the timing of a synchronous receiving terminal and the carrier signal.

4.7.4.2.3 Format of the performance report

The performance reports carried by both the received and the transmitted signals utilize the frame structure, field definitions and elements of procedure of the LAPD protocol defined in Recommendation Q.921 with different addresses. This application uses a subset of the full Q.921/LAPD capabilities. The message structure is shown in Figure 7, where the following abbreviations are used:

1) SAPI Service access point identifier
2) C/R Command/Response
3) EA Extended address
4) TEI Terminal endpoint identifier
5) FCS Frame check sequence

This message structure is that of a Q.921/LAPD, unnumbered and unacknowledged frame. The performance report uses only the SAPI value shown in Figure 7.

The source of the performance report generates the frame check sequence (FCS) and the zero stuffing required for transparency. Zero stuffing by a transmitter prevents the occurrence of the flag pattern (01111110) in the bits between the opening and closing flags of a Q.921/LAPD frame by inserting a binary ZERO after any sequence of five consecutive binary ONEs. (A receiver removes a binary ZERO following five consecutive binary ONEs). The data elements in the performance report are arranged so that zero stuffing is not required in the information field, but zero stuffing may occur in the FCS. Thus, except for the FCS, the line signal duplicates the list sequence of the report (octets 1 through 12, Figure 7), and the message is of constant length from the opening flag to the end of the information field. The performance report is always passed through the access digital section.

NOTES

1 The performance report with SAPI 14 shall be constructed and inserted on the data link by the source that frames the information payload of the 1544 kbit/s signal whether it is an ET (C/R = 1) or a TE (C/R = 0) source. The performance report with SAPI 14 should be delivered without alteration, to the sinks of the information payload of the 1544 kbit/s signal.

2 In the application of the performance monitoring within the access digital section, the bits “TEI” and “C/R” are used as addresses to indicate the monitored locations (ET to NT1 networkside) / (NT1 networkside to ET) / (NT1 userside to TE) / (TE to NT1 userside) of performance information contained in a message. C/R bit indicates the source of performance data, given in Table 8 and TEI bit indicates the monitored section, given in Table 9.

TABLE 8/I.431

C/R Bit Assignment

C/R	Source
0	NT1 networkside/TE
1	ET/NT1 userside

TABLE 9/I.431

TEI Bit Assignment

TEI	Monitored section
0	Monitored section between TE/NT1 and ET
1	Monitored section between TE and NT1

4.7.5 Maintenance Loopbacks

Loopbacks are maintenance tools used to assist in locating faults in the network and customer installation. All loopbacks are optional. Loopbacks are controlled by the codewords specified in Table 6.

Line loopback results in a full 1544 kbit/s loopback toward the interface of the received bit stream. Bit sequence integrity shall be maintained. Whenever a line loopback is activated, AIS shall be sent forward as a replacement for the looped signal.

Activation of line loopback shall be a two step process, as follows:

1) When line loopback activation code is detected, a state is set to prepare for activation.

2) The requested line loopback is activated when the line loopback code is no longer detected.

A payload loopback is implemented only in equipment that terminates framing of the primary rate access line, i.e., it is not applicable to simple NT1s which regenerate only. The signal looped back toward the received signal is 1536 kbit/s. The framing bits are originated at the loopback point. The payload loopback shall maintain bit sequence integrity for the information bits, however, the payload loopback need not maintain the integrity of eight-bit time slots, frames, or multi-frames.

When the payload loopback is activated the LB bit shall be set to binary ONE in the performance report message.

Line and payload loopbacks shall be deactivated upon receipt of any one (or combination) of the following:

1) The loopback deactivate codeword;

2) AIS;

3) A data link message consisting of two occurrences of the one-per-second performance message report separated by an uninterrupted idle code.

The various loopbacks are summarized below:

1) Loopback 3 is located in the TE. It shall be implemented as a line loopback. Optionally it may be implemented as a payload loopback, for which a different activation code is provided. Loopback 3 loops the complete signal toward the ET;

2) Loopback C is located in the NT1. It loops the complete signal toward the TE. It may be implemented as either a line loopback or payload loopback depending on whether the NT1 terminates framing.

5 Interface at 2048 kbit/s

5.1 Electrical characteristics

This interface should conform to 6/G.703 which recommends the basic electrical characteristics.

NOTE – The use of the unbalanced 75 ohm (coaxial) interface is required by some Administrations in the short-term. However, the balanced 120 ohm (symmetric pairs) interface is preferred for the ISDN primary rate application.

5.2 Frame structure

5.2.1 Number of bits per time slot

Eight, numbered from 1 to 8.

5.2.2 Number of time slots per frame

Thirty-two, numbered from 0 to 31. The number of bits per frame is 256 and the frame repetition rate is 8000 frames/s.

5.2.3 Assignment of bits in time slot 0

The bits of time slot 0 are in accordance with 2.3.2/G.704. The E bits are assigned to the CRC error information procedures.

S_a bits with bit position 4 and 8 are reserved for international standardization and shall be ignored by the TE for the time being. S_a bits with position 5, 6 and 7 are reserved for national use. The terminals not making use of these bits shall ignore any received pattern.

5.2.4 Time slot assignment

5.2.4.1 Frame alignment signal

Time slot 0 provides for frame alignment in accordance with Recommendation G.704.

5.2.4.2 D-channel

Time slot 16 is assigned to the D-channel when this channel is present.

5.2.4.3 B-channel and H-channels

A channel occupies an integer number of time slots and the same time slot positions in every frame.

A B-channel may be assigned any time slot in the frame and an H_0-channel may be assigned any six slots, in numerical order, not necessarily consecutive (Note 1).

The assignment may vary on a call-by-call basis (Note 2). Mechanisms for the assignment of these slots for a call are specified in Recommendation I.451.

An H_{12}-channel shall be assigned time slots 1 to 15 and 17 to 31 in a frame and an H_{11}-channel may be assigned time slots as in the example given in Annex B.

NOTES

1 In any case, time slot 16 should be kept free for D-channel utilization.

2 For an interim period, a fixed time slot allocation to form channels may be required. Examples of a fixed assignment of slots for the case where only H_0-channels are present at the interface are given in Annex A.

5.2.4.4 Bit sequence independence

Time slots 1 to 31 provide bit sequence independent transmission.

5.3 Timing considerations

The NT derives its timing from the network clock. The TE synchronizes its timing (bit, octet, framing) from the signal received from the NT and synchronizes accordingly the transmitted signal.

In an unsynchronized condition (e.g. when the access that normally provides network timing is unavailable) the frequency deviation of the free-running clock shall not exceed ± 50 ppm.

A TE shall be able to detect and to interpret the input signal within a frequency range of ± 50 ppm.

Any TE which provides more than one interface is declared to be a multiple access TE and shall be capable of taking the synchronizing clock frequency for its internal clock generator from one or more than one access (or all access links) and synchronize the transmitted signals at each interface accordingly.

5.4 Jitter

5.4.1 General considerations

The jitter specifications take into account subscriber configurations with only one access and configurations with multiple accesses.

In the case of one access only, this may be to a network with transmission systems of either high Q or low Q clock recovery circuits.

In the case of multiple accesses, all access transmission systems may be of the same kind (either low Q or high Q clock recovery circuits) or they may be of different kinds (some with high Q and some with low Q clock recovery circuit).

Examples of single and multiple accesses are given in Figure 9.

The reference signal for the jitter measurement is derived from the network clock. The nominal value for one UI is 488 ns.

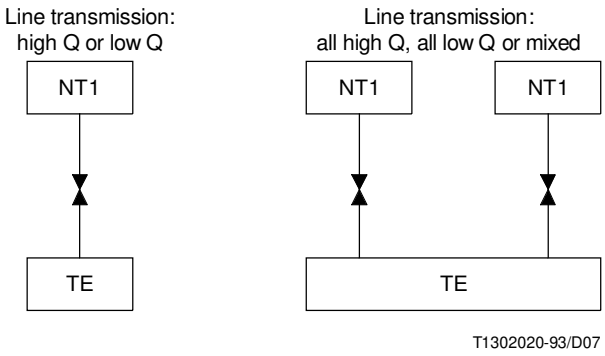


FIGURE 9/I.431

Examples of single and multiple accesses

5.4.2 Minimum tolerance to jitter and wander at TE inputs

The 2048 kbit/s inputs of a TE shall tolerate sinusoidal input jitter/wander in accordance with Figure 10 without producing bit errors or losing frame alignment.

A TE with multiple access shall respect the worst case phase deviation between TE inputs of maximum 41 UI.

5.4.3 TE and NT2 output jitter

Two cases must be considered.

5.4.3.1 TE and NT2 with only one user-network interface

The peak-to-peak output jitter shall meet the limits when measured with a bandpass filter having a high pass of first order (slope of 20 dB/decade) with cutoff frequencies as defined in Table 10 and Figure 11. At the input the signal shall be provided with the tolerable input jitter and with tolerable frequency deviations during measurement. Tests shall be made with normal operational frames (NOF) as well as AIS.

5.4.3.2 TE with more than one user-network interface to the same network

The peak-to-peak output jitter shall meet the limits when measured with a bandpass filter having a high pass of first order (slope of 20 dB/decade) with cutoff frequencies as defined in Table 11. At the input the signal shall be provided with the tolerable input jitter and with tolerable frequency deviations during measurement. Tests shall be made with normal operational frames.

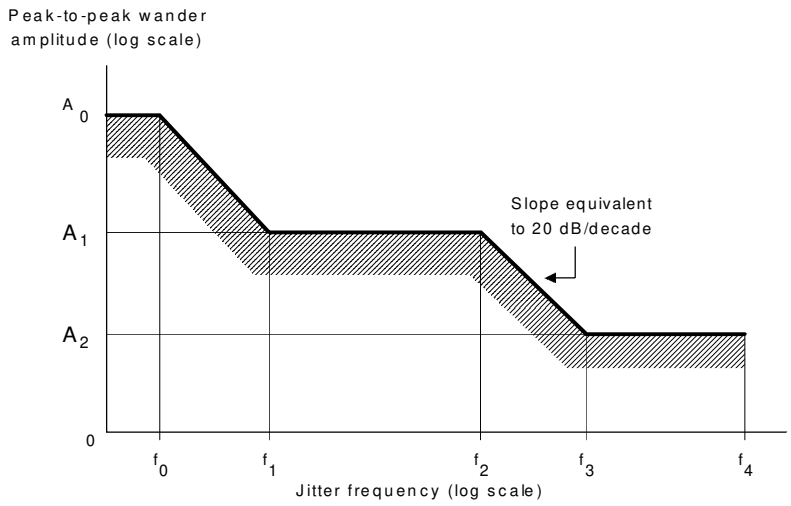
Equipment with more than one interface using timing selection method (only one input, being in operational state, is used to synchronize the equipment clock at a point in time) may be considered as an equipment with one interface only if it meets the requirements of 5.4.3.1 also during switch over to another interface (signal at input supplying timing changes from NOF with nominal frequency to AIS with ± 50 ppm from the nominal frequency while all other inputs still receive NOF with the nominal frequency). The signals provided to the inputs shall carry tolerable jitter and may have deviation of bit-phase up to 0.5 UI.

5.5 Tolerable longitudinal voltage

For minimum tolerance to longitudinal voltage at input ports, the receiver shall operate without errors with any valid input signal in the presence of a longitudinal voltage V_L.

V_L = 2 Vrms over the frequency range 10 Hz to 30 MHz.

The test configuration is given in Figure 12.



A_0	A_1	A_2	f_0	f_1	f_2	f_3	f_4
20.5 UI (Note 1)	1.0 UI (Note 2)	0.2 UI	12×10^{-6} Hz	20 Hz	3.6 kHz	18 kHz	100 kHz

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NOTES

1 Jitter/wander is maximum time interval error (MTIE) as defined in Recommendation G.811 and specified in 2.2/G.823 in practice, this jitter/wander is superimposed upon a timing signal which is reasonably stable (see Recommendation O.171). In the worst case, the phase deviation of a TE input from another TE input, in the multiple access configuration, can at a maximum, be twice the value A_0 given in the table.

2 With TEs for multiple access (e.g. when an access is connected to a long leased circuit leading to a distant PABX), a jitter tolerance of 1.5 UI (with a corresponding f_2 at 2.4 kHz) may be required.

FIGURE 10/I.431

Minimum tolerable jitter and wander at the TE input

5.6 Output signal balance

Output signal balance, which is measured in accordance with 2.7/O.9 shall meet the following requirements:

a) f = 1 MHz: ≥ 40 dB;

b) 1 MHz < f ≤ 30 MHz: minimum value decreasing from 40 dB at 20 dB/decade.

5.7 Impedance towards ground

The impedance towards ground of both the receiver input and the transmitter output shall meet the following requirements:

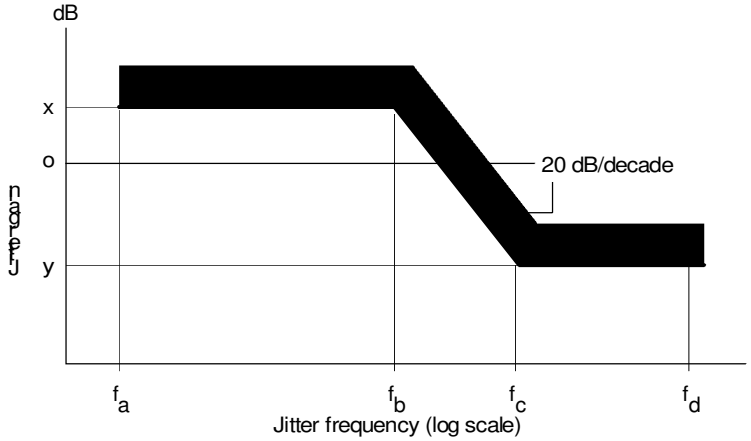
10 Hz < f ≤ 1 MHz: > 1000 ohm

The requirement is met if the test according to Figure 13 results in a voltage V_{Test} ≤ 20 mV rms.

TABLE 10/I.431

Output jitter limits for equipment with one user-network interface

Measurement filter bandwidth		Output jitter
Lower cutoff	Upper cutoff	(UI peak-to-peak)
20 Hz	100 kHz	1.1 UI
700 Hz	100 kHz	0.11 UI



Y	X	f_a	f_b	f_c	f_d
–19.5 dB	0.5 dB	10 Hz	40 Hz	400 Hz	100 kHz

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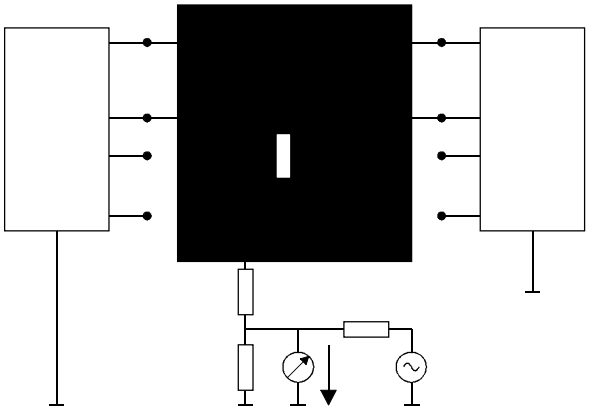
FIGURE 11/I.431

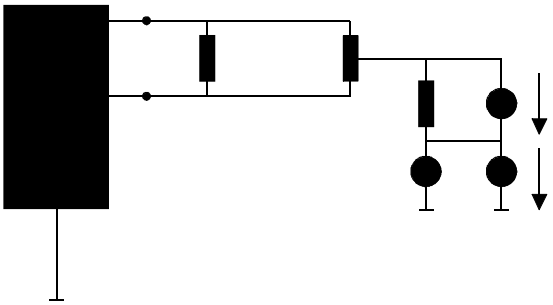
Jitter transfer characteristics

TABLE 11/I.431

Output jitter limits for equipment with more than one user-network interface

Measurement filter bandwidth		Output jitter
Lower cutoff	Upper cutoff	(UI peak-to-peak)
4 Hz	100 kHz	1.1 UI
40 Hz	100 kHz	0.11 UI





5.8 Interface procedures

5.8.1 Codes for idle channels and idle slots

A pattern including at least three binary ONEs in an octet must be transmitted in every time slot that is not assigned to a channel (e.g. time slots awaiting channel assignment on a per-call basis, residual slots on an interface that is not fully provisioned, etc.), and in every time slot of a channel that is not allocated to a call in both directions.

5.8.2 Interframe (layer 2) time fill

Contiguous HDLC flags will be transmitted on the D-channel when its layer 2 has no frames to send.

5.8.3 Frame alignment and CRC-4 procedures

The frame alignment and CRC procedures shall be in accordance with 4/G.706.

5.9 Maintenance at the interface

The network reference configuration for the maintenance activities on primary rate subscriber access is given in Recommendation I.604.

The associated maintenance procedure, which is described there, needs a continuous supervision procedure in layer 1 for automatic fault detection, automatic failure confirmation and information.

NOTE – The terms *anomaly*, *defect*, *fault* and *failure* are defined in Recommendation M.20.

5.9.1 Use of CRC procedure

5.9.1.1 Introduction

At the user-network interface the CRC procedure according to Recommendations G.704 and G.706 is applied to gain security in frame alignment and detect block errors. The CRC error information uses the E bits as defined in Table 4b/G.704. The coding E is set to binary ZERO for a block with failure; and E is set to binary ONE for a block without failure. With respect to CRC error information to the other side of the interface and processing of this information, two different options exist, one has CRC processing in the transmission link and the other not.

The use of the CRC procedure at the user-network interface implies:

i) that the user side shall generate towards the interface a 2048 kbit/s frame with associated CRC bits;

ii) that the network side shall generate towards the interface a 2048 kbit/s frame with associated CRC bits;

iii) that the user side shall monitor the CRC bits associated with the received frames (CRC codes calculation and comparison with received CRC code) (see Note);

iv) that the user side shall detect the CRC blocks received with error;

v) that the user side shall generate the CRC error information according to the CRC procedure;

vi) that the network side shall monitor the CRC bits associated with the received frames;

vii) that the network side shall detect the CRC blocks received with error;

viii) that the network side shall generate the CRC error information according to the CRC procedure;

ix) that the network side shall detect the CRC error information and process all the received information in accordance with Recommendation I.604.

NOTE – CRC error information processing (e.g. in terms of bit error thresholds or G.821 parameters) is optional.

5.9.1.2 Localization of the CRC functions in the subscriber access from the user point of view

5.9.1.2.1 No CRC processing in the transmission link

Figure 14 gives the locations of the CRC function processes in a subscriber access when there is no CRC processing in the transmission link.

5.9.1.2.2 CRC processing in the digital transmission link

Figure 15 gives the locations of CRC function processes in a subscriber access, with CRC processing in the NT.

5.9.2 Maintenance functions

5.9.2.1 General requirements

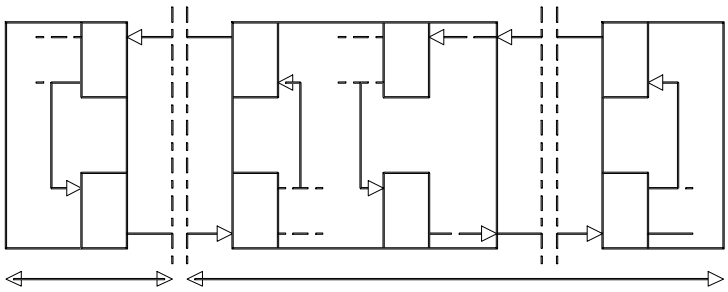
The equipment located on the user side and on the network side of the interface shall:

– detect the anomalies;

– detect the defects;

– take actions for reporting the detected anomalies and defects (defect indication signals AIS, RAI);

– detect the received defect indication signals.



5.9.2.2 Maintenance functions on the user side

5.9.2.2.1 Anomalies and defect detection

The user side shall detect the following defects or anomalies:

- loss of power on the user side;
- loss of incoming signal at interface (see Note)
- loss of frame alignment (see Recommendation G.706);
- CRC error.

NOTE – Only when loss of frame alignment has not yet occurred.

5.9.2.2.2 Detection of defect indication signals

The following defect indications received at interface shall be detected by the user side:

- remote alarm indication (RAI) (Note);
- alarm indication signal (AIS);

NOTE – The RAI signal is used to indicate loss of layer 1 capability. It may be used to indicate:

- loss of signal or loss of framing;
- excessive CRC errors (optional);
- loopbacks applied in the network.

The conditions of excessive CRC errors are outside the scope of this Recommendation.

5.9.2.2.3 Consequent actions

Table 12 gives the actions that the user side (TE function) has to take after the detection of a defect or of a defect indication signal.

When the defect conditions have disappeared or when the defect indication signals are no longer received, the defect indications AIS and RAI must disappear as soon as possible.

The following points are required to ensure that an equipment is not removed from service or put into service due to short breaks in transmission or on detection of normal operational frames by layer 1, respectively.

i) the persistent receipt of signals other than normal operational frames shall be verified by timer T1 of 100 to 1000 ms before PH-DI is issued.

ii) the persistent receipt of normal operational frames shall be verified by a timer T2 of 10 to 100 ms before PH-AI is issued.

iii) T1 shall be suspended when T2 is started. T1 shall resume running when T2 is reset.

iv) T1 shall be reset when T2 expires.

v) T2 shall be reset on receipt of signals other than normal operational frames.

5.9.2.3 Maintenance functions on the network side

5.9.2.3.1 Defect detection

All the following defect conditions shall be detected by the network side of the interface (NT1, LT, ET functions) (see Note 2):

- loss of power on the network side;
- loss of incoming signal;
- loss of frame alignment (see Recommendation G.706);
- CRC error.

NOTES

1 The equipment of the access connection element must detect loss of incoming signal and then shall generate downstream towards the interface the fault indication signal AIS.

2 Some equipment in the network may detect only part of the defects or fault conditions listed above.

TABLE 12/I.431

Defect conditions and defect indication signals detected by the user side and consequent actions

Defect conditions and defect indication signals detected by the user side	Consequent actions	
	Defect indications at the interface	
	Generation of RAI	Generation of CRC error information (see Note 4)
Loss of power on user side	Not applicable	Not applicable
Loss of signal	Yes	Yes (Note 1)
Loss of frame alignment	Yes	No (Note 2)
Reception of RAI	No	No
Reception of AIS	Yes	No (Note 3)
Detection by NT2 of CRC errors	No	Yes

NOTES

1 Only when loss of frame alignment has not yet occurred.

2 The loss of frame alignment inhibits the process associated with the CRC procedure.

3 The AIS signal is detected only after the fault "loss of frame alignment", thus the process associated with the CRC procedure is inhibited.

4 If CRC errors are detected in frames carrying the RAI signal, then CRC error reports should be generated.

5.9.2.3.2 Detection of defect indication signals

The following defect indications received at the interface shall be detected by the network side:

- remote alarm indication (RAI);
- CRC error information.

5.9.2.3.3 Consequent actions

Table 13 gives the actions that the network side (NT1, ET functions) has to take after defect detection or defect indication detection.

When the defect conditions have disappeared or the defect indication signals are no longer received, the defect indication signals AIS and RAI should disappear as soon as possible.

The following points are required to ensure that an equipment is not removed from service or put into service due to short breaks in transmission or on detection of normal operational frames by layer 1, respectively:

i) the persistent receipt of signals other than normal operational frames shall be verified by timer T1 of 100 to 1000 ms before PH-DI is issued;

ii) the persistent receipt of normal operational frames shall be verified by a timer T2 of 10 to 100 ms before PH-AI is issued;

iii) T1 shall be suspended when T2 is started. T1 shall resume running when T2 is reset;

iv) T1 shall be reset when T2 expires;

v) T2 shall be reset on receipt of signals other than normal operational frames.

TABLE 13/I.431

Defect conditions and defect indication signals detected by the network side of interface, and consequent actions

Defect conditions and defect signal indications detected by network side	Consequent actions		
	Defect indications at interface		
	Generation of RAI	Generation of AIS	Generation of CRC error information
Loss of power on network side	Not applicable	Yes, if possible	Not applicable
Loss of signal	Yes	No	Yes (Note 1)
Loss of frame alignment	Yes	No	Option 1: No Option 2: Yes (Note 3)
Detection of defect in the network-to-user direction	No	Yes	No
Reception of RAI	No	No	No (Note 2)
Detection of defect in the user-to-network direction up to ET	Yes	No	No
Detection of CRC errors	No	No	Yes
Reception of CRC error information	No	No	No
Excessive CRC error ratio	Yes (optional)	No	Not applicable

NOTES

1 Only when loss of frame alignment has not yet occurred.

2 If CRC errors are detected in frames carrying the RAI signal, then CRC error reports shall be generated.

3 See Recommendation I.604.

6 Connector

Interface connectors and contact assignments are described in ISO 10173. However, permanent wiring connections of TEs to NTs are also permitted.

7 Interface wiring

For interface wiring, symmetrical or coaxial cables shall be used, according to the interface provided.

The interface requirements are based on the following typical values:

a) in the case of 2048 kbit/s interface

- symmetrical wiring with the magnitude of the characteristic impedance of 120 ohm ± 20% in a frequency range 200 kHz to 1 MHz and 120 ohm ± 10% at 1 MHz.
- coaxial wiring with the magnitude of the characteristic impedance of 75 ohm ± 5% at 1024 kHz.

b) in the case of 1544 kbit/s interface

– symmetrical wiring with the magnitude of the characteristic impedance of 100 ohm ± 20% in a frequency range 200 kHz to 772 kHz and 100 ohm ± 10% at 772 kHz.

Wiring with different characteristic impedance (e.g. existing wiring) may be used but may impose constraints to the application of the interface (i.e. a limitation of interface wiring length could be required).

8 Power feeding

8.1 Provision of power

The provision of power to the NT via the user network interface using a separate pair of wires from those used for signal transmission, is optional.

8.2 Power Consumption

8.2.1 Power Available from the TE

The power available (from the TE) at the NT shall be a minimum of 7 watts. This shall take into account the loss in the wiring, and shall be the power available for the NT to draw.

8.2.2 NT power consumption

The power drawn by the NT from the user-network interface shall not exceed 7 watts, over the range of input voltage specified in 8.3.

8.3 Voltage range

8.3.1 Feeding voltage from TE

The TE shall provide a feeding voltage in the range –20 to –57 volts at the NT. The polarity of the voltage towards earth shall be negative.

8.3.2 NT input voltage

The NT shall be capable of operating with any feeding voltage (at its input) within the range of –20 to –57 volts.

8.4 Protection

8.4.1 Power Source (TE)

The power source and the user-network interface shall be protected against any overload condition, including a short circuit, for an unlimited time duration. This requirement may be checked by applying a short-circuit for a period of 30 minutes. After removal of the short-circuit, the power source shall be able to provide its rated output within 10 seconds.

8.4.2 Power Sink (NT)

The power sink in the NT shall be designed so that it is not damaged by reversal of polarity (interchange of wires).

Annex A

Time slot assignment for interfaces having only H_0-channels

(This annex forms an integral part of this Recommendation)

The following are examples of fixed assignment of time slots when only H_0-channels are present at the interface.

A.1 1544 kbit/s interface

H_0-channel	a	b	c	d
Time slots used	1 to 6	7 to 12	13 to 18	19 to 24[a)]
[a)] This fourth H_0-channel is available if time slot 24 is not used for a D-channel.				

A.2 2048 kbit/s interface

Example 1

H_0-channel	a	b	c	d	e
Time slots used	1-2-3 17-18-19	4-5-6 20-21-22	7-8-9 23-24-25	10-11-12 26-27-28	13-14-15 29-30-31

Example 2

H_0-channel	a	b	c	d	e
Time slots used	1-2-3 4-5-6	7-8-9 10-11-12	13-14-15 17-18-19	20-21-22 23-24-25	26-27-28 29-30-31
NOTE – The time slot assignment in Example 2 is the one described in Recommendation G.704 for $n \times 64$ kbit/s interface with $n = 6$ and fixed first time slot allocation. It is therefore the preferred assignment.					

Annex B

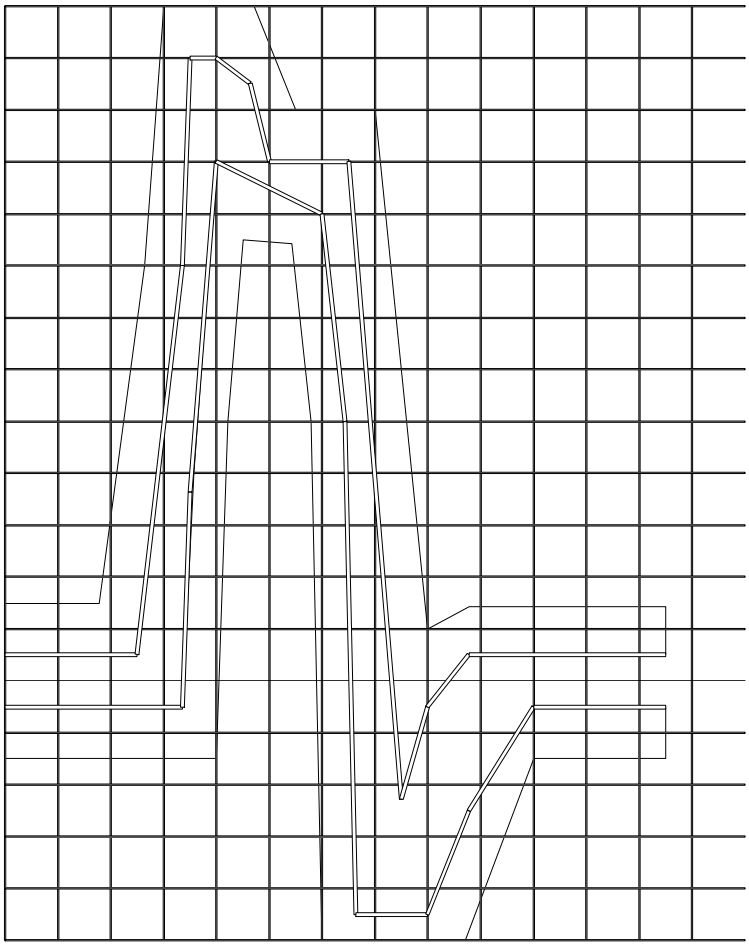
Time slot assignment for 2048 kbit/s interfaces having an H_{11}-channel

(This annex forms an integral part of this Recommendation)

The following is an example of fixed assignment of time slots when an H_{11}-channel is present at the interface.

H_{11}-channel	1 - 15	16 - 24
Time slots used	1 - 15	17 - 25
NOTE – Time slot 16 is to be assigned to the D-channel, when this channel is present. Time slots 26 to 31 may be used for an H_0-channel or six B-channels.		

Appendix I
Pulse mask for interface at 1544 kbit/s

(This appendix does not forms an integral part of this Recommendation)

An isolated pulse, when scaled by a constant factor, shall fit the pulse mask shown in Figure I-1.