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SERIES I: INTEGRATED SERVICES
DIGITAL NETWORK (ISDN)

OVERALL NETWORK ASPECTS AND FUNCTIONS,
ISDN USER-NETWORK INTERFACES

ISDN user-network interfaces – layer 1
Recommendations

PRIMARY RATE USER-NETWORK INTERFACE – LAYER 1 SPECIFICATION

Reedition of CCITT Recommendation I.431 published in
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NOTES

1   CCITT Recommendation I.431 was published in Fascicle III.8 of the *Blue Book*. This file is an extract from the *Blue Book*. While the presentation and layout of the text might be slightly different from the *Blue Book* version, the contents of the file are identical to the *Blue Book* version and copyright conditions remain unchanged (see below).

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

Recommendation I.431

PRIMARY RATE USER-NETWORK INTERFACE – LAYER I SPECIFICATION

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

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 very specific and not contained in the relevant terminology Recommendations. Therefore, Annex E to Recommendation I.430 provides terms and definitions used in this Recommendation. 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/I.431.

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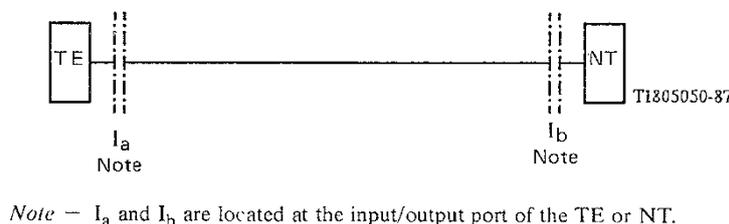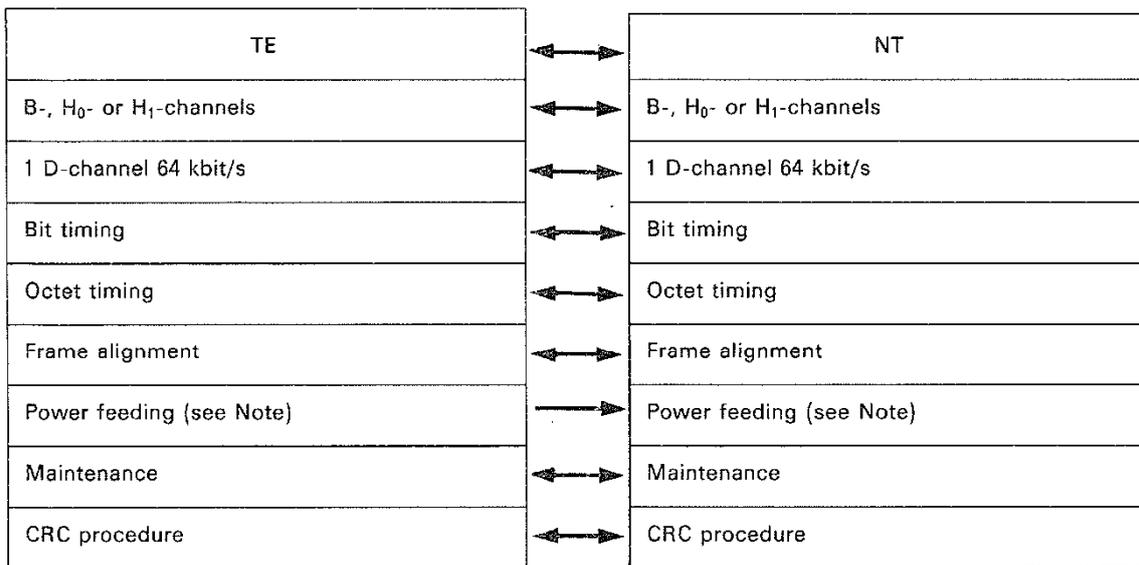

Note — I_a and I_b are located at the input/output port of the TE or NT.

FIGURE 1/I.431
Location of interfaces

3 Functional characteristics

3.1 *Summary of functions (Layer 1) (see Figure 2/I.431)*

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

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

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$_o$-channel

This function provides for the bidirectional transmission of independent Ho-channel signals each having a bit rate of 384 kbit/s as defined in Recommendation 1.412.

H$_1$-channels

This function provides for the bidirectional transmission of an H$_1$-channel signal having a bit rate of 1536 (H11) 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 procedure

This function provides for the 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 section 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 at the interface*

Signals exchanged between the network and user sides under normal and fault conditions are listed in Table 1/I.431. Further information on these signals is given in § 4.7.3 and § 5.9.1.

TABLE 1/1.431

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) – no defect indication
RAI	Operational frame with: – active associated CRC bits – CRC error information (Note) – with remote alarm indication, see Table 4a/G.704 (2048 kbit/s systems only)
LOS	No received incoming signal (Loss of signal)
AIS	Continuous stream of ONEs (Recommendation M.20)
CRC error information	E bit according to Recommendation G.704, Table 4b, set to "ZERO" if CRC block is received with error (2048 kbit/s systems only)

AIS   Alarm indication signal

CRC   Cyclic redundancy check

LOS   Loss of signal

RAI   Remote alarm indication

Note – The 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.

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 on the layer 1 states in relation to the different defects that could be detected.

For that 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 FC 1 to FC4 that could occur at the network side or between the network side and user side are defined in Figure 3/I.431. These fault conditions directly affect the F and G states. Information on these fault conditions are exchanged between the user and network sides in the form of signals defined in Table 1/I.431.

Note 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 detections of the CRC error information are not taken into account.

Note 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.

Note 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.
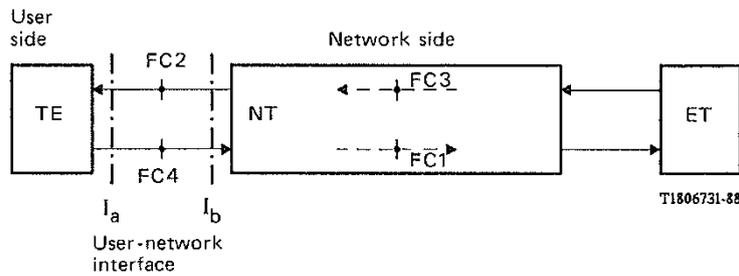
FIGURE 3/I.431
Location of fault conditions (FC) relative to interface

3.4.3   *Layer I states on the user side of the interface*

FO state : Loss of power on the user side

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

Fl 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. I

–   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.

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

Note 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.

Note 3 – Only in options 2 and 3 of Recommendation I.604, Annex A. 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 I states at the network side of the interface*

GO state : Loss of power in the NT1

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

GI 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 I).

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.

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

Note 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.

Note 3 – Only in options 2 and 3 of Recommendation I.604, Annex A.

3.4.5   *Definition of primitive*

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   Parameter which defines the failure condition relevant to the reported error 3.4.6 *State tables*

3.4.6   *State tables*

Operational functions are defined in Table 2/I.431 for the layer 1 states at the user side of the interface and in Table 3/I.431 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*

The signal shall have a bit rate of 1544 kbit/s ± 50 parts per million (ppm).

4.1.2   *Interchange circuit support*

One symmetric metallic pair shall be used for each direction of transmission.

4.1.3   *Code*

The B8ZS code is recommended (see Note 1 under Table 4/I.431 for definition of B8ZS code).

4.1.4   *Specifications at the output ports*

4.1.4.1 *Test load*

Test load impedance shall be 100 ohms, resistive.

4.1.4.2 *Pulse mask*

An isolated pulse measured at interfaces Ia or I_b defined in Figure 1/I.431 shall have an amplitude between 2.4 and 3.6 volts measured at the centre of the pulse.

A possible normalized pulse mask is shown in Figure I-1/I.431. This pulse mask is for further study. An isolated pulse shall satisfy the requirements set out in Table 4/1.431.

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 FCI and FC4 are indicated identically at the interface, therefore, the signal "RAI with continuous CRC error report" does not occur.

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 of 2048 kbit/s interfaces only) is used, but the network does not provide the distinction (see Note 1), 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.

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TABLE 3/I.431

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

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	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	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 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) – / G2	MPH-EI1 c) – / G2	MPH-EI1 G2
	Reception of RAI FC2	/	PH-DI MPH-EI2 G3	MPH-EI2 c) – / G3	–	MPH-EI2 c) – / G3	MPH-EI2 c) – / G3	MPH-EI2 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) G5 / G5	–	MPH-EI4 G5

Single fault conditions

—	No state change

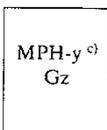|	
/	Impossible situation
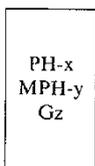
PH-x MPH-y Gz	Issue primitive x Issue management primitive y Go to state Gz

Double fault conditions

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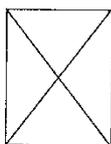
⊠	The disappearance of the first fault is not visible at the interface since the second fault is dominant and the state has changed already to Gz.
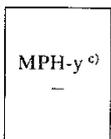
MPH-y [c)] —	First fault is dominant, therefore the state will not change when the second fault occurs but the error indication may be given to the management if possible.
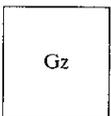
Gz	Action to be taken when first (dominant) fault disappears.

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.

TABLE 4/1.431

Digital interface at 1544 kbit/s

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

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

Note 2 – The signal level is the power level measured in a 3 kHz bandwidth at the output port for an all I s pattern transmitted.

4.1.4.3 *Voltage of zero*

The voltage within a time slot containing a zero (space) shall be no greater than either the value produced in that time slot by other pulses (marks) within the mask of Figure I-1/I.431 or $\pm 5\%$ of the zero-to-peak pulse (mark) amplitude, whichever is greater in magnitude.

4.1.5 *Specifications at the input ports*

The digital signal presented at the input port shall be as defined above but modified by the characteristic of the interconnecting pair. The attenuation of this pair shall be assumed to follow i f law and the loss at a frequency of 772 kHz shall be in the range 0 to 6 dB.

4.2 *Frame structure*

4.2.1   The frame structure is based on Recommendation G.704, §§ 3.1.1 and 3.1.2 and is shown in Figure 4/I.431.
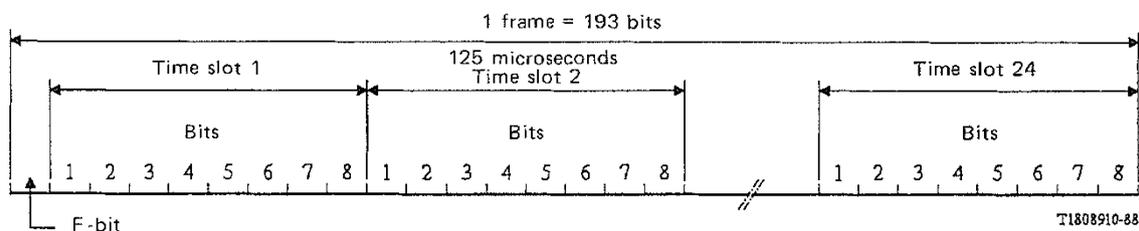

FIGURE 4/L431
Frame structure of 1544 kbit/s interface

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.

4.2.3   Each time slot consists of eight consecutive bits, numbered 1 to 8. 4.2.4 The frame repetition rate is 8000 frame/s.

4.2.4   The frame repetition rate is 8000 frame/s.

4.2.5   The multi-frame structure is shown in Table 5/I.431. 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...).

4.2.6   The bits e_1 to e_6 in Table 5/I.431 are used for error checking, as described in § 2.1.3.1.2 of Recommendation 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 of this Recommendation).

TABLE 5/I.431

Multi-frame structure

Multi-frame frame number	Multi-frame bit number	F-Bits		
		Assignments		
		FAS	See Note	See § 4.2.6
1	1	–	M	n
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_s
19	3475	–	M	–
20	3668	1	–	–
21	3861	–	M	–
22	4054	–	–	e_6
23	4247	–	M	–
24	4440	1	–	–

Note — With the exception of § 4.7.3, the use of the m bit is for further study (for
example, for maintenance and operational information).

4.3   *Timing considerations*

This section 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.

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 Ho-channel may be assigned any six slots in the frame, in numerical order (not necessarily consecutive), and an H11-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 Ho-channels are present at the interface is given in Annex A.

4.5 *Jitter*

4.5.1 *Timing jitter*

Timing jitter is specified as follows:

4.5.1.1 *Tolerable jitter at TE input*

A TE shall tolerate a sinusoidal input jitter according to the amplitude-frequency characteristic of Figure 5/I.431 without producing bit errors or losing frame alignment.
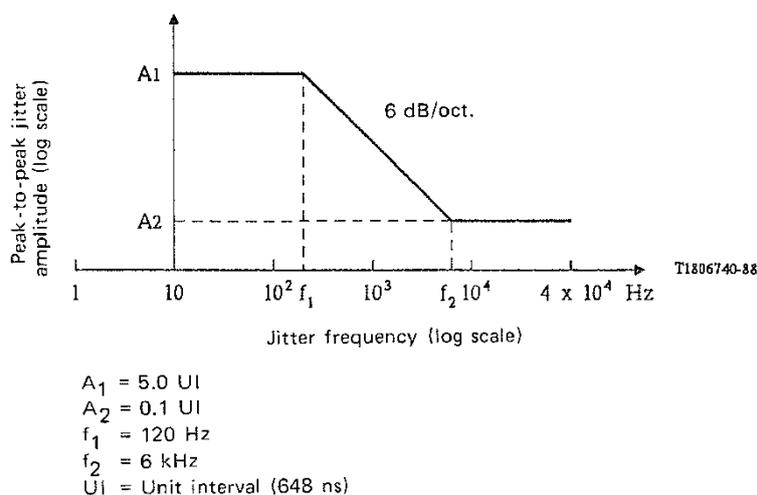

$A_1 = 5.0$ UI
$A_2 = 0.1$ UI
$f_1 = 120$ Hz
$f_2 = 6$ kHz
UI = Unit interval (648 ns)

FIGURE 5/I.431
Tolerable TE input jitter characteristic

4.5.1.2 *TE output jitter*

With no jitter on the TE input signal that provides timing, jitter at the TE output shall not exceed the following two limitations simultaneously:

  i)   Band 1 (10 Hz-40 kHz) : 0.5 UI (Unit Interval) peak-to-peak

  ii)   Band 2 (8 kHz-40 kHz) : 0.07 UI peak-to-peak.

4.5.2 *Wander*

Wander is specified for frequencies below 10 Hz.

4.5.2.1 *Signal from the network side*

Wander shall not exceed 5 UI peak-to-peak in any 15 minute interval and shall not exceed 28 UI peak-to-peak within a period of 24 hours.

4.5.2.2 *Signal from the user side*

Wander shall not exceed 5 UI peak-to-peak in any 15 minute interval and shall not exceed 28 UI peak-to-peak within a period of 24 hours.

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 Recommendation G.706, § 2.

4.7 *Maintenance*

4.7.1 *General introduction*

Recommendation 1.604 specifies an overall approach to be employed in maintaining ISDN primary rate access. However, since the required maintenance functions may influence the design of terminating pieces of equipment, a brief description of primary rate access maintenance is presented in this Recommendation.

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.

   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.).

c)   Other maintenance functions are for further study.

4.7.3 *Definition of maintenance signals at the interface*

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. RAI is coded as continuously repeated 16-bit sequences of eight binary ONEs and eight binary ZEROs (1111111100000000) in the m bit. *[Note – HDLC flag patterns (01111110) are transmitted in the m bits when no information signal is to be sent.]*

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 coded as a binary all ONEs, 1544 kbit/s bit stream.

In leased line circuit applications with no D-channel, some channel-associated layer maintenance messages may need to be transferred across the interface. These maintenance messages would be transported in the m bit. Further characteristics of these messages are for further study.

4.7.4 *CRC-6 in-service performance monitoring and reporting*

Messages in the m bit that exercise CRC-6 performance monitoring capabilities can be used to sectionalize troubles in the primary rate access. This sectionalization could be accomplished from either the NT or the TE. Characteristics of these maintenance messages are for further study.

5   Interface at 2048 kbit/s

5.1   *Electrical characteristics*

This interface should conform to Recommendation G.703, § 6, 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 pair) 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 frame/s.

5.2.3   *Assignment of bits in time slot 0*

The bits of time slot 0 are in accordance with Recommendation G.704, § 2.3.2. 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. Sa bits with position 5, 6, 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 § 5.2.3.

5.2.4.2   *D-channel*

Time slot 16 is assigned to the D-channel when this channel is present. The assignment of time slot 16 when not used for a D-channel is for further study.

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 Ho-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_{t2}-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.

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

Note 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 Ho-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.

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 6/1.431.

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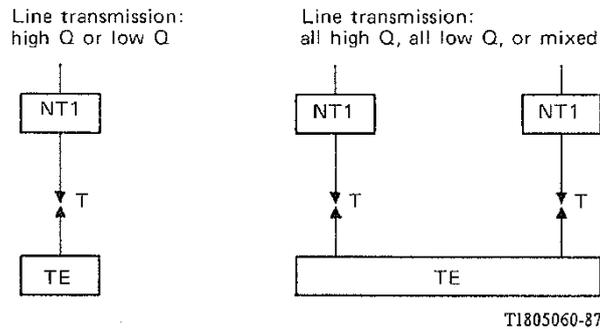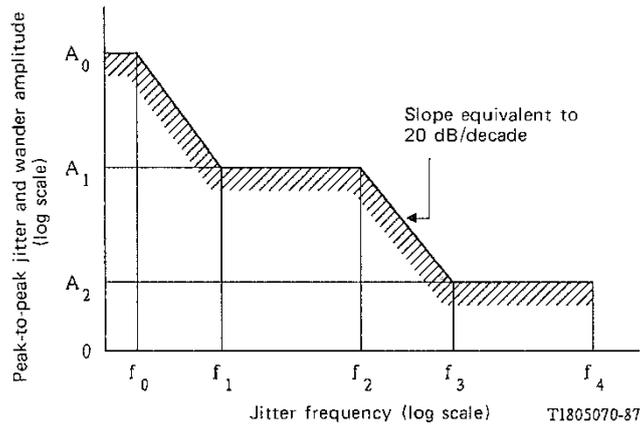

FIGURE 6/1.431
Examples of single and multiple accesses

5.4.2 *Minimum tolerance to jitter and wander at TE inputs*

The 2 0 4 8   kbit/s inputs of a TE shall tolerate sinusoidal input jitter/wander in accordance with Figure 7/I.431 without producing bit errors or losing frame alignment.

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

Note 1 — A_0 represents Maximum Relative Time Interval Error (MRTIE) as defined in Recommendation G.812, i.e. a phase difference between the synchronizing input and the input being considered.

Note 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 7/I.431

Minimum tolerable jitter and wander at the TE input

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*

a)   With no jitter at the input supplying timing or in the free-running mode, the TE output jitter shall be in accordance with Table 6/I.431.

b)   With jitter present at the input supplying timing, the output jitter is the sum of the intrinsic jitter of the TE plus the input jitter multiplied by the jitter transfer characteristics.

The jitter transfer characteristics shall conform to Figure 8/1.431.

TABLE 6/I.431T

Measurement filter bandwidth		Output jitter: (UI peak to-peak)
Lower cutoff	Upper cutoff	
20 Hz	100 kHz	≤ 0.125
700 Hz	100 Hz	≤ 0.12
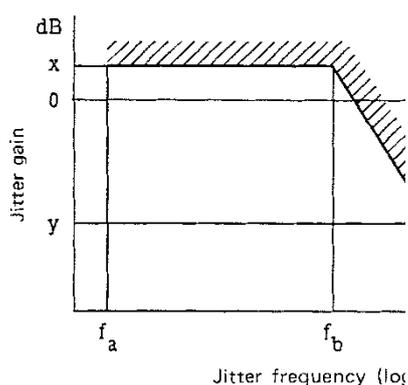
Y	X	f_a	f_b
−19.5 dB	0.5 dB	10 Hz	40 H

FIGURE 8/I.431
Jitter transfer characteristics

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

a) With no jitter at the input (or inputs) supplying timing or in the free running mode see § 5.4.3.1 a).

b) In the multiple access case the output jitter depends on:

- the input jitter of each access;
- the transfer characteristic;
- the timing extraction and distribution concept;
- the future growth of the TE. Since the timing extraction and distribution concept of the TE is outside of the scope of this Recommendation, the output jitter at each individual individual access can be controlled only by the definition of the appropriate jitter transfer characteristic in the TE.

In order to restrict the output jitter to tolerable values and to simplify testing, the jitter transfer characteristic between any receiver and its associated transmitter shall be tested to the transfer characteristic given in Figure 8/I.431 and the following parameters:

Y	X	f_a	f_b	F_c	f_d
−19.8 dB	0.2 dB	not to be defined	0.1 Hz	1 Hz	100 Hz

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 9/I.431.
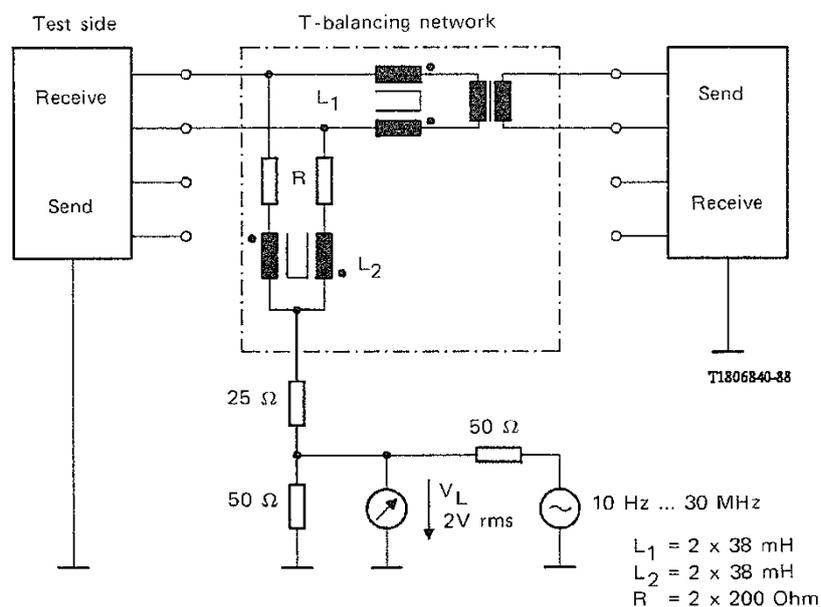
Note − The inherent longitudinal conversion loss of the T-balancing network should be 20 dB better than required at the interface under test (see Recommendation O.121).

FIGURE 9/I.431
Test of tolerance to longitudinal voltage

5.6   *Output signal balance*

Output signal balance, which is measured in accordance with Recommendation 0.9, § 2.7, shall meet the following requirements:

 a) f = 1 MHz: $\geq$ 40 dB

 b)   1 MHz $< f \leq$ 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:

$$10 \text{ Hz} < f \leq 1 \text{ MHz: } > 1000 \text{ ohm}$$

This requirement is met if the test according to Figure 10/I.431 results in a voltage $V_{Test} \leq 20$ mV rms.

G = CRC generator
M = CRC monitor
— = Mandatory
... = Optional
L = Local "CRC error" information
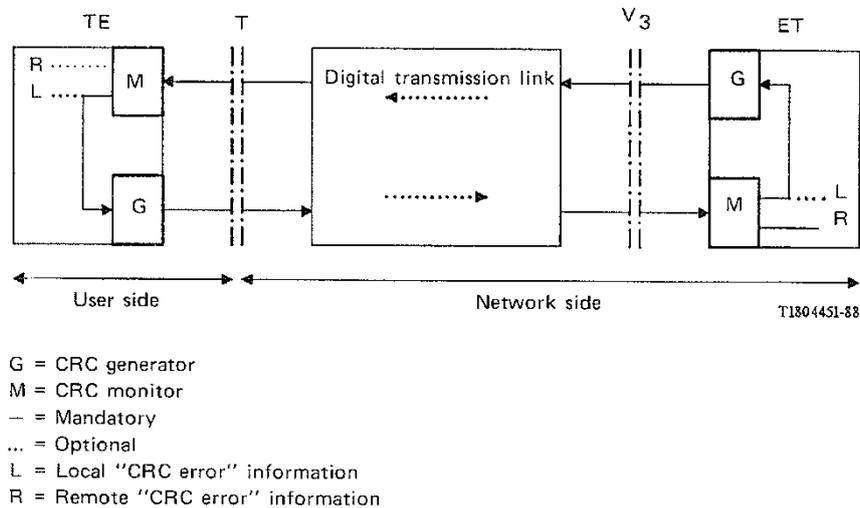R = Remote "CRC error" information

FIGURE 10/I.431
Test of minimum impedance towards ground

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 Recommendation G.706, § 4.

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 on layer 1 for the 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   *Definitions of maintenance signals*

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. 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 1

RAI not present: A-bit set to 0.

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 coded as a binary all ONEs, 2048 kbit/s bit stream.

CRC error report: E bit (see Table 4b/G.704) in operational frames.

5.9.2   *Use of CRC procedure*

5.9.2.1   *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 is E = "0" for a block with failure and E = "1" 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 codes);

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.

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

5.9.2.2.1   *No CRC processing in the transmission link*

Figure 11/I.431 gives the locations of the CRC function processes in a subscriber access when there is no CRC processing in the transmission link.
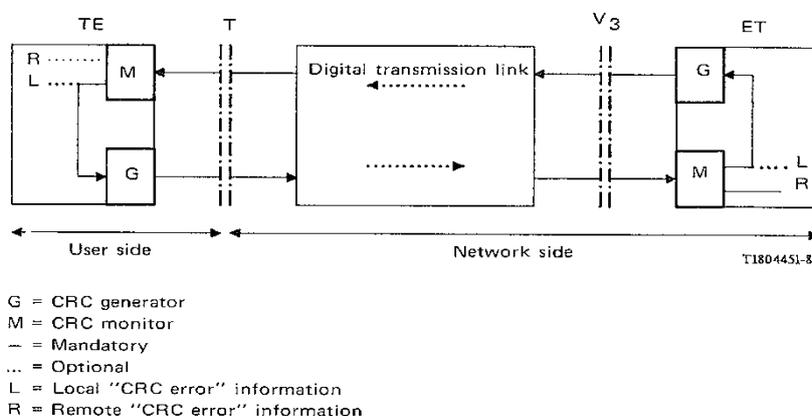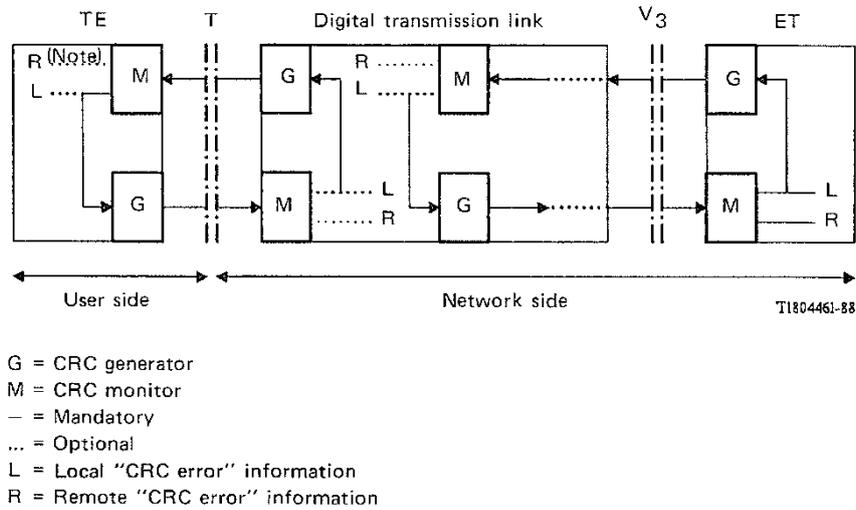

FIGURE 11/I.431
**Localization of CRC processing functions for a subscriber access
when the transmission link does not process the CRC**

5.9.2.2.2 *CRC processing in the digital transmission link*

Figure 12/I.431 gives the locations of CRC function processes in a subscriber access, with CRC processing in the NT.

G = CRC generator
M = CRC monitor
— = Mandatory
... = Optional
L = Local "CRC error" information
R = Remote "CRC error" information

Note — The processing of remote CRC error information provides enhanced defect localization from the user point of view.

FIGURE 12/I.431
**Localization of CRC processing function for a subscriber access
with CRC processing in the digital transmission link**

5.9.3 *Maintenance functions*

5.9.3.1 *General requirements*

The equipments 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.

5.9.3.2 *Maintenance functions on the user side*

5.9.3.2.1 *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 – The detection of this defect is required only when it has not the effect of a loss of frame alignment indication.

5.9.3.2.2 *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.

5.9.3.2.3   *Consequent actions*

Table 7/I.431 gives the actions that the user side (TE function) has to take after the detection of a defect or of a defect indication signal.

Note 1 — 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.

Note 2 — The following points are required to ensure that an equipment is not removed from service due to short breaks in transmission:

i)   The persistence of an RAI or of an AIS shall be verified for at least 100 ms before action is taken;

ii)   When an RAI or an AIS disappears, action shall be taken immediately.

5.9.3.3   *Maintenance functions on the network side*

5.9.3.3.1   *Defect detection*

All the following defect conditions shall be detected by the network side of the T interface (NTI, 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.

Note 1 – The equipment of the primary rate digital link (NTI, LT, etc.) have to detect loss of incoming signal and then to generate downstream towards the interface the fault indication signal AIS.

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

TABLE 7/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

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

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

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

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

5.9.3.3.2 *Detection of defect indication signals*

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

– remote alarm indication (RAI);

– CRC error information.

5.9.3.3.3 *Consequent actions*

Table 8/I.431 gives the actions that the network side (NT1, ET functions) has to take after defect detection or defect indication detection.

Note 1 – 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.

Note 2 – The following points are required to ensure that an equipment is not removed from service due to short breaks in transmission:

i) the persistence of an RAI or of an AIS shall be verified for at least 100 ms before action is taken;

ii) when an RAI or an AIS disappears, action shall be taken immediately.

TABLE 8/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

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

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

Note 3 – See CCITT Recommandation 1.604.

6 Connector

Interface connectors and contact assignments are the subject of ISO and IEC standards. However, permanent wiring connections of TEs to NTs are also permitted.

7 Interface wiring

In case of symmetrical wiring, the magnitude of the characteristic impedance of the interface cables shall be 120 ohm ± 20% in a frequency range 200 kHz to 1 MHz and 120 ohm ± 10% at 1 MHz.

For coaxial interfaces, the magnitude of the characteristic impedance of the interface cables shall be 75 ohm (± 5% at 1024 kHz).

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 transmission, is optional.

8.2 *Power available at the NT*

The power available at the NT via the user-network interface, when provided, shall be at least 7 watts.

8.3 *Feeding voltage*

The feeding voltage for the NT shall be in the range of – 32 to – 57 volts.

The polarity of the voltage towards ground shall be negative.

8.4 *Safety requirements*

In principle, safety requirements are outside the scope of this Recommendation. However, in order to harmonize power source requirements the following information is provided:

i) the voltage source and the feeding interface should be protected against short circuit or overload. The specific requirements are for further study;

ii) the power input of NT1 shall not be damaged by an interchange of wires.

With respect to the feeding interface of the power source, which is regarded as a touchable part in the sense of IEC Publication 950, the protection methods against electric shock specified in IEC Publication 950 may be applied.

ANNEX A

(to Recommendation I.431)

Time slot assignment for interfaces having only Ho-channels

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

A.1   *1544 kbit/s interface*

Ho-channel	a	b	c	d
Time slots used	1 to 6	7 to 12	13 to 18	19 to 24[a]

[a] This fourth Ho-channel is available if time slot 24 is not used for a D-channel.

A.2   *2048 kbit/s interface*

Example I

Ho-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

Ho-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

(to Recommendation I.431)

Time slot assignment for 2048 kbit/s interfaces having an H11-channel

The following is an example of fixed assignment of times slots when an $H_1 1$-channel is present at the interface.
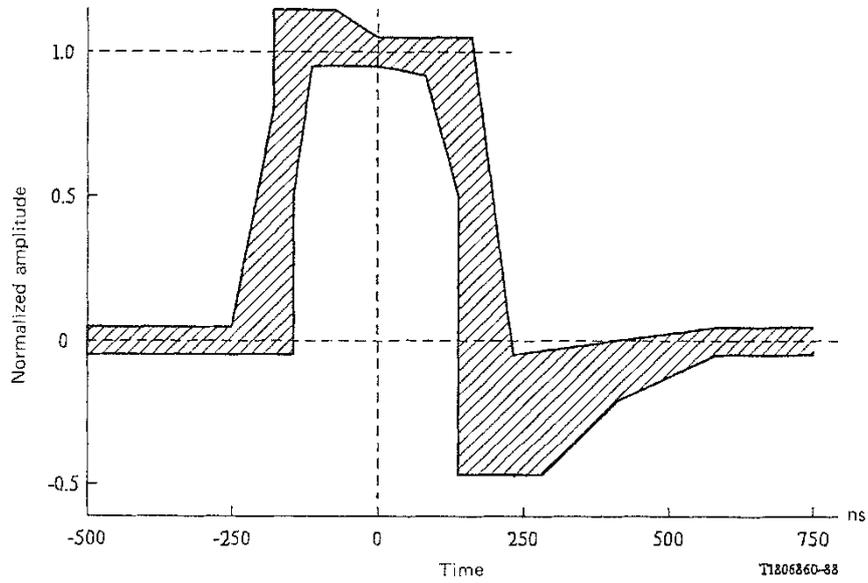
H_{11}-channel	1-15	16-24
Time slots used	1-15	17-25

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 Ho-channel or six B-channels.

APPENDIX I

(to Recommendation I.431)

Pulse mask for interface at 1544 kbit/s

An isolated pulse, when scaled by a constant factor, shall fit the pulse mask shown in Figure I-1/I.431.

Corner points for upper curve

Time	ns	−500	−250	−175	−175	−75	0,0	175	225	600	750
	UI	−0.77	−0.39	−0.27	−0.27	−0.12	0.0	0.27	0.35	0.93	1.16
Amplitude		0.05	0.05	0.80	1.15	1.15	1.05	1.05	−0.07	0.05	0.05

Corner points for lower curve

Time	ns	−500	−150	−150	−100	0.0	0.15	150	150	300	425	600	750
	UI	−0.77	−0.23	−0.23	−0.15	0.0	100	0.23	0.23	0.46	0.66	0.93	1.16
Amplitude		−0.05	−0.05	0.50	0.95	0.95	0.90	0.50	−0.45	−0.45	−0.20	−0.05	−0.05

Note − UI = Unit Interval = 647.7 ns.

FIGURE I-1/I.431
Pulse mask for interface at 1544 kbit/s

ITU-T RECOMMENDATIONS SERIES

Series A	Organization of the work of the ITU-T
Series B	Means of expression: definitions, symbols, classification
Series C	General telecommunication statistics
Series D	General tariff principles
Series E	Overall network operation, telephone service, service operation and human factors
Series F	Non-telephone telecommunication services
Series G	Transmission systems and media, digital systems and networks
Series H	Audiovisual and multimedia systems
Series I	**Integrated services digital network**
Series J	Transmission of television, sound programme and other multimedia signals
Series K	Protection against interference
Series L	Construction, installation and protection of cables and other elements of outside plant
Series M	TMN and network maintenance: international transmission systems, telephone circuits, telegraphy, facsimile and leased circuits
Series N	Maintenance: international sound programme and television transmission circuits
Series O	Specifications of measuring equipment
Series P	Telephone transmission quality, telephone installations, local line networks
Series Q	Switching and signalling
Series R	Telegraph transmission
Series S	Telegraph services terminal equipment
Series T	Terminals for telematic services
Series U	Telegraph switching
Series V	Data communication over the telephone network
Series X	Data networks and open system communications
Series Y	Global information infrastructure and Internet protocol aspects
Series Z	Languages and general software aspects for telecommunication systems