4. Recommendation I.431

PRIMARY RATE USER-NETWORK INTERFACE - LAYER 1 SPECIFICATION

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 Ia and Ib defined in Figure 1/I.431.

Note - Ia and Ib are located at the input/output port of the TE/NT.

FIGURE 1/I.431

Location of interfaces

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

3. Functional characteristics

3.1 Summary of functions (Layer 1)

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.

H0 Channel

This function provides for the bidirectional transmission of independent H0 Channel signals each having a bit rate of 384 kbit/s as defined in Recommendation I.412.

H1 Channels

This function provides for the bidirectional transmission of an H1 Channel signal having a bit rate of 1536 (H11) or 1920 (H12) bit/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 enabling 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 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 possible exception of 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 as defined in Recommendations I.420 and I.421 (see § 3.4.5). The primitives PH-AR, ± PH-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 paragraph the term network is used to indicate either:

- NT1, LT and ET functional groups in case of interface at T reference point;

or

- relevant parts of NT2 functional group in case of interface at S reference point.

The term 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/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 - CRC error information (see Recommendation G.704) - no defect indication
R A I	Operational frame with: - active associated CRC - CRC error information (Note) - with defect indication (see Recommendation G.704) (2048 kbit/s systems only)
LOS	No received incoming signal (Loss of signal)
AIS	Continuous stream of ONEs (Recommendation G.803)
CRC error information	E bit according to Recommendation G.704, Table 4b, set to "ZERO" if CRC block received with error (2048 kbit/s systems only)

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, the first one at the user side and the second 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.

Defect conditions FC1-FC4 that could occur at the network side or between the network side and user side are defined in Figure 3/I.431. These defect conditions directly affect the F and G states. Information on these defect 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 user and network side of the interface (system reactions, user and network responsible 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 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:

- the network clock and layer 1 service is available;

- the user side transmits and receives operational frames with associated CRC and with temporary CRC error information (Note 1);

- the user side checks the received frames and the associated CRC, and generates towards the network 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;

- the network clock is available at the user side;

- the user side receives operational frames with associated CRC and with temporary CRC error information (Note 1);

- the received frames contain RAI;

- the user side transmits operational frames with associated CRC;

- the user side checks the received frames and the associated CRC 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;
- the network clock 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 and RAI (Note 3).

F4 STATE: Fault condition No. 3:

- this fault state corresponds to fault condition FC3;
- the network clock is not available at the user side;
- the user side detects AIS;
- the user side transmits towards the network operational frames with associated CRC and RAI (Note 3).

F5 STATE: Fault condition No. 4:

- this fault state corresponds to the fault condition FC4;
- the network clock is available at the user side;
- the user side receives operational frames with continuous CRC error information (optional) (Note 2);
- the received frames contain RAI;
- the user side transmits operational frames with associated CRC;
- the user side checks the received frames and the associated CRC which may generate 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 - Only in options 2 and 3, as defined in Recommendation I.604, for CRC error information.

Note 3 - 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.

3.4.4 Layer 1 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.

G1 STATE: Operational state:

- the network clock and layer 1 service is available;
- the network side transmits and receives operational frames with associated CRC and temporary CRC error information;
- the network side checks the received frames and the associated CRC and generates towards 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;
- the network clock is provided to the user side;
- the network side receives operational frames with associated CRC;
- the network side transmits operational frames with associated CRC 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;
- the network clock is not provided to the user side;
- the network side transmits operational frames with associated CRC;
- the network side receives operational frames with associated CRC and RAI (Note 3).

G4 STATE: Fault condition No. 3:

- this fault state corresponds to the fault condition FC3;
- the network clock is not provided to the user side;
- the network side transmits AIS;
- the network side receives operational frames with associated CRC and RAI (Note 3).

G5 STATE: Fault condition No. 4:

- this fault states corresponds to the fault condition FC4;
- the network clock is provided to the user side;
- the network side detects loss of incoming signal or loss of frame alignment;
- the network side transmits operational frames with associated CRC 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 - Only in options 2 and 3, as defined in Recommendation I.604 for CRC error information.

Note 3 - 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.

3.4.5 Definition of primitive

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

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.

TABLE 2/I.431

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

PA-AI = PH Activate Indication

PH-DI = PH Deactivate Indication

MPH-EIn = MPH error Indication with parameter n (n = 0 to 4)

Note 1 - These events cover 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) 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, therefore, the signal "RAI with continuous CRC error report" does not occur.

Note 2 - These states cover 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 not processing CRC-error information when accompanied with RAI, even if provided, merges states F2 and F5.

TABLE 3/I.431

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

PH-AI = PH Activate Indication

PH-DI = PH Deactivate Indication

MPH-EIn = MPH Error Indication with parameter n (n = Q to 4)

Note 1 - In the case of no CRC processing in the digital link, the state G5 is identical to state G2.

Note 2 - 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 identical at the interface (see § 5.9).

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

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 medium

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 Ib 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 (Appendix 1). This pulse mask is for further study.

An isolated pulse shall satisfy the requirements set out in Table 4/I.431.

TABLE 4/I.431

Digital interface at 1544 kbit/s

Note 1 - B8ZS is a modified AMI code in which eight consecutive zeros are replaced with 000 + - 0 - + if the preceding pulse was positive (+) : 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 1s 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 ± 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 a $\sqrt{f}$ 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/I.431

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 8 000 frames/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

Note 1 - With the exception of § 4.7.3 the use of the m bit/s is for further study (for example, for maintenance and operational information).

4.3 Timing considerations

This paragraph 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 H0 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 H0 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.

A1 : 5.0 UI
A2 : 0.1 UI
f1 : 120 Hz
f2 : 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

The pattern including at least three binary ONEs in an octet must be transmitted on 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 on every time slot of a channel that is not allocated to a call in both directions.

4.6.2 Interframe (layer 2) timefill

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 I.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 clock 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 8 000 frames/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.

Sa 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 H0 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 H12 Channel shall be assigned time slots 1 to 15 and 17 to 31 in a frame and an H11 Channel may be assigned time slots as in the example given in Annex B.

Note 1 - 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 H0 Channels are present at the interface are given in Annex A.

5.2.4.4 Bit sequence independent

Time slots 1 to 31 provide bit sequence independent transmission.

5.3 Timing considerations

The NT derives its timing clock 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 circuits).

Examples of single and multiple accesses are given in Figure 6/I.431.

The reference signal for the jitter measurement is derived from the network clock. The nominal value for 1 UI is 488 ns.

FIGURE 6/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 7/I.431 without producing bit errors or losing frame alignment.

A_0	A_1	A_2	f_0	f1	f2	f3	f4
Note 1 20.5 UI	Note 2 1.0 UI	0.2 UI	12×10^{-6} Hz	20 Hz	3.6 kHz	18 kHz	100 kHz

Note 1 - Jitter/wander (MRTIE - Maximum Relative Time Interval Error) as defined in Recommendation G.812.

Note 2 - TEs for multipurpose application (i.e., also to private circuit run by public telecommunications operator) a jitter tolerance of 1.5 (with corresponding f2 at 2.4 kHz) may be required.

FIGURE 7/I.431

Minimum Tolerable jitter and wander at 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 running mode, the TE output jitter shall be in accordance with the table below:

Measurement Filter bandwidth:		Output jitter:
Lower Cutoff	Upper Cutoff	UI Peak-to-peak
20 Hz	100 kHz	≤ 0.125 UI
700 Hz	100 kHz	≤ 0.02 UI

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 with the jitter transfer characteristics.

The jitter transfer characteristics shall conform to Figure 8/I.431:

y	x	fa	fb	fc	fd
-19.5 dB	0.5 dB	10 Hz	40 Hz	400 Hz	100 kHz

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 multi-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 out of the scope of this Recommendation the output jitter at each 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	fa	fb	fc	fd
-19.8 dB	0.2 dB	not to be defined	0.1 Hz	1 Hz	100 kHz

5.5 Tolerable longitudinal voltage

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 VL.

VL = 2 Vrms over 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 0.121).

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 0.121, § 2.7, shall meet the following requirements:

a) $f = 1$ MHz : ≥ 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 Hz $< f \leq$ 1 MHz: > 1 000 Ohm

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

FIGURE 10/I.431

Test of minimum impedance towards ground

5.8 Interface procedures

5.8.1 Codes for idle channels and idle slots

The pattern including at least three binary ONEs in an octet must be transmitted on 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 on 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 - A-bit set to 1

No RAI - 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 clock provided to the TE may not be the network clock. AIS is coded as a binary all ONEs, 2048 kbit/s bit stream.

The CRC error information: E bit in time slot 0 of operational frames not containing the frame alignment signal.

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 of Recommendation G.704, the coding is E = "0" for block with failure and E = "1" for 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, the one has CRC processing in the transmission link and the other not.

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

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

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

iii) that the user side shall monitor the CRC procedure associated to 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 with the CRC procedure;

vi) that the network side shall monitor the CRC procedure associated to 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 with the CRC procedure;

ix) that the network side shall detect the CRC error information and to process all the received information according 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 without CRC processing in the transmission link.

LEGEND:

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

FIGURE 11/I.431

<u>Localization of CRC processing functions for a subscriber access when the transmission link does not process the CRC</u>

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.

LEGEND:

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

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 6/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 not received any more, 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.

TABLE 6/I.431

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

Defect conditions and signals detected by the user side	Consequent actions: Defect indication	Defect indications at the interface: Generation of RAI	Generation of CRC error info (see Note 4)
Loss of power on user side		Not applicable	Not applicable
Loss of signal		Yes	Yes (see Note 1)
Loss of frame alignment		Yes	No (see Note 2)
Reception of RAI		No	No
Reception of AIS		Yes	No (see 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 loss of frame alignment fault, so 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 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 T 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.

Note 1 - The equipment of the primary rate digital link (NT1, LT,...) 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.

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 informations.

5.9.3.3.3 Consequent actions

Table 7/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 not received any more, 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 7/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 RAI	Generation AIS	Generation of CRC error info
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 (Note 2)	No
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 rate	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 Recommendation I.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 1 024 kHz).

8. Power feeding

8.1 Provision of power

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

8.2 Power available at the NT

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

8.3 Feeding voltage

The feeding voltage for the NT shall be in the range of -32 to -57 volt.

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 H0 Channels

The following are examples of fixed assignment of time slots when only H0 Channels are present at the interface.

i) 1544 kbit/s interface

* This fourth H0 Channel is available if time slot 24 is not used for a D Channel.

ii) 2048 kbit/s interface

Example 1

Example 2

Note - The time slot assignment in Example 2 is the one described in Recommendation G.704 for n x 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 H11 Channel

The following is an example of fixed assignment of times slots when H11 Channel is present at the interface.

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 H0 Channel or six B Channels.

Appendix I/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.

Note - UI = Unit Interval = 647.7 ns

FIGURE I-1/I.431

Pulse mask for interface at 1544 kbit/s