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INTERNATIONAL TELECOMMUNICATION UNION

CCITT **I.432**

THE INTERNATIONAL
TELEGRAPH AND TELEPHONE
CONSULTATIVE COMMITTEE

INTEGRATED SERVICES DIGITAL NETWORK (ISDN) OVERALL NETWORK ASPECTS AND FUNCTIONS, ISDN USER-NETWORK INTERFACES

B-ISDN USER-NETWORK INTERFACE — PHYSICAL LAYER SPECIFICATION

Recommendation I.432

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FOREWORD

permanent organ of the International Telecommunication Union (ITU). CCITT is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The Plenary Assembly of CCITT which meets every four years, establishes the topics for study and approves Recommendations prepared by its Study Groups. The approval of Recommendations by the members of CCITT between Plenary Assemblies is covered by the procedure laid down in CCITT Resolution No. 2 (Melbourne, 1988).

Recommendation I.432 was prepared by Study Group XVIII and was approved under the Resolution No. 2 procedure on the 5th of April 1991.

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CCITT NOTES

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indicate both a telecommunication Administration and a recognized private operating agency.

2) A list of abbreviations used in this Recommendation can be found in Annex C.

Preamble to B-ISDN Recommendations

In 1990, CCITT SG XVIII approved a first set of Recommendations on B-ISDN. These are:

I.113 — Vocabulary of terms for broadband aspects of ISDN

I.121 — Broadband aspects of ISDN

I.150 — B-ISDN asynchronous transfer mode functional characteristics

I.211 — B-ISDN service aspects

I.311 — B-ISDN general network aspects

I.321 — B-ISDN Protocol Reference Model and its application

I.327 — B-ISDN functional architecture

I.361 — B-ISDN ATM Layer specification

I.362 — B-ISDN ATM Adaptation Layer (AAL) functional description

I.363 — B-ISDN ATM Adaptation Layer (AAL) specification

I.413 — B-ISDN user-network interface

I.432 — B-ISDN user-network interface — Physical Layer specification

I.610 — Operation and maintenance principles of B-ISDN access

These Recommendations address general B-ISDN aspects as well as specific service- and network-oriented issues, the fundamental characteristics of the asynchronous transfer mode (ATM), a first set of relevant ATM oriented parameters and their application at the user-network interface as well as impact on operation and maintenance of the B-ISDN access. They are an integral part of the well established I-Series Recommendations. The set of Recommendations are intended to serve as a consolidated basis for ongoing work relative to B-ISDN both within CCITT and in other organizations. They may also be used as a first basis towards the development of network elements.

CCITT will continue to further develop and complete these Recommendations in areas where there are unresolved issues and develop additional Recommendations on B-ISDN in the I-Series and other series in the future.

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B-ISDN USER-NETWORK INTERFACE — PHYSICAL LAYER SPECIFICATION

1 Introduction

This Recommendation defines a limited set of Physical Layer interface structures to be applied to the SB and TB reference points of the reference configurations of the B-ISDN user-network interface (UNI). It addresses separately the physical media and the transmission system structure that may be used at these interfaces and addresses also the implementation of the UNI related OAM functions.

The selection of the physical medium for the interfaces at the SB and TB reference points should take into account that optical fibre is agreed as the preferred medium to be used to cable customer equipment. However, in order to accommodate existing cabling of customer equipment, other transmission media (e.g. coaxial cables) should not be precluded. Also, implementations should allow terminal interchangeability.

This Recommendation reflects in its structure and content the desire to take care of such early configurations and introduces a degree of freedom when choosing a physical medium at the Physical Layer.

Maximum commonality between functions of the Physical Layer described here at the UNI and corresponding functions to be defined in the future at the NNI (network-node interface) is aimed at.

2 Physical medium characteristics of the UNI at 155 520 Mbit/s

2.1 *Characteristics of the interface at the TB reference point*

2.1.1 *Bit rate and interface symmetry*

The bit rate of the interface is 155 520 Mbit/s. The interface is symmetric, i.e. it has the same bit rate in both transmission directions.

2.1.2 *Physical characteristics*

Both optical and electrical interfaces are recommended. The implementation selected depends on the distance to be covered and user requirements arising from the details of the installation.

2.1.2.1 *Electrical interface*

2.1.2.1.1 *Interface range*

The maximum range of the interface is for further study. The connecting media between the transmitter and receiver must cover a span from 0 to 100 metres and possibly up to 200 metres.

2.1.2.1.2 *Transmission medium*

Two coaxial cables, one for each direction, are recommended. The wiring configuration is point-to-point.

2.1.2.1.3 *Electrical parameters*

The parameters for the 155 520 Mbit/s electrical interface in Recommendation G.703 should be used as appropriate.

2.1.2.1.4 *Connectors*

For further study.

2.1.2.2 *Optical interface*

2.1.2.2.1 *Interface range*

The range of the interface is for further study. The connecting media between the transmitter and receiver must cover a span from 0 to 800 metres and possibly up to 2000 metres.

2.1.2.2.2 *Transmission medium*

The optical media (e.g. single mode fibre, multimode fibre, single fibre, dual fibre, etc.) are for further study.

2.1.2.2.3 *Optical parameters*

The optical parameters are for further study [1]) .

2.1.2.2.4 *Connectors*

For further study.

2.2 *Characteristics of the interface at the SB reference point*

For further study.

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The parameters of Recommendation G.957, FDDI Standard ISO DIS-9314-3, etc. should be considered as a basis for these further studies.

3 Physical medium characteristics of the UNI at 622 080 Mbit/s

3.1 *Characteristics of the interface at the TB reference point*

3.1.1 *Bit rate and interface symmetry*

The bit rate of the interface in at least one direction is 622 080 Mbit/s. The symmetry of the interface is for further study. The following possible interfaces have been identified:

a) an asymmetrical interface with 622 080 Mbit/s in one direction and 155 520 Mbit/s in the other direction,

b) a symmetrical interface with 622 080 Mbit/s in both directions.

Note — Other solutions are for further study.

If option a) is chosen, then the 155 520 Mbit/s component should comply with the characteristics of § 2.

3.1.2 *Physical characteristics*

3.1.2.1 *Electrical interface*

The feasibility and range of application of an electrical interface is for further study.

3.1.2.2 *Optical interface*

The parameters of § 2.1.2.2 should be used as appropriate.

3.2 *Characteristics of the interface at the SB reference point*

For further study.

4 Functions provided by the transmission convergence sublayer

4.1 *Transfer capability*

4.1.1 *Interface at 155 520 Mbit/s*

At the physical level at the interface at the TB reference point the bit rate is 155 520 Mbit/s. The bit rate available for user information cells, signalling cells and ATM and higher layers OAM information cells, excluding Physical Layer related OAM information, transported in bytes or cells, is 149 760 Mbit/s.

4.1.2 *Interface at 622 080 Mbit/s*

At the physical level at the interface at the TB reference point, the bit rate is 622 080 Mbit/s in at least one direction (see § 3.1). The bit rate available for user information cells, signalling cells, and ATM and higher layer OAM information cells, excluding Physical Layer related OAM information, transported in bytes or cells, is for further study.

4.2 *Transmission frame adaptation*

4.2.1 *Physical Layer for the cell-based interface*

4.2.1.1 *Timing*

At the customer side of the interface at the TB reference point, the cell-based Physical Layer may derive its timing from the signal received across the interface or provide it locally by the clock of the customer equipment.

The tolerance value of the bit rate is for further study.

4.2.1.2 *Interface structure*

The interface structure consists of a continuous stream of cells. Each cell contains 53 octets.

4.2.1.3 *OAM implementation*

4.2.1.3.1 *Transmission overhead allocation*

Physical Layer OAM cells are used for the conveyance of the Physical Layer OAM information. How often OAM cells are inserted should be determined by OAM requirements.

4.2.1.3.2 *OAM cell identification*

The Physical Layer OAM cell must have a unique header so that it can be properly identified by the Physical Layer at the receiver. The pattern to be used is shown in Table 1/I.432 (see Note 1).

The possible need to identify other header values among those reserved for the use of the Physical Layer (see Recommendation I.361, § 2.2.1) to accommodate future identified OAM flows is for further study.

µTABLE 1/I.432

Header pattern for OAM cell identification

	Header pattern
Octet 1	00000000
Octet 2	00000000
Octet 3	00000000
Octet 4	00001001
Octet 5	HEC = Valid code (Note 2)

Note 1 — There is no significance to any of these individual fields from the point of view of the ATM Layer, as Physical Layer OAM cells are not passed to the ATM Layer.

Note 2 — This value depends on the outcome of the studies of the suitability of the scrambler of § 4.5.3 for the cell-based Physical Layer

4.2.1.3.3 *Allocation of OAM functions in information field*

Overhead allocation for the OAM functions (listed in Table 2/I.610) via the physical OAM cell is for further study.

4.2.1.3.4 *Maintenance signals*

Two maintenance signals are defined:

— alarm indication signal (AIS),

— far end receive failure (FERF).

The use, generation and detection of AIS and FERF is for further study.

Other maintenance signals are for further study.

4.2.1.3.5 *Transmission performance monitoring*

Transmission performance monitoring across the UNI is performed to detect and report transmission errors.

An error code calculated over all cells between two successive Physical Layer OAM cells is inserted in the information field of the relevant OAM cell. The encoding is for further study.

4.2.1.3.6 *Control communication*

For further study.

4.2.1.3.7 *OAM procedures*

For further study.

4.2.2 *Physical Layer for the SDH-based interface*

4.2.2.1 *Timing*

In normal operation, timing for the transmitter is locked to the timing received across the interface. The exact tolerance under fault conditions is for further study.

4.2.2.2 *Interface structure at 155 520 Mbit/s*

The bit stream of the interface has an external frame based on the synchronous digital hierarchy (SDH) as described in Recommendations G.707, G.708, and G.709. Specifically, the frame is given in Recommendation G.709, and illustrated in Figure 1/I.432.

The ATM cell stream is first mapped into the C-4 and then packed in the VC-4 container along with the
VC-4 path overhead (see Figure 1/I.432). The ATM cell boundaries are aligned with the STM-1 octet boundaries. Since the C-4 capacity (2340 octets) is not an integer multiple of the cell length (53 octets), a cell may cross a C-4 boundary.
FIGURE 1/I.432 = 12 cm

The AU-4 pointer (bytes H1 and H2 in the SOH) is used for finding the first byte of the VC-4. Path overhead (POH) bytes J1, B3, C2, G1 and H4 are utilised. Use of the remaining POH bytes is for further study.

The H4 pointer will be set at the sending side to indicate the next occurrence of a cell boundary. The H4 pointer provides a cell boundary indication which may optionally be used to supplement the mandatory HEC cell delineation mechanism (see § 4.5).

The H4 octet indicates the offset in octets from itself to the first cell boundary following the H4 octet in the C-4 payload. The permissible range of values of H4 is 0 to 52. The bit allocation for the H4 octet is given in Figure 2/I.432

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Unused

Unused

Cell offset indicator

1

2

MSB
3

4

5

6

7

LBS
8

Note — The bit numbering used in Figure 2/I.432 is different from the conventions used in I.361 but in accordance with Recommendation G.709.
FIGURE 2/I.432

H4 octet bit allocation for ATM cell mapping into SDH

4.2.2.3 *Interface structure at 622 080 Mbit/s*

This section is for further study.

4.2.2.4 *OAM implementation*

4.2.2.4.1 *Transmission overhead allocation*

Transmission overhead allocation for the SDH Physical Layer functions (listed in Table 1/I.610) is given in Table 2/I.432. Use of these overheads (e.g. for frame alignment, AU pointer generation/interpretation, bit interleaved parity (BIP) code calculation, etc.) shall be in accordance with specifications in Recommendations G.708 and G.709 for the SDH network node interface.

4.2.2.4.2 *Maintenance signals*

Two types of maintenance signals are defined for the Physical Layer to indicate the detection and location of a transmission failure. These signals are:

- alarm indication signal (AIS);
- far end receive failure (FERF).

which are applicable at both the SDH section and path layers of the Physical Layer.

AIS is used to alert the associated downstream termination point and connection point that an upstream failure has been detected and alarmed.

Far end receive failure (FERF) is used to alert the associated upstream termination point that a failure has been detected downstream. Path FERF alerts the upstream path termination point that a failure has occurred along the downstream path.

Generation and detection of section and path AIS or FERF shall be in accordance with Recommendation G.709.

µTABLE 2/I.432

SDH overhead bytes allocation at B-UNI

Octet

Function

Coding (Note 1)

STM-1 section overhead

A1, A2
C1
B1
B2
H1, H2
H3
K2 (bits 6-8)
Z2 (bits 18-24)

Frame alignement
STM-1 identifier
Section error monitoring (Note 2)
Section error monitoring
AU-4 pointer, Path AIS (Note 4)
Pointer action
Section AIS/section FERF
Section error reporting (FEBE)
(Note 5)

BIP-8
BIP-24
A11 1s

111/110
B2 error count

VC-4 path overhead

J1
B3

C2
G1 (bits 1-4)
G1 (bit 5)

4.2.2.4.3 *Transmission performance monitoring*

Transmission performance monitoring across the UNI is performed to detect and report transmission errors. Performance monitoring is provided for the section and for the path corresponding respectively to maintenance flows F2 and F3 in Figure 5/I.610.

At the SDH section (F2 flow), monitoring of the incoming signal is performed using the BIP-24 inserted into the B2 field. Monitoring of the outgoing signal is performed using the far end block error (FEBE). This error count, obtained from comparing the calculated BIP-24 and the B2 value of the incoming signal at the far end, is inserted in the Z2 field bits 18 to 24 and send back and reports to the near end section termination point about the error performance of its outgoing signal as FEBE.

Similar to the SDH section, at the SDH path (F3 flow), monitoring of the incoming signal is performed using the BIP-8 of the B3 octet. Monitoring of the outgoing signal is performed using the path FEBE of bits 1-4 of the G1 octet.

Regenerator section monitoring (F1 flow) across the UNI is optional. If required, the incoming signal is monitored using the BIP-8 of the B1 octet. Capabilities in the SDH section overhead for monitoring the outgoing signal are not provided.

4.2.2.4.4*Control communication*

Section layer communication channels and orderwires across the UNI are not required and are not provided.

Additional functions such as loopbacks (or their functional equivalent) or path layer communication channels could be provided. Requirements for additional functions are for further study.

The use of octets K1 and K2 (bits 1-5) for automatic protection switching across the UNI is for further study.

4.2.2.4.5*OAM procedures*

For further study.

4.3 *Header error control*

4.3.1 *Header error control functions*

The header error control (HEC) covers the entire cell header. The code used for this function is capable of either:

— single-bit error correction, or

— multiple-bit error detection.

The detailed description of the HEC procedure is given in § 4.3.2. Briefly, the transmitting side computes the HEC field value. The receiver has two modes of operation as shown in Figure 3/I.432. The default mode provides for single-bit error correction. Each cell header is examined and, if an error is detected, one of two actions takes place. The action taken depends on the state of the receiver. In “correction mode” only single-bit errors can be corrected and the receiver switches to “detection mode”. In “detection mode”, all cells with detected header errors are discarded. When a header is examined and found not to be in error, the receiver switches to “correction mode”.
FIGURE 3/I.432 = 8 cm

The flow chart in Figure 4/I.432 shows the consequence of errors in the ATM cell header. The error protection function provided by HEC provides both recovery from single-bit header errors, and a low probability of the delivery of cells with errored headers under bursty error conditions. The error characteristics of fibre-based transmission systems appears to be a mix of single-bit errors and relatively large burst errors. For some transmission systems the error correction capability might not be invoked.

FIGURE 4/I.432 = 21 cm

Annex A gives information on how random bit errors impact the probability of occurrence of discarded cells and valid cells with errored headers.

4.3.2 *Header error control (HEC) sequence generation*

The transmitter calculates the HEC value across the entire ATM cell header and inserts the result in the appropriate header field.

The notation used to describe the header error control is based on the property of cyclic codes. (For example a code vector such as 1000000100001 can be represented by a polynomial $P(x) = x^{12} + x^5 + 1$.) The elements of an
n-element code word are thus the coefficients of a polynomial of order n-1. In this application, these coefficients can have the value 0 or 1 and the polynomial operations are performed using modulo 2 operations. The polynomial representing the content of a header excluding the HEC field is generated using the first bit of a header as the coefficient of the highest order term.

The HEC field shall be an 8-bit sequence. It shall be the remainder of the division (modulo 2) by the generator polynomial $x^8 + x^2 + x + 1$ of the product x^8 multiplied by the content of the header excluding the HEC field.

At the transmitter, the initial content of the register of the device computing the remainder of the division is preset to all 0s and is then modified by division of the header excluding the HEC field by the generator polynomial (as described above); the resulting remainder is transmitted as the 8-bit HEC.

To significantly improve the cell delineation performance in the case of bit-slips the following is recommended:

— the check bits calculated by the use of the check polynomial are added (modulo 2) to an 8-bit pattern before being inserted in the last octet of the header;

— the recommended pattern is "01010101" (the left bit is the most significant bit);

— the receiver must subtract (equal to add modulo 2) the same pattern from the 8 HEC bits before calculating the syndrome of the header.

This operation in no way affects the error detection/correction capabilities of the HEC.

As an example if the first 4 octets of the header were all zeros the transmitted header would be "00000000 00000000 00000000 00000000 01010101". The starting value for the polynomial check is 0 . . 00 (binary).

4.4 *Idle cells*

Idle cells cause no action at a receiving node except for cell delineation. They are inserted and discarded for cell rate decoupling.

Idle cells are identified by the standardized pattern for the cell header [2]) shown in Table

2)

There is no significance to any of these individual fields from the point of view of the ATM

3/I.432.

µTABLE 3/I.432

Header pattern for idle cell identification

	Header pattern
Octet 1	00000000
Octet 2	00000000
Octet 3	00000000
Octet 4	00000001
Octet 5	HEC = Valid code

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Layer, as idle cells are not passed to the ATM Layer.

The content of the information field is for further study.

4.5 *Cell delineation and scrambling*

4.5.1 *Cell delineation and scrambling objectives*

Cell delineation is the process which allows identification of the cell boundaries.

The ATM cell header contains a header error control (HEC) field which is used to achieve cell delineation.

The ATM signal is required to be self-supporting in the sense that it has to be transparently transported on every network interface without any constraints from the transmission systems used.

Scrambling will be used to improve the security and robustness of the HEC cell delineation mechanism as described in § 4.5.1.1. In addition it helps randomizing the data in the information field for possible improvement of the transmission performance.

Any scrambler specification must not alter the ATM header structure (as described in Recommen-dation I.361), header error control (as described in § 4.3), and cell delineation algorithm (as described in § 4.5.1.1).

4.5.1.1 *Cell delineation algorithm*

The recommended cell delineation method is performed by using the correlation between the header bits to be protected (32 bits) and the relevant control bits (8 bits) introduced in the header by the HEC (header error control) using a shortened cyclic code with generating polynomial $x8 + x2 + x + 1$.

Figure 5/I.432 shows the state diagram of the HEC cell delineation method.
FIGURE 5/I.432 = 12 cm

The details of the state diagram are described below:

1) In the HUNT state, the delineation process is performed by checking bit by bit whether the HEC coding law is respected (i.e. syndrome equals zero) for the assumed header field. Once such an agreement is found, it is assumed that one header has been found, and the method enters the PRESYNCH state. When octet boundaries are available within the receiving Physical Layer prior to cell delineation, the cell delineation process may be performed octet by octet.
2) The process repeats until the encoding law has been confirmed DELTA times consecutively.
3) In the SYNCH state the cell delineation will be assumed to be lost if the HEC coding law is recognized incorrectly ALPHA times consecutively.

The parameters ALPHA and DELTA have to be chosen to make the cell delineation process as robust and secure as possible and able to satisfy the performance specified in § 4.5.2.

Robustness against false misalignments due to bit errors depends on ALPHA.

Robustness against false delineation in the resynchronization process depends on the value of DELTA.

Values of ALPHA = 7 and DELTA = 6 are suggested.

4.5.2 *Cell delineation performance*

This section is for further study. Figures B-1/I.432 and B-2/I.432 give provisional information on the performance of the cell delineation algorithm described in § 4.5.1.1 in the presence of random bit errors, for various values of ALPHA and DELTA.

4.5.3 *Scrambler operation*

The following polynomial has been identified for the SDH-based Physical Layer.

Self synchronizing scrambler *x*43 + 1

This self synchronizing scrambler polynomial has been selected to minimize the error multiplication (two) introduced by the self synchronizing scrambler.

The operation of this scrambler in relation to the HEC cell delineation state diagram is as follows:

— the scrambler randomizes the bits of the information field only;
— during the five octet header the scrambler operation is suspended and the scrambler state retained;
— in the HUNT state the descrambler is disabled;
— in the PRESYNCH and SYNC states the descrambler is enabled for a number of bits equal to the length of the information field, and again disabled for the following assumed header.

ANNEX A

(to Recommendation I.432)

Impact of random bit errors on HEC performance

FIGURE A-1/I.432 = 16 cm

ANNEX B

(to Recommendation I.432)

Impact of random bit errors on cell delineation performance

FIGURE B-1/I.432 = 14 cm

FIGURE B-2/I.432 = 13 cm

ANNEX C

(to Recommendation I.432)

Alphabetical list of abbreviations used in this Recommendation

AIS	Alarm indication signal
BIP	Bit interleaved parity
FEBE	Far end block error
FERF	Far end receive failure

HEC	Header error control
POH	Path overhead
SDH	Synchronous digital hierarchy
UNI	User network interface