INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

I.432.2
(02/99)

SERIES I: INTEGRATED SERVICES DIGITAL NETWORK

ISDN user-network interfaces – Layer 1 Recommendations

B-ISDN user-network interface – Physical layer specification: 155 520 kbit/s and 622 080 kbit/s operation

ITU-T Recommendation I.432.2

(Previously CCITT Recommendation)

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ITU-T RECOMMENDATION I.432.2

B-ISDN USER-NETWORK INTERFACE – PHYSICAL LAYER SPECIFICATION: 155 520 kbit/s AND 622 080 kbit/s OPERATION

Summary

This Recommendation covers Physical Layer characteristics for transporting ATM cells at nominal bit rates of 155 520 kbit/s and 622 080 kbit/s over coaxial cable and optical fibre interfaces at the T_B and S_B reference points of the B-ISDN User-Network Interface (UNI). The maximum distance is approximately 2 km for optical fibre and approximately 200 m for coaxial cable.

This Recommendation is part of the I.432 series, and includes references to Recommendation I.432.1 on general characteristics.

Source

ITU-T Recommendation I.432.2 was revised by ITU-T Study Group 13 (1997-2000) and was approved under the WTSC Resolution No. 1 procedure on the 26th of February 1999.

Keywords

ATM, B-ISDN, UNI, user-network.

FOREWORD

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B-ISDN USER-NETWORK INTERFACE – PHYSICAL LAYER SPECIFICATION: 155 520 kbit/s AND 622 080 kbit/s OPERATION

(revised in 1999)

1 Scope

This Recommendation covers Physical Layer characteristics for transporting ATM cells at nominal bit rates of 155 520 kbit/s and 622 080 kbit/s over coaxial cable and optical fibre interfaces at the T_B and S_B reference points of the B-ISDN User-Network Interface (UNI). The maximum distance is approximately 2 km for optical fibre and approximately 200 m for coaxial cable. The selection of the physical medium for the interfaces at the S_B and T_B reference points should take into account that optical fibre is agreed as the preferred medium to be used to cable customer equipment.

Functionality is presented in terms of physical media dependent and transmission convergence sublayers, and both SDH-based and cell-based formats are included.

The goal is to have maximum commonality between Physical Layer functions at the UNI described in the I.432-series Recommendations and any functions which may be defined in future at the Network-Node Interface (NNI). Implementations should allow terminal interchangeability.

2 Background

This Recommendation was previously contained in Recommendation I.432 (as published in March 1993), along with material now published as Recommendation I.432.1. Recommendation I.432.1 [12] contains those general characteristics which are relevant to all B-ISDN transmission systems at the UNI.

This Recommendation contains only those characteristics that are specific to transmission systems operating at 155 520 kbit/s and 622 080 kbit/s. Information on other bit rates can be found in other Recommendations of the I.432 series.

3 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; all users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published.

[1] ITU-T Recommendation G.825 (1993), *The control of jitter and wander within digital networks which are based on the Synchronous Digital Hierarchy (SDH).*

[2] ITU-T Recommendation G.703 (1998), *Physical/electrical characteristics of hierarchical digital interfaces*.

[3] ITU-T Recommendation G.957 (1995), *Optical interfaces for equipments and systems relating to the synchronous digital hierarchy*.

[4] ITU-T Recommendation G.652 (1997), *Characteristics of a single-mode optical fibre cable*.

[5] IEC Publication 825 (1993), *Safety of laser products*.

[6] ITU-T Recommendation G.707 (1996), *Network node interface for the synchronous digital hierarchy (SDH).*

[7] ITU-T Recommendation I.361 (1999), *B-ISDN ATM Layer specification*.

[8] ITU-T Recommendation I.610 (1999), *B-ISDN operation and maintenance principles and functions*.

[9] ITU-T Recommendation G.826 (1999), *Error performance parameters and objectives for international, constant bit rate digital paths at or above the primary rate*.

[10] ITU-T Recommendation G.783 (1997), *Characteristics of Synchronous Digital Hierarchy (SDH) equipment functional blocks.*

[11] IEC Publication 950 (1991), *Safety of information technology equipment, including electrical business equipment.*

[12] ITU-T Recommendation I.432.1 (1999), *B-ISDN User-network interface physical layer specification: General characteristics.*

4 Definitions and abbreviations

4.1 Definitions

None

4.2 Abbreviations

This Recommendation uses the following abbreviations:

AIS	Alarm Indication Signal
ATM	Asynchronous Transfer Mode
AU	Administrative Unit
BER	Bit Error Ratio
BIP	Bit Interleaved Parity
B-ISDN	Broadband Integrated Services Digital Network
B-NT1	Broadband Network Termination 1
B-NT2	Broadband Network Termination 2
B-TE	Broadband Terminal Equipment
B-UNI	Broadband User-Network Interface
CATV	Cable Television
CEC	Cell Error Control
CMI	Coded Mark Inversion
CRC	Cyclic Redundancy Check
EDC	Error Detection Code
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference

IEC	International Electrotechnical Commission
LCD	Loss of Cell Delineation
LOF	Loss of Frame
LOM	Loss of Maintenance Flow
LOP	Loss of Pointer
LOS	Loss of Signal
LSB	Least Significant Bit
MPH	Management Physical Header
MSB	Most Significant Bit
NNI	Network-Node Interface
NRZ	Non Return to Zero
OAM	Operations, Administration and Maintenance
OCD	Out of Cell Delineation
PL	Physical Layer
PL-OAM	Physical Layer Operations, Administration and Maintenance
POH	Path Overhead
PSN	PL-OAM Sequence Number
RDI	Remote Defect Indication
REB	Remote Errored Blocks
REI	Remote Error Indication
RS-RDI	Regenerator Section Remote Defect Indication
SDH	Synchronous Digital Hierarchy
SOH	Section Overhead
STI	Surface Transfer Impedance
STM	Synchronous Transport Module
TBD	To Be Defined
TFV	Terminal Failure Voltage
TP-AIS	Transmission Path Alarm Indication Signal
TP-FEBE	Transmission Path Far End Bit Error
TP-RDI	Transmission Path Remote Defect Indication
UNI	User-Network Interface
VC	Virtual Container

5 Reference configuration

Refer to Recommendation I.432.1 [12].

6 Characteristics of the physical media dependent sublayer

These characteristics apply to interfaces at the T_B and S_B reference points.

6.1 Physical medium characteristics of the UNI at 155 520 kbit/s

6.1.1 Bit rate and interface symmetry

The bit rate of the interface is 155 520 kbit/s. The interface is symmetric, i.e. it has the same bit rate in both transmission directions. The nominal bit rate in free running clock mode is 155 520 kbit/s with a tolerance of ±20 ppm.

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.

6.1.2 Timing

6.1.2.1 SDH-based

In normal operation, timing for the transmitter is locked to the timing received from the network clock. The tolerance under fault conditions is 155 520 kbit/s ± 20 ppm.

6.1.2.2 Cell-based

At the customer side of the interface at the T_B and S_B reference points, 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 under fault conditions is 155 520 kbit/s ± 20 ppm.

6.1.3 Jitter and wander

For both electrical and optical B-UNIs, the interface output jitter is in accordance with the appropriate limits given in Recommendation G.825 [1] for the electrical and optical interfaces.

Equipments having an electrical or optical B-UNI (e.g. B-NT1, B-NT2, B-TE), and which meet the input jitter tolerance and the jitter transfer specifications given in Recommendation G.825 [1], are assured of proper operation when the interface output jitter conforms to the limits in Recommendation G.825 [1].

6.1.4 Electrical interface

6.1.4.1 Interface range

The maximum range of the interface depends on the specific attenuation of the transmission medium used. For example a maximum range of about 100 metres for microcoax (4 mm dia.) and 200 metres for CATV type (7 mm dia.) will be achieved.

6.1.4.2 Transmission medium

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

The impedance is 75 ohms with a tolerance of ±5% in the frequency range 50 MHz to 200 MHz.

The attenuation of the electrical path between the interface points I_a and I_b is assumed to follow an approximate square root (f) law and to have a maximum insertion loss of 20 dB at a frequency of 155 520 kHz.

6.1.4.3 Electrical parameters at interface points I_a and I_b

The digital signal presented at the output port and the port impedance should conform to Table 12 and Figures 22 and 23 of Recommendation G.703 [2] for the interface at 155 520 kbit/s.

The digital signal presented at the input port and the port impedance should also conform to Table 12 and Figures 22 and 23 of Recommendation G.703 [2] for the interface at 155 520 kbit/s, but modified by the characteristics of the interconnecting coaxial pair.

6.1.4.4 Electrical connectors

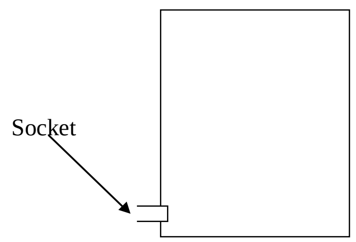
The presentation of interface point I_b at B-NT1 or B-NT2 is via a socket.

The presentation of interface point I_a at B-TE or B-NT2 is using either:

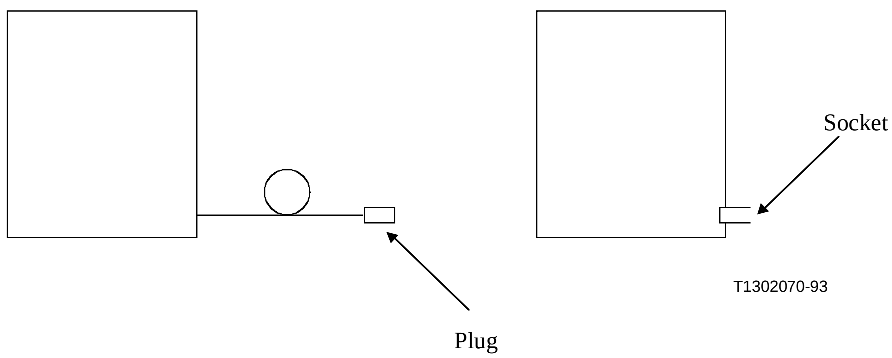
a) a socket, i.e. the connection is to be made to the equipment toward the network with a cable with plugs on both ends; or

b) an integral connecting cord with plug on the free end.

Refer to Figure 1.



Presentation of interface point I_b at B-NT1 and B-NT2



Presentation of interface point I_a at B-TE and B-NT2

Figure 1/I.432.2 – Connector types

6.1.4.5 Line coding

The line coding is CMI (Coded Mark Inversion) (refer to Recommendation G.703 [2]).

6.1.4.6 EMC/EMI requirements

Shielding properties of connectors and cables are defined by the specification of the respective values for the Surface Transfer Impedance (STI). The template indicating the maximum STI values for CATV cables is given in Figure 2 and Table 1. The applicability of these values for microcoax cables is for further study. For connectors, these template values are multiplied by 10 (20 dB).

The immunity of the interface against induced noise on the transmission medium should be specified by means of a Terminal Failure Voltage (TFV) which is overlaid to the digital signal at the output port. Figure 3 shows a possible measurement configuration.

The receiver should tolerate a sinusoidal TFV with the values defined in Figure 4 and Table 2 without degradation of the Bit Error Ratio (BER) performance.

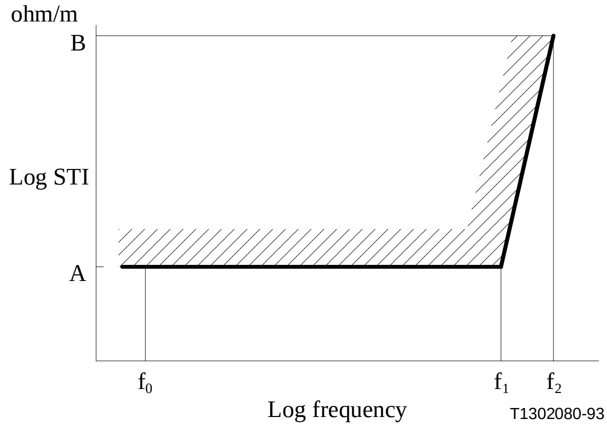


Figure 2/I.432.2 – Maximum STI values as function of frequency

Table 1/I.432.2 – STI values

Frequency [MHz]	STI value [ohm/m]
$f_0 = 0.1$	A = 0.01
$f_1 = 100$	
$f_2 = 1000$	B = 1

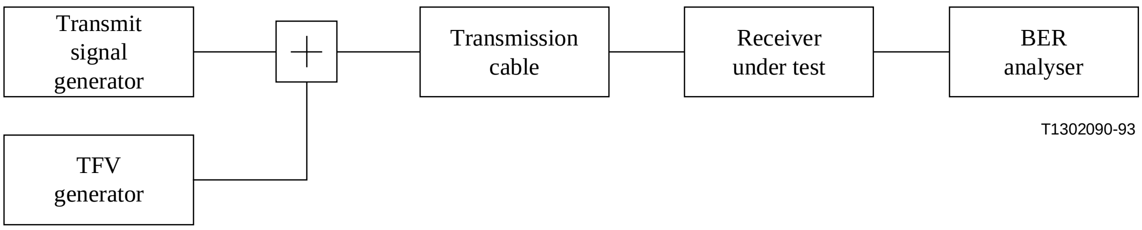


Figure 3/I.432.2 – Measurement configuration

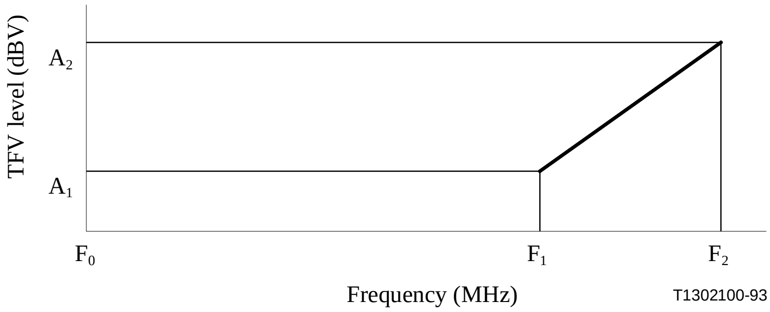


Figure 4/I.432.2 – Terminal failure voltage frequency response

Table 2/I.432.2 – Terminal failure voltage values

Frequency [MHz]	**TFV amplitude [dBV]** **0 dBV = 1V_{op}**
$F_0 = 1$	
$F_1 = 200$	A1 ≥ –17
$F_2 = 400$	A2 ≥ –11

6.1.5 Optical interface

6.1.5.1 Attenuation range

The attenuation of the optical path between the specification points S and R, as defined in Recommendation G.957 [3], are in the range of 0 dB to 7 dB. Refer to 6.1.5.5.

6.1.5.2 Transmission medium

The transmission medium consists of two single-mode fibres according to Recommendation G.652 [4], one for each direction. Some national applications may use multimode fibres.

6.1.5.3 Line coding

The line coding is NRZ (Non Return to Zero).

The convention used for optical logic level is:

– emission of light for a binary ONE;

– no emission of light for a binary ZERO.

The extinction ratio must be in accordance with Recommendation G.957 [3] (classification I-1).

6.1.5.4 Operating wavelength

The operating wavelength is around 1310 nm (second window).

6.1.5.5 Input and output port characteristics

The optical parameters will be in accordance with Recommendation G.957 [3] (classification I-1). Some national application may use optical parameters for multimode fibres.

The specification points associated with interface points I_a and I_b correspond to measurement "reference points" S and R as defined in Recommendation G.957 [3]. The optical parameters are specified for the transmitter and receiver at these specification points and for the optical path between these specification points, i.e. the connector at the interface is considered to be part of the equipment and not part of the fibre installation.

6.1.5.6 Optical connectors

The presentation of interface point I_b at B-NT1 or B-NT2 is via a socket.

The presentation of interface point I_a at B-TE or B-NT2 is using either:

a) a socket, i.e. the connection is to be made to the equipment toward the network with a cable with plugs on both ends; or

b) an integral connecting cord with plug on the free end.

Refer to Figure 1.

6.1.5.7 Safety requirements

For safety reasons, the parameters for IEC Publication 825 [5] Class 1 devices should not be exceeded even under failure conditions.

6.2 Physical medium characteristics of the UNI at 622 080 kbit/s

These characteristics apply to interfaces at the T_B and S_B reference points.

6.2.1 Bit rate and interface symmetry

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

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

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

NOTE – Other solutions are for further study.

If option a) is chosen, then the 155 520 kbit/s component should comply with the characteristics of 6.1.

The nominal bit rate in free running clock mode is 622 080 kbit/s with a tolerance of ±20 ppm.

6.2.2 Timing

6.2.2.1 SDH-based

In normal operation, timing for the transmitter is locked to the timing received from the network clock. The nominal bit rate under fault conditions is 622 080 kbit/s ± 20 ppm.

6.2.2.2 Cell-based

At the customer side of the interface at the T_B and S_B reference points, 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 nominal bit rate under fault conditions is 622 080 kbit/s ± 20 ppm.

6.2.3 Jitter and wander

For both electrical and optical B-UNI, the interface output jitter is in accordance with the appropriate limits given in Recommendation G.825 [1] for the electrical and optical interfaces.

Equipments having an electrical or optical B-UNI (e.g. B-NT1, B-NT2, B-TE) are assured of proper operation when the interface output jitter conforms to the limits in Recommendation G.825 [1].

6.2.4 Electrical interface

The feasibility of an electrical interface is for further study.

6.2.5 Optical interface

6.2.5.1 Attenuation range

The attenuation of the optical path between the specification points S and R is in the range of 0 dB to 7 dB (refer to 6.1.5.5).

6.2.5.2 Transmission medium

The transmission medium consists of two single-mode fibres according to Recommendation G.652 [4], one for each direction.

6.2.5.3 Line coding

The line coding is NRZ (Non Return to Zero).

The convention used for optical logic level is:

– emission of light for a binary ONE;

– no emission of light for a binary ZERO.

The extinction ratio must be in accordance with Recommendation G.957 [3] (classification I-4).

6.2.5.4 Operating wavelength

The operating wavelength is around 1310 nm (second window).

6.2.5.5 Input and output port characteristics

The optical parameters will be in accordance with Recommendation G.957 [3] (classification I-4). Some national application may use optical parameters for multimode fibres.

The specification points associated with interface points I_a and I_b correspond to measurement 'reference points' S and R as defined in Recommendation G.957 [3]. The optical parameters are specified for the transmitter and receiver at these specification points and for the optical path between these specification points, i.e. the connector at the interface is considered to be part of the equipment and not part of the fibre installation.

6.2.5.6 Optical connectors

The presentation of interface point I_b at B-NT1 or B-NT2 is via a socket.

The presentation of interface point I_a at B-TE or B-NT2 is using either:

a) a socket, i.e. the connection is to be made to the equipment toward the network with a cable with plugs on both ends; or

b) an integral connecting cord with plug on the free end.

Refer to Figure 1.

6.2.5.7 Safety requirements

For safety reasons, the parameters for IEC Publication 825 [5] Class 1 devices should not be exceeded even under failure conditions.

7 Functions provided by the Transmission Convergence (TC) sublayer

7.1 Transfer capability

7.1.1 SDH-based

7.1.1.1 Interface at 155 520 kbit/s

The bit rate available for the ATM cells (user information cells, signalling cells, OAM cells, unassigned cells and cells used for cell rate decoupling) is 149 760 kbit/s. The remainder (5760 kbit/s) is available for Physical Layer overhead.

7.1.1.2 Interface at 622 080 kbit/s

The bit rate available for the ATM cells (user information cells, signalling cells, OAM cells, unassigned cells and cells used for cell rate decoupling) is 599 040 kbit/s. The remainder (23 040 kbit/s) is available for Physical Layer overhead.

7.1.2 Cell-based

7.1.2.1 Interface at 155 520 kbit/s

For cell-based systems, Physical Layer overhead cells include Physical Layer OAM cells and idle cells. The transfer capacity is 149 760 kbit/s.

7.1.2.2 Interface at 622 080 kbit/s

For cell-based systems, Physical Layer overhead cells include Physical Layer OAM cells and idle cells. The transfer capacity is 599 040 kbit/s.

7.2 Transport-specific TC functions

7.2.1 SDH-based

7.2.1.1 Interface structure at 155 520 kbit/s

The bitstream of the interface has an external frame based on the Synchronous Digital Hierarchy (SDH) as described in Recommendation G.707 [6] and illustrated in Figure 5. The application of the SDH frame synchronous scrambler is described in Recommendation G.707 [6].

The ATM cell stream is first mapped into the C-4 and then packed into the VC-4 container along with the VC-4 path overhead (refer to Figure 5). 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.

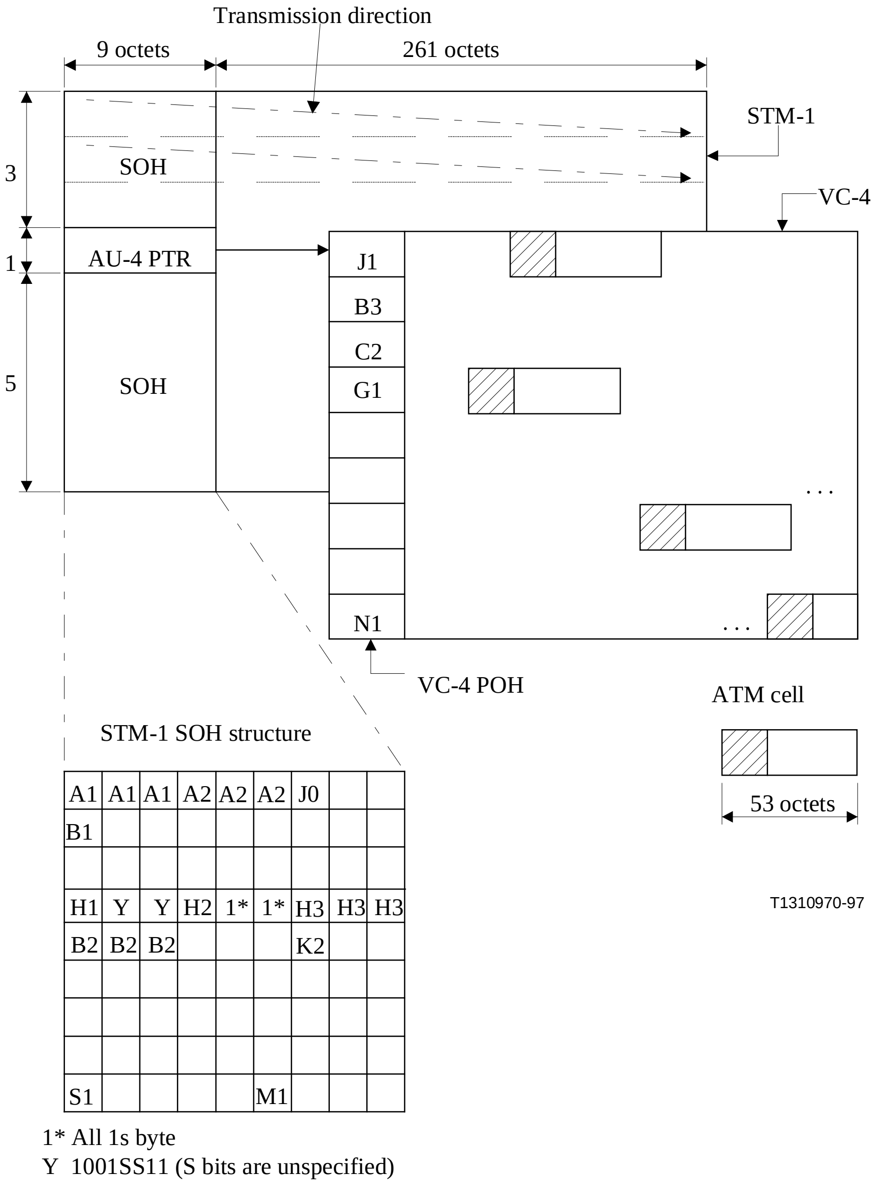


Figure 5/I.432.2 – 155 520 kbit/s frame structure for SDH-based UNI

The AU-4 pointer (octets H1 and H2 in the SOH) is used for finding the first octet of the VC-4. Path Overhead (POH) octets J1, B3, C2, and G1 are utilized. Path overhead octet N1 is reserved for network operator purposes, and is undefined at the B-UNI. Use of the remaining POH octets is for further study.

For all representations shown in this Recommendation in binary format, bits are numbered within the octet as shown in Table 3 with the order of transmission being from left to right.

Table 3/I.432.2 – Order of transmission of bits within a byte

MSB 1	2	3	4	5	6	7	LSB 8
First bit transmitted	→	→	→	→	→	→	Last bit transmitted

NOTE – The bit numbering used in this figure is different from the convention used in Recommendation I.361 [7] but in accordance with Recommendation G.707 [6].

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7.2.1.2 Interface structure at 622 080 kbit/s

The bit stream of the interface has an external frame based on the Synchronous Digital Hierarchy (SDH) as described in Recommendation G.707 [6]. Specifically, the AU-4-4c structure as given in Recommendation G.707 [6] is specified, and is illustrated in Figure 6. The application of the SDH frame synchronization scrambler is described in Recommendation G.707 [6].

The ATM cell stream is first mapped into the C-4-4c and then packed in the VC-4-4c container along with the VC-4-4c path overhead (see Figure 6). The ATM cell boundaries are aligned with the STM-4 octet boundaries. Since the C-4-4c capacity (9360 octets) is not an integer multiple of the cell length (53 octets), a cell may cross a C-4-4c boundary.

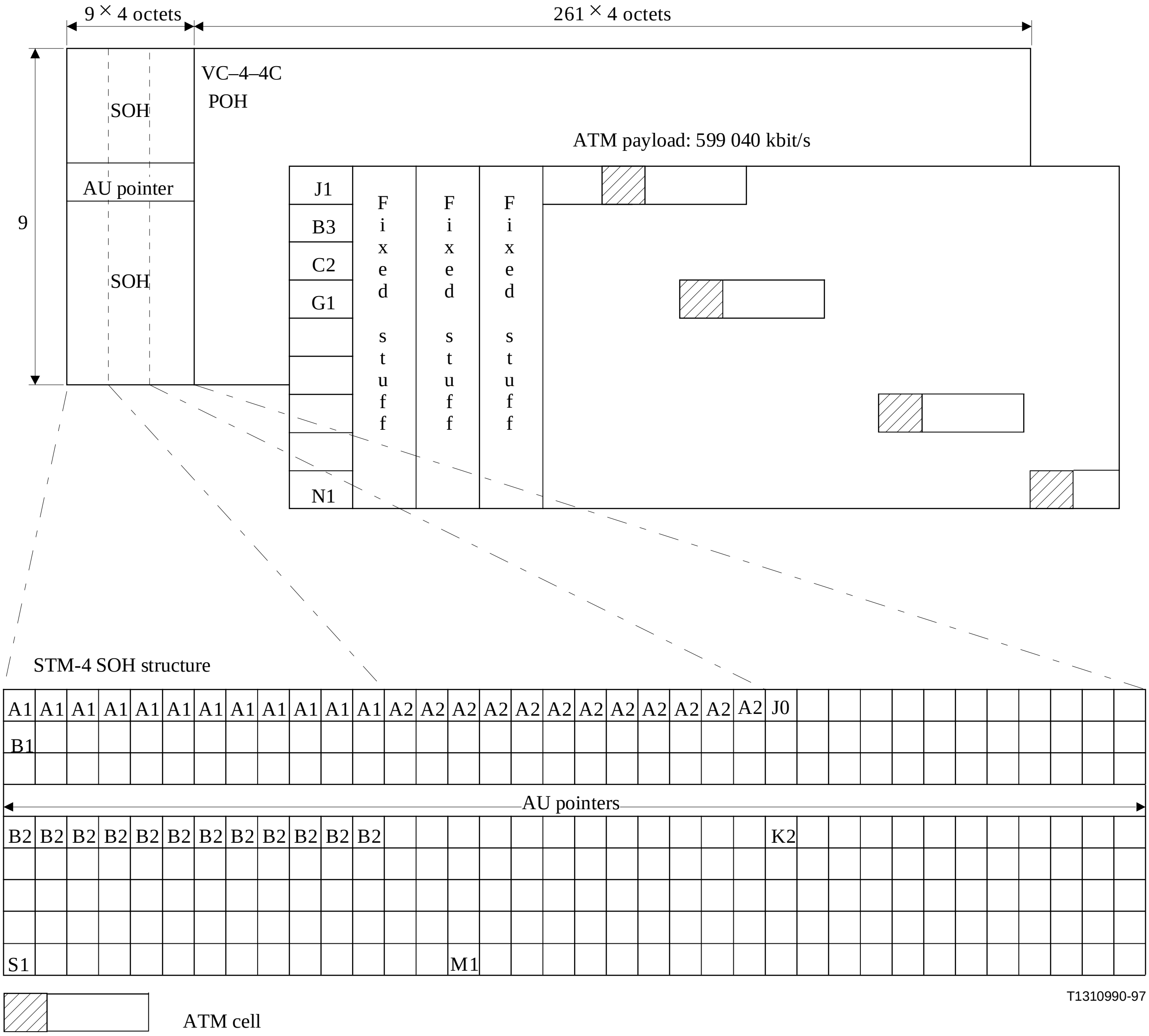


Figure 6/I.432.2 – 622 080 kbit/s frame structure for SDH-based UNI

The AU-4-4c pointer is used for finding the first octet of the VC-4-4c. Path overheads octets J1, B3, C2, and G1 are utilized. Path overhead octet N1 is reserved for network operator purposes, and is undefined at the B-UNI. Use of the remaining POH octets is for further study.

7.2.1.3 OAM functionality

Transmission overhead allocation for the SDH Physical Layer functions (listed in Recommendation G.707 [6]) is given in Table 4. Use of these overheads (e.g. for frame alignment, AU pointer generation/interpretation, Bit Interleaved Parity (BIP) code calculation, etc.) should be in accordance with specifications in Recommendations G.707 [6] and G.783 [10].

Remote defect indications should be as defined in Recommendations G.707 [6] and G.783 [10].

Table 4/I.432.2 – SDH Overhead Octets Allocation at B-UNI

Octet (Note 4)	Function	Coding (Note 1)
STM section overhead		
A1, A2	Frame alignment	
J0 (Note 7)	Regenerator Section trace	
B1	Regenerator Section error monitoring (Note 2)	BIP-8
B2	Multiplex Section error monitoring	BIP-24 (155 520 kbit/s)
		BIP-96 (622 080 kbit/s)
H1, H2	AU AIS, AU-4 pointer	All 1s
H3	Pointer action	
K2 (bits 6-8)	Multiplex Section AIS/Multiplex Section RDI (Note 6)	111/110
M1 (Note 5)	Multiplex Section error reporting (REI)	B2 error count
S1 (bits 5-8)	Synchronization Status	Rec. G.707 [6]
VC path overhead		
J1	Access point ID/verification	
B3	Path error monitoring	BIP-8
C2	Path signal label	ATM cells (Note 3)
G1 (bits 1-4)	Path error reporting (REI)	B3 error count
G1 (bit 5)	Path RDI	"1"

NOTE 1 – Only octet coding relevant to OAM function implementation is listed.

NOTE 2 – The use of B1 for regenerator section error monitoring across the UNI is application-dependent and is therefore optional.

NOTE 3 – Signal label code for ATM cell payload is 0001 0011 for VC.

NOTE 4 – The bit numbering of this table is different from the conventions used in Recommendation I.361 [7] but in accordance with Recommendation G.707 [6].

NOTE 5 – Using the notation of Recommendation G.707 [6], the bits to be used are bits (2-8) of octet S (9, 6, 1) in the case of the interface at 155 520 kbit/s, and bits (2-8) of octet S (9, 4, 3) in the case of the interface at 622 080 kbit/s.

NOTE 6 – The applicability of Multiplex Section AIS (MS-AIS) at the B-UNI is for further study.

NOTE 7 – The need of this octet is for further study.

7.2.1.3.1 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);

– Remote Defect Indication (RDI),

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

AIS is used to alert associated termination point in the direction of transmission that a failure has been detected and alarmed.

RDI is used to alert associated termination point in the opposite direction of transmission that a defect has been detected. Path RDI alerts the path termination point in the opposite direction of transmission that a failure has occurred along the path.

Operation of these signals is described further in clause 8 on OAM operational functionality.

Generation and detection of AIS and RDI are in accordance with Recommendations G.707 [6] and G.783 [10].

7.2.1.3.2 Transmission performance monitoring

Transmission performance monitoring across the UNI is performed to detect and report transmission errors. Performance monitoring is provided for the SDH Section and for the Path corresponding respectively to maintenance flows F2 and F3 in Recommendation I.610 [8].

At the SDH Multiplex Section (F2 flow), monitoring of the incoming signal is performed using the BIP-24 or BIP-96 inserted into the B2 field (for the 155 520 kbit/s bit rates and 622 080 kbit/s respectively). Monitoring of the outgoing signal is performed using the Remote Error Indication (REI). This error count, obtained from comparing the calculated BIP and the B2 value of the incoming signal at the far end, is inserted in the M1 field and sent back: it reports to the near end multiplex section termination point about the error performance of its outgoing signal as REI.

Similar to the SDH Multiplex 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 Higher order Path REI 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.

Generation and detection of BIP and REI are in accordance with Recommendations G.707 [6] and G.783 [10].

7.2.1.3.3 Control communication

Section layer communication channels and order-wires across the UNI are not required and are not provided.

Additional functions such as loopbacks (or their functional equivalent) or path layer communication channels 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.

7.2.2 Cell-based

7.2.2.1 Format structure

The interface structure for both 155 520 kbit/s and 622 080 kbit/s consists of a continuous stream of cells. Each cell contains 53 octets.

After 26 contiguous ATM layer cells or 'idle cells' have been transmitted, a Physical Layer cell is inserted in order to adapt the transfer capability to the interface rate (i.e. 149 760 kbit/s and 599 040 kbit/s). The Physical Layer cells which are inserted are either "idle cells" or Physical Layer OAM cells, depending on the OAM requirements. These Physical Layer cells are inserted prior to any other cell.

When the OAM flows are implemented, the OAM cells can only be inserted as part of the Physical Layer cells which are used to adapt the transfer capability to the interface rate. The OAM cells shall not be inserted at any other time in the cell flow. Figure 7 shows the interface structure for both the 155 520 kbit/s and the 622 080 kbit/s bit rates, based on the OAM requirements detailed in 7.2.2.3.

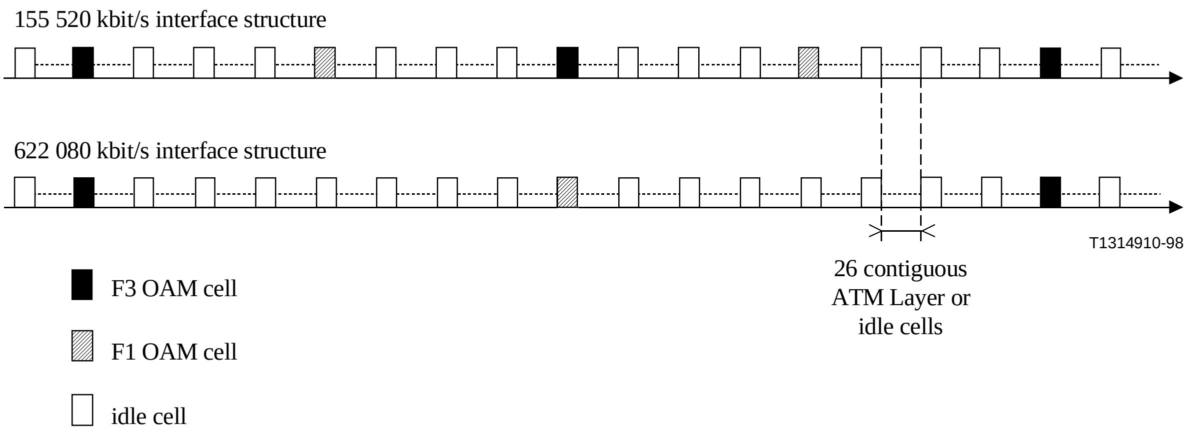


Figure 7/I.432.2 – Interface structure

Note that there are two reasons for the insertion of idle cells; they are first inserted as part of the Physical Layer cells which adapt the transfer capability to the interface rate (1/27 cell insertion rate). They are also inserted for cell rate decoupling when there is no ATM Layer cell to transmit.

7.2.2.2 OAM functionality

Physical Layer OAM cells are used for the conveyance of the Physical Layer OAM information.

Recommendation I.610 [8] identifies three types of PL-OAM flows carried by maintenance cells using a specific pattern in the header:

– F1: Regenerator level;

– F2: Digital section level;

– F3: Transmission path level.

The F1 cell carries the OAM functions for the Regenerator level. This flow is inserted in the cell flow on a recurrent basis as part of the Physical Layer cells which are used to adapt the transfer capability to the interface rate (see 7.2.2.1).

The OAM flow F2 is not used and the corresponding functions are supported by the F3 OAM flow because there is no transmission frame passed across the cell-based UNI.

The F3 cell carries the OAM functions for the Transmission Path level. This flow is inserted in the cell flow on a recurrent basis as part of the Physical Layer cells which are used to adapt the transfer capability to the interface rate (see 7.2.2.1).

The Physical Layer OAM cells must have a unique header so that they can be properly identified by the Physical Layer at the receiver. The patterns to be used are shown in Table 5 (see Note). The header patterns shown are given prior to scrambling.

Table 5/I.432.2 – Header pattern for Physical Layer OAM cell identification

Flow	Octet 1	Octet 2	Octet 3	Octet 4	Octet 5
F1	00000000	00000000	00000000	00000011	HEC=Valid code 01011100
F3	00000000	00000000	00000000	00001001	HEC=Valid code 01101010

NOTE – 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.

The possible need to identify other header values among those reserved for the use of the Physical Layer (refer to Recommendation I.361 [7]) to accommodate future identified OAM flows is for further study.

7.2.2.3 Allocation of OAM functions in information field

Octet allocation for the F1 PL-OAM and F3 PL-OAM cells is shown in Table 6.

Table 6/I.432.2 – Allocation of OAM functions in information field

1	R	25	R
2	AIS (Note 1)	26	R
3	PSN	27	R
4	R	28	R
5	R	29	R
6	R	30	RDI
7	R	31	R
8	EDC-B1	32	R
9	EDC-B2	33	R
10	EDC-B3	34	R
11	EDC-B4	35	R
12	EDC-B5	36	R
13	EDC-B6	37	R
14	EDC-B7	38	R
15	EDC-B8	39	R
16	R	40	R
17	R	41	R
18	R	42	R
19	R	43	R
20	R	44	R
21	R	45	R
22	R	46	REB
23	R	47	CEC (2)
24	R	48	CEC (8) (Note 2)

NOTE 1 – For F1 OAM cells this byte is coded 6A hexa.

NOTE 2 – MSB is bit 2 of byte 47 and LSB is bit 1 of byte 48. Bits 3 to 8 of byte 47 are set to 0.

The following fields are identified for both the F1 and F3 flows:

- **PL-OAM Sequence Number (PSN)**: It is designed so as to have a sufficiently large cycle compared with the duration of cell loss and insertion. 8 bits are allocated to PSN. The counting is then done modulo 256. This field is incremented by one at each new PL-OAM cell being sent.

- **Error Detection Code (EDC-Bn)**: This code is a BIP-8 calculated on a block of contiguous cells repeated for each monitored block. One octet is allocated for each block. The number of monitored blocks is equal to 8. The field EDC-Bn corresponds to the BIP-8 calculated on the monitored block number n.

  For the 155 520 kbit/s interface, each monitored block includes 27 cells. For the 622 080 kbit/s interface, each monitored block includes 54 cells. For F3 cell number n (F1 cell number n), the first monitored block begins with the first cell following the F3 cell number n–1 (F1 cell number n–1). The last monitored block ends at the end of the F3 cell number n (F1 cell number n), as indicated on Figure 8.

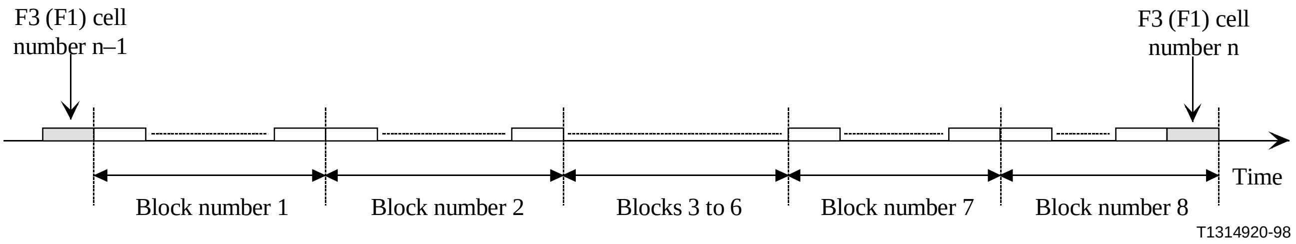


Figure 8/I.432.2 – Monitored blocks boundaries

  F1 and F3 OAM cells are not taken into account by the BIP-8 calculation. This means the BIP-8 calculation is stopped during F1 and F3 OAM cells. For the other cells (ATM Layer cells and idle cells), the BIP-8 is calculated only on the cell payload before the scrambling is performed.

  One octet is allocated for each EDC-Bn field. Each bit of the EDC-Bn field is equal to the BIP calculated on the same range bits of each monitored octet (i.e. the Most Significant Bit of each EDC-Bn octet is equal to the BIP calculated on the Most Significant Bit of each octet of the monitored block).

- **Remote Errored Blocks (REB)**: Indicates to the far end the total number of errored blocks between two consecutive PL-OAM cells in accordance with anomalies a1 to a4 defined in Annex D/G.826 [9]. For F3 OAM cells, the REB field shall be the value of a running counter (modulo 256) increased periodically by the number of errored blocks detected in one direction of transmission (in accordance with Annex D/G.826). The value of this running counter shall be put in the REB field of each F3 OAM cell being sent in the opposite direction. By subtracting the values contained in the REB fields of two consecutively received valid F3 OAM cells (i.e. CEC field indicates a valid cell payload), the receiving system knows the total number of errored blocks measured by the far end system. This mechanism is identical for F1 OAM cells.

- **Transmission Path Alarm Indication Signal (TP-AIS)**: This field is used only in the F3 OAM cells to alert the equipment in the direction of transmission that a failure has been detected. The coding of this field is as follows:

MSB							LSB
0	0	0	0	LOM	LCD	LOS	AIS_indication

When a defect is detected (LOM, LCD or LOS), the corresponding bit is set to 1, else it is set to 0. When at least one defect is detected, the AIS_indication bit is set to 1, else it is set to 0. For the F1 OAM cells, the TP-AIS field is coded 6A hexa.

- **Remote Defect Indication (RS-RDI and TP-RDI)**: This field is used to alert the upstream equipment in the opposite direction of transmission that a defect has been detected along the downstream path. For the F1 flow the possible defects are LOM, LCD and LOS. For the F3 flow the possible defects are TP-AIS, LOM, LCD and LOS. The coding of this field is as follows:

MSB							LSB
0	0	0	TP-AIS[a)]	LOM	LCD	LOS	RDI_indication

[a)] TP-AIS defect is only used in F3 OAM flow.

When a defect is detected, the corresponding bit is set to 1, else it is set to 0. When at least one defect is detected, the RDI_indication bit is set to 1, else it is set to 0.

- **Cell Error Control (CEC)**: Used to detect errors in the cell payload. A CRC 10 is implemented. This CRC-10 is the same as in F4/F5 flows.
- **Reserved Field (R)**: Contains the pattern of the octet of the idle cells (hexa 6A).

Other fields such as activation/deactivation or switch-on/switch-off status of the B-NT2 are for further study.

7.2.2.4 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);
- Remote Defect Indication (RDI).

AIS is used to alert associated termination point in the direction of transmission that a failure has been detected and alarmed.

RDI is used to alert associated termination point in the opposite direction of transmission that a failure has been detected.

Operation of these signals is described further in clause 8 on OAM operational functionality.

7.2.2.5 Transmission performance monitoring

Transmission performance monitoring across the UNI is performed to detect and report transmission errors. At the transmission path (F3) level, this function is performed on the ATM layer and idle cells. At the regenerator section (F1) level, this function is performed on ATM layer and idle cells. Both at the path level and section level, transmission performance monitoring is performed on 8 blocks of contiguous cells by using a BIP-8 calculation. For the 155 520 kbit/s interface the size of the monitored block is equal to 27 cells and for the 622 080 kbit/s interface the size of the monitored block is equal to 54 cells. For each monitored block the PL-OAM cell (F1 or F3) carries the result of the BIP-8 calculation in the corresponding EDC-Bn field. At the regenerator section (F1) level, errors in the F3 OAM cells are detected by the HEC and CRC-10 check, but not by the BIP-8.

7.2.2.6 Error performance reporting

This function reports to the equipment in the opposite direction of transmission, the results of the regenerator section and the path error monitoring carried out as contained in the REB field. The REB field gives the total number of errored blocks between two consecutive PL-OAM cells in accordance with anomalies a1 to a4 defined in Annex D/G.826 [9].

7.2.2.7 Control communication

The provision of a data communication channel is for further study. Two possibilities could be applicable in the case of cell-based Physical Layer: the data communication channel can be provided either by allocating specific bytes among the several reserved bytes in the F1 or F3 OAM cell payload or by using a new Physical Layer cell which header and payload have to be defined.

7.3 ATM-specific TC functions

For information on ATM cell formatting, header error control, cell delineation, scrambling and idle cells, refer to Recommendation I.432.1 [12].

8 OAM operational functionality

8.1 SDH-based

8.1.1 Description of signals defined in Recommendation G.783 [10]

The following signals related to maintenance are defined below.

Indication of LOS, LOF and LOP are generated within the functional equipment.

Multiplex Section-AIS, AU-AIS, Multiplex Section-RDI, Higher order Path-RDI are signals transmitted/received across the B-UNI (see Note 6 to Table 4).

Detection of SDH-based defects is in accordance with Recommendation G.783 [10].

8.1.2 Cell delineation signals

Out of Cell Delineation (OCD) – An OCD anomaly occurs when the cell delineation process changes from SYNC state to HUNT state while in a working state (refer to Figure 5/I.432.1 [12]). An OCD anomaly terminates when the PRESYNC to SYNC state transition occurs (refer to Figure 5/I.432.1 [12]) or when the OCD anomaly persists and the LCD maintenance state is entered (see below).

Loss of Cell Delineation (LCD) – An LCD defect occurs when an OCD anomaly (see above) has persisted for x ms. An LCD defect terminates when the cell delineation process (refer to Figure 5/I.432.1 [12]) enters and remains in the SYNC state for x continuous milliseconds. The value of x is in the range 0 to 4 for SDH-based UNIs.

NOTE – For implementations where the value of x is zero, the conditions for entering OCD and LCD signal states are identical, and are equivalent to the signal LCD (Loss of Cell Delineation) used in the 1993 version of Recommendation I.432.

8.1.3 Maintenance signals as defined in Recommendation G.783 [10]

Generation and detection of MS-AIS, AU-AIS, MS-RDI and HP-RDI are in accordance with Recommendation G.783 [10].

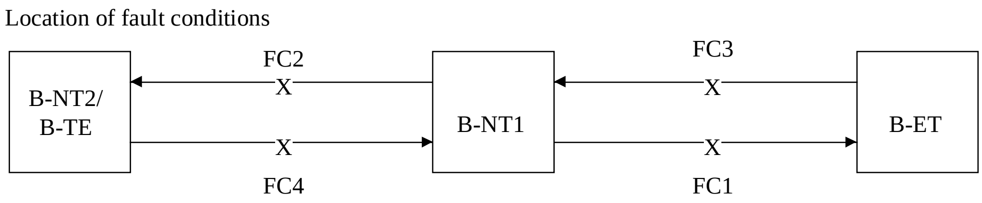
8.1.4 Maintenance state tables

This subclause applies for broadband access configurations that provide transmission path continuity between B-NT2/B-TE and B-ET. The more general case where the transmission path is terminated between the B-TE and the B-ET is for further study.

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

For the purpose, two state tables are defined, one at the user side and one at the network side. States at the user side (F states) are defined in 8.1.4.1 and states at the network side (G states) are defined in 8.1.4.2. The state tables are defined in 8.1.4.4.

Fault conditions FC1 to FC4 that could occur at the network side or between the network side and user side are defined in Figure 9. These fault conditions directly affect the F and G states. Information on these fault conditions is exchanged between the user and network sides in the form of signals defined above.



Fault condition	Definition
FC4	Fault in the upstream direction of the interface
FC2	Fault in the downstream direction of the interface
FC3	Fault in the downstream direction in access digital section
FC1	Fault in the upstream direction in access digital section

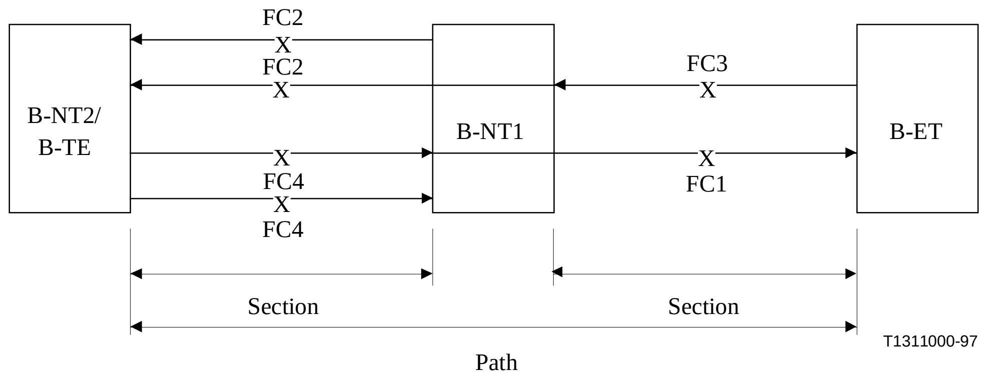


Figure 9/I.432.2 – Fault conditions and operational span of section path maintenance signals

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 error information are not taken into account except for power on/off transient states F6 and G13.

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 performance associated with each direction of its adjacent section. The supervision of the quality of this section is the user's responsibility.

8.1.4.1 Layer 1 states on the user side of the interface

F0 state: Loss of power on the user side

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

F1 state: Operational state

– Network timing and layer 1 service are available.

– The user side transmits and receives operational frames.

F2 state: Fault condition No. 1

– This fault state corresponds to the fault condition FC1.

– Network timing is available at the user side.

– The user side transmits operational frames.

– The user side receives frame containing HP-RDI indication.

F3 state: Fault condition No. 2

– This fault state corresponds to any combination of FC2 with FC1, FC3 and FC4.

– Network timing may not be available at the user side.

– The user side detects LOS, LOF, MS-AIS, AU-AIS, AU-LOP, LCD.

– The user side transmits frames with associated Multiplex Section RDI and HP-RDI.

F4 state:

– This fault state corresponds to fault condition FC3, or FC1 and FC3.

– Network timing may not be available at the user side.

– The user side detects AU-AIS, or LCD.

– The user side transmits frames containing HP-RDI indication.

F5 state: Fault condition No. 4

– This fault state corresponds to the fault condition FC4 or FC1 and FC4.

– Network timing is available at the user side.

– The user side transmits operational frames.

– The user side receives frames containing Multiplex Section RDI and HP-RDI indications.

F6 state:

– This fault corresponds to fault conditions FC3 + FC4 or FC3 + FC4 + FC1.

– Network timing may not be available at the user side.

– The user side receives frames containing MS-RDI and AU-AIS.

– The user side transmits frames containing HP-RDI.

F7 state: Power on state

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

8.1.4.2 Layer 1 states at the network side of the interface

G0 state: Loss of power on the Network side

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

G1 state: Operational state

– The network timing and layer 1 service are available.

– The network side transmits and receives operational frames.

G2 state: Fault condition No. 1

– This fault state corresponds to the fault condition FC1.

– Network timing is provided to the user side.

– The path terminating equipment within the access network detects LOS, LOF, AU-LOP, AU-AIS or Multiplex Section-AIS.

– The network side transmits frames containing HP-RDI indication.

G3 state: Fault condition No. 2

– This fault state corresponds to the fault condition FC2.

– Network timing is not available to the user side.

– The network side transmits operational frames.

– The network side receives frames containing Multiplex Section RDI and HP-RDI indications.

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 B-NT1 detects LOS/LOF, Multiplex Section AIS or AU-AIS from the access network.

– The network side transmits AU-AIS.

– The network side receives frames containing HP-RDI indication.

G5 state:

– This fault states corresponds to the fault condition FC4 or FC2 and FC4.

– The network side transmits frame containing Multiplex Section RDI and HP-RDI indication to the user side.

G6 state:

– This fault state corresponds to fault conditions FC1 and FC2.

– Network timing is not available at the user side.

– The network side transmits frames containing HP-RDI indication.

– The B-NT1 receives Multiplex Section RDI and HP RDI indications from the user side.

G7 state:

– This fault state corresponds to fault conditions FC1 and FC3.

– Network timing is not available at the user side.

– The network side transmits frames containing AU-AIS indication.

– The network side receives frames containing HP-RDI indication.

G8 state:

– This fault state corresponds to fault conditions FC1 and FC4 or FC1 and FC2 and FC4.

– The network side transmits frames containing Multiplex Section RDI and HP-RDI indications to the user side.

G9 state:

– This fault state corresponds to fault conditions FC2 and FC3.

– Network timing is not available to the user side.

– The network side transmits frames containing AU-AIS.

– The network side receives frames containing Multiplex Section RDI and HP-RDI indications.

G10 state:

– This fault state corresponds to fault conditions FC3 and FC4 or FC2 and FC3 and FC4.

– Network timing is not provided to the user side.

– The network side transmits frames containing AU-AIS and Multiplex Section RDI indication to the user side.

G11 state:

– This fault state corresponds to fault conditions FC1 and FC2 and FC3.

– Network timing is not available at the user side.

– The network side transmits AU-AIS to the user side.

– The network side receives frames containing MS-RDI.

G12 state:

– This fault state corresponds to fault conditions FC1 and FC3 and FC4 or FC1 and FC2 and FC3 and FC4.

– Network timing is not available at the user side.

– The network side transmits frames containing AU-AIS and MS RDI to the user side

G13 state: Power on state

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

8.1.4.3 Description of primitives

The following primitives should be used between the physical media dependent layer and the management entity [Management Physical Header (MPH) primitives].

MPH-AI MPH Activate Indication (is used as error recovery and initialization information)

MPH-DI MPH Deactivate Indication

MPH-EIn MPH Error Indication with parameter n (n defines the failure condition relevant to the reported error)

MPH-CIn MPH Correction Indication with parameter n (n defines the failure condition relevant to the reported recovery)

8.1.4.4 State tables

Operational functions are defined in Table 7 for the layer 1 states at the user side of the interface and in Table 8 for the network side.

Explanations of the symbols used in Tables 7 and 8:

Table 7/I.432.2 – F-state Table – Physical Layer 1 state matrix at the user side (Note 1)

	Initial state →	**F0**	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**
Definition of the states	Operational condition or fault condition	Power off at user side	Operational	FC1	FC2 fault conditions (Note 4)	FC3 or FC3& FC1	FC4 or FC4&FC1	FC3&FC 4 or FC3& FC4 &FC1	Power on at user side
	Signal transmitted by user towards the interface	No signal	Normal operational frames	Normal operation al frames	Frames with MS-RDI and HP-RDI	Frames with HP-RDI	Normal operational frames	Frames with HP-RDI	No signal
New event detected at the receiving side	Loss of power or power down mode at user side	/	PH-DI MPH-EI0 F0	MPH-EI0 F0	MPH-EI0 F0	MPH-EI0 F0	MPH-EI0 F0	MPH-EI0 F0	MPH-EI0 F0
	Return of power to user side	F7	/	/	/	/	/	/	/
	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	PH-AI MPH-AI F1	PH-AI MPH-AI F1
	Reception of Path-RDI (FC1)	/	MPH-DI MPH-EI1 F2	–	ndp	–	–	–	MPH-EI1 F2
	LOS or LOF or (FC2) (Note 2)	/	MPH-DI MPH-EI2 F3	MPH-EI2 F3	–	MPH-EI2 F3	MPH-EI2 F3	MPH-EI2 F3	MPH-EI2 F3
	LCD or LOP or Path-AIS (FC3) or (FC1&FC3) (Note 3)	/	MPH-DI MPH-EI3 F4	MPH-EI3 F4	ndp	–	MPH-EI3 F4	–	MPH-EI3 F4
	Reception of Path-RDI and MS-RDI (FC4)	/	MPH-DI MPH-EI4 F5	MPH-EI4 F5	ndp	MPH-EI4 F5	–	–	MPH-EI4 F5
	Path AIS and MS-RDI or LCD, MS-RDI and Path-RDI or LOP MS-RDI (FC3 and FC4)	/	PH-DI MPH-EI3 MPH-EI4 F6	MPH-EI3 MPH-EI4 F6	ndp	MPH-EI4 F6	MPH-EI3 F6	–	MPH-EI3 MPH-EI4 F6

NOTE 1 – If the path trace is used, the path trace mismatch will be a path-related failure as LOP or LCD. In this table "LCD" will be substituted by "LCD or path trace mismatch".

NOTE 2 – When FC2 occurs, other fault conditions (FC1 or FC3 or FC4) can not be detected but they may occur simultaneously.

NOTE 3 – When FC3 occurs, FC1 (HP-RDI) can not be detected but it may occur simultaneously.

NOTE 4 – The user side cannot distinguish among FC2, FC2&FC1, FC2&FC3, FC2&FC4, FC2&FC1&FC3, FC2&FC1&FC4, FC2&FC3&FC4, or FC2&FC1&FC3&FC4.

Table 8/I.432.2 – G-state Table – Physical Layer 1 state matrix at the network side

	Initial state →	**G0**	**G1**	**G2**	**G3**	**G4**	**G5**	**G6**	**G7**	**G8**	**G9**	**G10**	**G11**	**G12**	**G13**
Definition of the state	Operational condition or failure condition	Power off at NT1	Operational	FC1	FC2	FC3	FC4 or FC2& FC4	FC1& FC2	FC1& FC3	FC1& FC4 or FC1& FC2 &FC4	FC2& FC3	FC3&FC4 or FC2& FC3&FC4	FC1& FC2 &FC3	FC1&FC3 &FC4 or FC3& FC4&FC1 &FC2	Power on at NT
	Signal transmitted toward the interface	No signal	Normal operational signal	Signal with HP-RDI	Normal operational signal	Signal with AU-AIS	Signal with MS and HP-RDI	Signal with HP-RDI	Signal with AU-AIS	Signal with MS and HP-RDI	Signal with AU-AIS	Signal with AU-AIS and MS-RDI	Signal with AU-AIS	Signal with AU-AIS and MS-RDI	No signal
New detected event	Loss of power or power down mode at NT1	–	PH-DI MPH-EI0 G0	MPH-EI0 G0	MPH-EI0 G0	MPH-EI0 G0	MPH-EI0 G0	MPH-EI0 G0	MPH-EI0 G0	MPH-EI0 G0	MPH-EI0 G0	MPH-EI0 G0	MPH-EI0 G0	MPH-EI0 G0	MPH-EI0 G0
	return of power at NT1	MPH-CI0 G13	/	/	/	/	/	/	/	/	/	/	/	/	/
	Normal operational frames	/	–	PH-AI MPH-AI G1	PH-AI MPH-AI G1	PH-AI MPH-AI G1	PH-AI MPH-AI G1	PH-AI MPH-AI G1	PH-AI MPH-AI G1	PH-AI MPH-AI G1	PH-AI MPH-AI G1	PH-AI MPH-AI G1	PH-AI MPH-AI G1	PH-AI MPH-AI G1	PH-AI MPH-AI G1
New appearing event	Internal network failure FC1	/	PH-DI MPH-EI1 G2	–	MPH-EI1 G6	MPH-EI1 G7	MPH-EI1 G8	–	–	–	MPH-EI1 G11	MPH-EI1 G12	–	–	MPH-EI1 G2
	Reception of MS&P-RDI (FC2)	/	PH-DI MPH-EI2 G3	MPH-EI2 G6	–	MPH-EI2 G9	ndp	–	MPH-EI2 G11	ndp	–	ndp	–	ndp	MPH-EI2 G3
	Internal network failure (FC3) (Note)	/	PH-DI MPH-EI3 G4	MPH-EI3 G7	MPH-EI3 G9	–	MPH-EI3 G10	MPH-EI3 G11	–	MPH-EI3 G12	–	–	–	–	MPH-EI3 G4
	LOS or LOF (FC4)	/	PH-DI MPH-EI4 G5	MPH-EI4 G8	MPH-EI4 G5	MPH-EI4 G10	–	MPH-EI4 G8	MPH-EI4 G12	–	MPH-E-I4 G10	–	MPH-EI4 G12	–	MPH-EI4 G5
Dis-appearing FC	FC1	/	/	MPH-CI1 G1	/	/	/	MPH-CI1 G3	MPH-CI1 G4	MPH-CI1 G5	/	/	MPH-CI1 G9	MPH-CI1 G10	/
	FC2	/	/	/	MPH-CI2 G1	/	–	MPH-CI2 G2	/	–	MPH-CI2 G4	–	MPH-CI2 G7	–	/
	FC3	/	/	/	/	MPH-CI3 G1	/	/	MPH-CI3 G2	/	MPH-CI3 G3	MPH-CI3 G5	MPH-CI3 G6	MPH-CI3 G8	/
	FC4	/	/	/	/	/	MPH-CI4 G3	/	/	MPH-CI4 G6	/	MPH-CI4 G9	/	MPH-CI4 G11	/

NOTE – If FC3 represents a path-related fault condition (e.g. LCD), the consequent reaction is not applicable for the G-state table, because this failure can not be recognized at the network side. Therefore, no state change will occur.

8.2 Cell-based

8.2.1 Description of signals defined in Recommendation I.610 [8]

The following signals related to maintenance are defined below:

– indication of LOS, LCD and LOM are generated within the functional equipment;

– TP-AIS, RS-RDI, TP-RDI are signals transmitted/received across the B-UNI.

Loss of Signal (LOS): LOS is considered to have occurred when the amplitude of the relevant signal has dropped below prescribed limits for a prescribed period.

Loss of Maintenance flow (LOM): Loss of one OAM cell is detected when no F3 or F1 OAM cell is received when the maximum spacing between two F3 or F1 OAM cells is exceeded. The defect LOM is declared when two successive anomalies Loss of one F3 or F1 OAM cell are detected.

8.2.2 Cell delineation signals

Out of Cell Delineation (OCD): an OCD anomaly occurs when the cell delineation process changes from SYNC to HUNT state while in a working state (refer to Figure 5/I.432.1 [12]). An OCD anomaly terminates when the PRESYNC to SYNC state transition occurs (refer to Figure 5/I.432.1 [12]) or when the OCD anomaly persists and the LCD maintenance state is entered (see below).

Loss of Cell Delineation (LCD): an LCD defect occurs when an OCD anomaly (see above) has persisted for *x* ms. An LCD defect terminates when the cell delineation process (refer to Figure 5/I.432.1 [12]) enters and remains in the SYNC state for *x* continuous milliseconds. The value of *x* is in the range 1 to 4 for Cell-based UNIs.

8.2.3 Maintenance signals as defined in Recommendation I.610 [8]

Regenerator Section Remote Defect Indication (RS-RDI): RS-RDI is provided to alert the equipment in the opposite direction of transmission that a defect has been detected along the regenerator section. It is set when a LCD, LOM or LOS defect has been detected at the regenerator section level. The time to set this signal must be as short as possible but long enough to filter intermittent defect information.

Transmission Path Alarm Indication Signal (TP-AIS): TP-AIS is used to alert associated termination point in the direction of transmission that a failure has been detected and alarmed. It is set when a LCD, LOM or LOS defect has been detected at the regenerator section level. The time to set this signal must be as short as possible but long enough to filter intermittent defect information.

Transmission Path Remote Defect Indication (TP-RDI): TP-RDI is used to alert the equipment in the opposite direction of transmission that a defect has been detected along the path. It is set when a LCD, LOM, LOS or TP-AIS defect has been detected at the transmission path level. The time to set this signal must be as short as possible but long enough to filter intermittent defect information.

8.2.4 Maintenance state tables

This subclause applies for broadband access configurations that provide transmission path continuity between B-NT2/B-TE and B-ET. The more general case where the transmission path is terminated between the B-TE and the B-ET is for further study.

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

For the purpose, two state tables are defined, one at the user side and one at the network side. States at the user side (F states) are defined in 8.2.4.1 and states at the network side (G states) are defined in 8.2.4.2. The state tables are defined in 8.2.4.4.

Fault conditions FC1 to FC4 that could occur at the network side or between the network side and user side are defined in Figure 9. These fault conditions directly affect the F and G states. Information on these fault conditions is exchanged between the user and network sides in the form of signals defined above.

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 error information are not taken into account except for power on/off transient states F6 and G13.

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 performance associated with each direction of its adjacent section. The supervision of the quality of this section is the user's responsibility.

8.2.4.1 Layer 1 states on the user side of the interface

F0 state: Loss of power on the user side

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

F1 state: Operational state

– Network timing and layer 1 service are available.
– The user side transmits and receives operational cells.

F2 state: Fault condition No. 1

– This fault state corresponds to the fault condition FC1.
– Network timing is available at the user side.
– The user side transmits operational cells.
– The user side receives physical layer OAM cells containing TP-RDI and not RS-RDI.

F3 state: Fault condition No. 2

– This fault state corresponds to any combination of FC2 with FC1, FC3 and FC4.
– Network timing may no longer be available through the link.
– The user side detects LOS, LCD.
– The user side transmits physical layer OAM cells with associated RS-RDI and TP-RDI.

F4 state:

– This fault state corresponds to fault condition FC3, or FC1 and FC3.
– Network timing may no longer be available through the link.
– The user side detects TP-AIS or LCD.
– The user side transmits physical layer OAM cells containing TP-RDI.

F5 state: Fault condition No. 4

– This fault state corresponds to the fault condition FC4 or FC1 and FC4.
– Network timing is available at the user side.

– The user side transmits operational cells.
– The user side receives physical layer OAM cells containing RS-RDI and TP-RDI.

F6 state:

– This fault corresponds to fault conditions FC3 + FC4 or FC3 + FC4 + FC1.
– Network timing may no longer be available through the link.
– The user side receives physical layer OAM cells containing RS-RDI and TP-AIS.
– The user side transmits physical layer OAM cells containing TP-RDI.

F7 state: Power on state

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

8.2.4.2 Layer 1 states at the network side of the interface

G0 state: Loss of power on the network side

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

G1 state: Operational state

– The network timing and layer 1 service are available.
– The network side transmits and receives operational cells.

G2 state: Fault condition No. 1

– This fault state corresponds to the fault condition FC1.
– Network timing is provided to the user side.
– The path terminating equipment within the access network detects LOS or LCD.
– The network side transmits physical layer OAM cells containing TP-RDI and not RS-RDI.

G3 state: Fault condition No. 2

– This fault state corresponds to the fault condition FC2.
– Network timing may no longer be available through the link.
– The network side transmits operational cells.
– The network side receives physical layer OAM cells containing RS-RDI and TP-RDI.

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 B-NT1 detects LOS from the access network.
– The network side transmits TP-AIS.
– The network side receives physical layer OAM cells containing TP-RDI.

G5 state:

– This fault state corresponds to the fault condition FC4 or FC2 and FC4.
– The network side detects LOS, LCD or LOM;
– The network side transmits physical layer OAM cells containing RS-RDI and TP-RDI to the user side.

G6 state:

– This fault state corresponds to fault conditions FC1 and FC2.

– Network timing may no longer be available through the link.

– The network side transmits physical layer OAM cells containing TP-RDI.

– The B-NT1 receives RS-RDI and TP-RDI from the user side and the path terminating equipment detects LOS or LCD.

G7 state:

– This fault state corresponds to fault conditions FC1 and FC3.

– Network timing may no longer be available through the link.

– The network side transmits physical layer OAM cells containing TP-AIS.

– The network side receives physical layer OAM cells containing TP-RDI.

G8 state:

– This fault state corresponds to fault conditions FC1 and FC4 or FC1 and FC2 and FC4.

– The network side transmits physical layer OAM cells containing RS-RDI and TP-RDI to the user side.

G9 state:

– This fault state corresponds to fault conditions FC2 and FC3.

– Network timing may no longer be available through the link.

– The network side transmits physical layer OAM cells containing TP-AIS.

– The network side receives physical layer OAM cells containing RS-RDI and TP-RDI.

G10 state:

– This fault state corresponds to fault conditions FC3 and FC4 or FC2 and FC3 and FC4.

– Network timing is not provided to the user side.

– The network side transmits physical layer OAM cells containing TP-AIS and RS-RDI to the user side.

G11 state:

– This fault state corresponds to fault conditions FC1 and FC2 and FC3.

– Network timing may no longer be available through the link.

– The network side transmits TP-AIS to the user side.

– The network side receives physical layer OAM cells containing RS-RDI and TP-RDI.

G12 state:

– This fault state corresponds to fault conditions FC1 and FC3 and FC4 or FC1 and FC2 and FC3 and FC4.

– Network timing may no longer be available through the link.

– The network side transmits physical layer OAM cells containing TP-AIS and RS-RDI to the user side.

G13 state: Power on state

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

8.2.4.3 Description of primitives

The following primitives should be used between the physical media dependent layer and the management entity [Management Physical Header (MPH) and the upper layer (Physical Header (PH) primitives]:

MPH-AI MPH Activate Indication (is used as error recovery and initialization information)

MPH-DI MPH Deactivate Indication

MPH-EIn MPH Error Indication with parameter n (n defines the failure condition relevant to the reported error)

MPH-CIn MPH Correction Indication with parameter n (n defines the failure condition relevant to the reported recovery)

PH-AI PH Active Indication

PH-DI PH Deactivate Indication

8.2.4.4 State tables

Operational functions are defined in Table 9 for the layer 1 states at the user side of the interface and in Table 10 for the network side.

Explanations of the symbols used in Tables 9 and 10.

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Table 9/I.432.2 – F-state table – Physical layer 1 state matrix at the user side

	Initial state	**F0**	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**
Definition of the states	Operational condition or fault condition	Power off at user side	Operational	FC1	FC2 fault conditions (Note 1)	FC3 or FC1 & FC3	FC4 or FC4 & FC1	FC3 & FC4 or FC3 & FC4 & FC1	Power on at user side
	Signal transmitted by user towards interface	No signal	Normal operational cells	Normal operational cells	physical layer OAM cells with RS-RDI & TP-RDI	physical layer OAM cells with TP-RDI	Normal operational cells	physical layer OAM cells with TP-RDI	No signal
New event detected at receiving side	Loss of power at user side	/	PH-DI MPH-EI0 F0	MPH-EI0 F0	MPH-EI0 F0	MPH-EI0 F0	MPH-EI0 F0	MPH-EI0 F0	MPH-EI0 F0
	Return of power to user side	F7	/	/	/	/	/	/	/
	Normal operational cells from network side	/	–	PH-AI MPH-AI F1	PH-AI MPH-AI F1	PH-AI MPH-AI F1	PH-AI MPH-AI F1	PH-AI MPH-AI F1	PH-AI MPH-AI F1
	TP-RDI (FC1)	/	PH-DI MPH-EI1 F2	–	ndp	–	–	–	MPH-EI1 F2
	LOS or LCD (FC2) (Note 2)	/	PH-DI MPH-EI2 F3	MPH-EI2 F3	–	MPH-EI2 F3	MPH-EI2 F3	MPH-EI2 F3	MPH-EI2 F3
	TP-AIS (FC3) or (FC1&FC3) (Note 3)	/	PH-DI MPH-EI3 F4	MPH-EI3 F4	ndp	–	MPH-EI3 F4	–	MPH-EI3 F4
	TP-RDI and RS-RDI (FC4)	/	PH-DI MPH-EI4 F5	MPH-EI4 F5	ndp	MPH-EI4 F5	–	–	MPH-EI4 F5
	TP-AIS & RS-RDI & TP-RDI	/	PH-DI MPH-EI3 MPH-EI4 F6	MPH-EI3 MPH-EI4 F6	ndp	MPH-EI4 F6	MPH-EI3 F6	–	MPH-EI3 & 4 F6

NOTE 1 – The user side cannot distinguish between:

– FC2;

– FC2 + FC1;

– FC2 + FC3;

– FC2 + FC4;

– FC2 + FC1 + FC3;

– FC2 + FC1 + FC4;

– FC2 + FC3 + FC4; or

– FC2 + FC1 + FC3 + FC4.

NOTE 2 – When FC2 occurs, other fault conditions (FC1 or FC3 or FC4) can not be detected but they may occur simultaneously.

NOTE 3 – When FC3 occurs, FC1 (TP-RDI) cannot be detected but it may occur simultaneously

Table 10/I.432.2 – G-state table – Physical layer 1 state matrix at the network side

	Initial state	G0	G1	G2	G3	G4	G5	G6	G7	G8	G9	G10	G11	G12	G13
Definition of the states	Operation condition or failure condition	Power off at NT1	Operational	FC1	FC2	FC3	FC4 or FC2 & FC4	FC1 & FC2	FC1 & FC3	FC1 & FC4 or FC1 & FC2 & FC4	FC2 & FC3	FC3 & FC4 or FC2 & FC3 & FC4	FC1 & FC2 & FC3	FC1 & FC3 & FC4 or FC1 & FC2 & FC3 & FC4	Power on at NT1
	Signal transmitted towards interface	No signal	Normal operational signal	Signal with TP-RDI	Normal operational signal	Signal with TP-AIS	Signal with RS-RDI & TP-RDI	Signal with TP-RDI	Signal with TP-AIS	Signal with RS-RDI & TP-RDI	Signal with TP-AIS	Signal with TP-AIS & RS-RDI	Signal with TP-AIS	Signal with TP-AIS & RS-RDI	No signal
New detected event	Loss of power or powerdown mode at NT1	–	PH-DI MPH-EI0 G0	MPH-EI0 G0	MPH-EI0 G0	MPH-EI0 G0	MPH-EI0 G0	MPH-EI0 G0	MPH-EI0 G0	MPH-EI0 G0	MPH-EI0 G0	MPH-EI0 G0	MPH-EI0 G0	MPH-EI0 G0	MPH-EI0 G0
	Return of power at NT1	MPH-CI0 G13	/	/	/	/	/	/	/	/	/	/	/	/	/
	Normal operational cells	/	–	PH-AI MPH-AI G1	PH-AI MPH-AI G1	PH-AI MPH-AI G1	PH-AI MPH-AI G1	PH-AI MPH-AI G1	PH-AI MPH-AI G1	PH-AI MPH-AI G1	PH-AI MPH-AI G1	PH-AI MPH-AI G1	PH-AI MPH-AI G1	PH-AI MPH-AI G1	PH-AI MPH-AI G1
New appearing event	Internal network failure FC1	/	PH-DI MPH-EI1 G2	–	MPH-EI1 G6	MPH-EI1 G7	MPH-EI1 G8	–	–	–	MPH-EI1 G11	MPH-EI1 G12	–	–	MPH-EI1 G2
	Reception of RS-RDI & TP-RDI (FC2)	/	PH-DI MPH-EI2 G3	MPH-EI2 G6	–	MPH-EI2 G9	ndp	–	MPH-EI2 G11	ndp	–	ndp	–	ndp	MPH-EI2 G3
	Internal network failure FC3 (Note)	/	PH-DI MPH-EI3 G4	MPH-EI3 G7	MPH-EI3 G9	–	MPH-EI3 G10	MPH-EI3 G11	–	MPH-EI3 G12	–	–	–	–	MPH-EI3 G4
	LOS , LCD or LOM (FC4)	/	PH-DI MPH-EI4 G5	MPH-EI4 G8	MPH-EI4 G5	MPH-EI4 G10	–	MPH-EI4 G8	MPH-EI4 G12	–	MPH-EI4 G10	–	MPH-EI4 G12	–	MPH-EI4 G5
Dis-appearing FC	FC1	/	/	MPH-CI1 G1	/	/	/	MPH-CI1 G3	MPH-CI1 G4	MPH-CI1 G5	/	/	MPH-CI1 G9	MPH-CI1 G10	/
	FC2	/	/	/	MPH-CI2 G1	/	–	MPH-CI2 G2	/	–	MPH-CI2 G4	–	MPH-CI2 G7	–	/
	FC3	/	/	/	/	MPH-CI3 G1	/	/	MPH-CI3 G2	/	MPH-CI3 G3	MPH-CI3 G5	MPH-CI3 G6	MPH-CI3 G8	/
	FC4	/	/	/	/	/	MPH-CI4 G3	/	/	MPH-CI4 G6	/	MPH-CI4 G9	/	MPH-CI4 G11	/

NOTE – If FC3 represents a path related fault condition (e.g. LCD), the consequent reaction is not applicable for the state table, because this failure can not be recognized at the network side. Therefore, no state change will occur.

9 Power feeding

9.1 Provision of power

The provision of power to the B-NT1 via the user-network interface is optional. When the power is provided, the following conditions should be considered.

A separate pair of wires is used for the provision of power to the B-NT1 via the T_B reference point.

The power sink is fed by either:

– a source under the responsibility of the user when requested by the network provider; or

– a power supply unit under the responsibility of the network provider connected to the mains electric supply in the customer premises.

The capability of the provision of power by the user side is available either:

– as an integral part of the B-NT2/B-TE; and/or

– physically separated from the B-NT2/B-TE as an individual power supply unit.

A power source capable to feed more than one B-NT1 should meet the requirements at each individual B-NT1 power feeding interface at the same point in time. A short circuit or overload condition in any B-NT1 should not affect the power feeding interface of the other B-NT1s.

9.2 Power available at B-NT1

The power available at the B-NT1 via the user-network interface should be at least 15 watts.

9.3 Feeding voltage

The feeding voltage at the B-NT1 should be in the range of –20 V to –57 V relative to ground.

9.4 Safety requirements

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

– The power source should be protected against short circuits and overload.

– The power sink of B-NT1 should 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 [11], the protection methods against electric shock specified in IEC Publication 950 [11] may be applied.

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