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Contents

1. Foreword

The aim of this document is to provide a first draft version of the Technical Report dealing with the transport of ATM cells over various transmission systems including Cell based transmission systems.

Some times, for reference only, part of other Recommendations have been extracted and inserted here in order to make this document readable and self-explanatory. This has been done with the intention to give as complete as possible view of the principles that should form the basis for the ATM cell transport.

2. Scope

The purpose of this document is to foresee the basic principles for the transport of ATM cells over various transmission systems, including Cell based transmission systems, independently from the interfaces which they will apply to be. The following information should form the basis for future activities and should be applicable both to the Network Node Interfaces (NNI) and to the User Network Interfaces (UNI).

3. Normative references

This document refers to CCITT recommendations ::

- G.703, G.704, G.706, G.751

- I.321, I.361, I.432, I.610

4. Introduction

The Asynchronous Transfer Mode (ATM) is considered the more suitable technique to support the broadband applications. The advantages offered by this technique suggest to urgently define the transport of the ATM cells through the network using both the existing transmission systems and the available network flexibility elements (i.e.. Digital Cross Connect).

The transport of the ATM cells into the existing transmission systems should be based both on the Plesiochronous Digital Hierarchy (PDH) and into the Synchronous Digital Hierarchy (SDH).

The broadband services provided by a generic ATM broadband termination (i.e.. terminal, user termination, user cluster termination ..), could be inserted in the network through predefined "gates". In particular two different entry point, for ATM cell transport, can be identified: one using the payload of the frame structure defined at each level of the existing hierarchy (PDH and SDH), the other using the gross bit rate of each interface (Cell based).

In the following the different structure options and their interaction with the ATM applications are reported.

In particular chapter 2 reports the functions to be performed at the Physical Layer and the information that should be exchanged between the Physical Layer and the ATM layer for the transport of the ATM cells.

Chapter 3 reports a list of OAM functions that should be performed at the Physical Layer and shows alternative solutions that can be used to implement them.

In chapter 4 are reported the cells that may be used at the Physical Layer for cell rate decoupling and for OAM functions.

Chapter 5 shows different method of mapping ATM cells into framed structure (PDH and SDH).

Chapter 6 reports the basic concepts for using the full capacity of a transmission systems to transport a continuous flow of ATM cells (unframed structure).

Chapter 7 shows a preliminary activity on burst ATM transmission system.

5. Definitions, symbols and abbreviations

Idle cell	Cell which is inserted and extracted by the Physical Layer in order to adapt the cell flow rate at the boundary between the ATM Layer and the Physical Layer to the available payload capacity of the transmission used.
Valid cell	Cell whose header has no errors or has been modified by the cell Header Error Control (HEC) verification process.
Invalid cell	Cell whose header has errors and has not been modified by the cell HEC verification process (discarded at the Physical Layer).
Assigned cell	Cell which provides a service to an application using the ATM Layer service.
Unassigned cell	ATM Layer cell which is not an assigned cell.
NNI	Network Node Interfaces
UNI	User Network Interfaces
ATM	Asynchronous Transfer Mode
PDH	Plesyochronous Digital Hierarchy
SDH	Synchronous Digital Hierarchy
UNA	User Network Access
PRM	Protocol Reference Model
PL	Physical Layer
PM	Physical Medium
TC	Transmission Convergence
HEC	Header Error Control
OAM	Operation and Maintenance
CRC	Cyclic Redundancy Check
TBA	Text to Be Added
FFS	For Further Study

6. Physical Layer functions for ATM cell transport

This section reportes the functions and the information flows that must be performed in the lower part of the general Protocol Reference Model (PRM) defined in the CCITT Recommendation I.321 for the transmission of ATM cells over any transmission system.

The Physical Layer (PL) must be able to transport valid cells without any constraint on the functions to be performed at the ATM layer.

The primitives that the PL and the ATM layer exchange each other are always the same and are independent from the selected Physical Layer.

The Physical Layer consists of two sublayers: the Physical Medium (PM) sublayer and the Transmission Convergence (TC) sublayer. The PM sublayer includes only physical medium dependent functions, while the TC sublayer performs all functions required to transform a flow of cells into a flow of data units (i.e.. bits) which can be transmitted and received over a physical medium.

6.1 Physical Medium sublayer functions

The Physical Medium sublayer provides bit transmission capability including bit transfer and bit alignment. It may include line coding and electrical/optical transformation.

6.1.1 Physical medium

The transmission functions are highly dependent on the medium used.

6.1.2 Bit timing

The principal function is the generation and reception of waveforms suitable for the medium, the insertion and extraction of bit timing information and line coding (if required).

The flow of informations identified at the border between PM and TC sublayers are a continuous flow of bits or symbols with its associated timing information.

6.2 Transmission Convergence sublayer functions

6.2.1 Transmission frame generation and recovery

This function performs the generation and recovery of the transmission frame if such a frame is utilized.

6.2.2 Transmission frame adaptation

This function performs the actions which are necessary to structure the cell flow according to the structure of the transmission frame payload (transmit direction) and to extract this cell flow out of the transmission frame envelope (receive direction). The envelope may be a cell equivalent (i.e. no external envelope is added to the cell flow), a SDH envelope, a PDH envelope, etc.

6.2.3 Cell delineation

Cell delineation prepares the cell flow in order to enable the receiving side to recover cell boundaries according to the self-delineating mechanism defined in Recommendation I.432. In the transmit direction the ATM cell stream is scrambled. In the receive direction, cell boundaries are identified and confirmed using the Header Error Control (HEC) mechanism and the cell flow is descrambled at the receiver.

6.2.4 HEC sequence generation and verification

In transmit direction, it calculates the HEC sequence and inserts it in the header. In the receive direction, cell headers are checked for errors and, if possible, the header is corrected. Cells whose headers are determinated to be errored and non-correctable are discarded.

In particular in the receive direction there are two modes of operation: "Correction Mode" and "Detection Mode". In "Detection Mode", all cells with detected header errors are discarded. 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".

6.2.5 Cell rate decoupling

Cell rate decoupling includes insertion and suppression of idle cells, in order to adapt the rate of valid ATM cells to the payload capacity of the transmission system.

6.2.6 Physical Layer OAM functions insertion and extraction

This function performs the insertion and extraction of Physical Layer OAM flows. The OAM information, related to the Physical Layer, is carried in transmission overhead or in PL-OAM cells, depending on the transmission structure used.

6.3 Physical Layer information flows

The present section defines the information flows between the Physical Medium (PM), the Transmission Convergence sublayer (TC) and their adjacent entities (ATM layer and Management Plane). The information flows identified here do not imply any physical realization. Information flows identified in this section may not be exhaustive.

6.3.1 Information exchanged between the PM and TC sublayers

a) From the PM sublayer to the TC sublayer:

The PM sublayer provides at least the following information to the TC sublayer:
- a flow of logical symbols (i.e.. bits);
- associated timing information.

b) From the TC sublayer to the PM sublayer:

The TC sublayer provides at least the following information to the PM sublayer:
- a flow of logical symbols (i.e.., bits);
- associated timing information.

6.3.2 Information exchanged between the Physical Layer and ATM layer

a) From the Physical Layer to the ATM layer:

The Physical Layer provides at least the following primitives to the ATM layer:
- valid cells (excluding idle cells and Physical Layer OAM cell);
- associated timing (i.e.., presence of data and clock information).

b) From the ATM layer to Physical Layer:
- assigned and unassigned cells if any available
- associated timing (i.e.., presence of data and clock information).

In case no cells are available, no data are transferred and the Physical Layer inserts Physical Layer cells (idle cells and PL-OAM cells if applicable) to build up the data flow to be transmitted.

6.3.3 Information exchanged between the Physical Layer and the Management Plane

a) From the Physical Layer to the Management Plane:
- indication loss of incoming signal;
- indication of far end receive fault;
- indication of received errors or indication of degraded error performance.
- indication of far end block errors;

Detection of bit errors may be based on received unexpected code violations or other bit error detecting schemes.

In addition other informations may be provided to the Management Plane. This is for further study.

b) From the Management Plane to the Physical Layer:
For further study.

7. Physical Layer OAM functions

Table 1 and 2 in Recommendation I.610 give a non exhaustive list of the functions to be provided at each of the OAM level in the Physical Layer. These functions can be ordered according to the following structure :

Maintenance functions
Performance monitoring and report
Defect detection and report
Operation functions
Failure localization

• The levels at which these functions are performed are :

Regenerator section level (flow F1)
Digital section level (flow F2)
Transmission path level (flow F3)

7.1 F1, F2 functions for the Physical Layer

7.1.1 Maintenance functions

7.1.1.1 Performance monitoring and report

- **Regenerator section error monitoring** : several mechanisms are candidates for this function (BIP, HEC, idle cells,...)(*).
- **Digital section error monitoring** : several mechanisms are candidates for this function (BIP, HEC, idle cells,...)
- **Performance reporting.**

7.1.1.2 Defect detection and report

- **Loss of signal:** This state is detected when no valid signal is received.
- **Defect indication signal:** It is provided by the Alarm Indication Signal (AIS) which is used to alert the downstream equipment that an upstream defect has been detected and that the support of the service no longer is provided.
- **Far End Receive Failure (FERF):** It is provided to alert the upstream equipment that a AIS signal or the conditions to set this signal have been detected along the downstream section.

7.1.2 Operation functions

The following functions are proposed as a preliminary approach.

- **Transmission Quality monitoring.** Three states are defined: Normal (NPS), Degraded (DPS), Unacceptable (UPS) Performance State. The criteria to define these grades are to be defined. They are derived from the previous error information.
- **Activation/deactivation.** If needed.
- **Loss of main power feeding.** When it has been detected that the main power feeding has failed, means must be provided (for example by short term backup battery) to allow to send a message to the management plane and a downstream defect indication signal.

7.1.3 Failure localization

When a defect has been detected a process of localization of the fault has to be carried out. This is for

(*) Recommendation I.610 does not foresee the need for such a function because it is an OAM function of the transmission system used.

further study.

7.2 F3 functions for the Physical Layer

The mechanisms used for F3 should be suitable for the transmission sections that constitute tha path carrying the OAM flows including sections according to G.703.

7.2.1 Maintenance functions

7.2.1.1 Performance monitoring and report

- **Error monitoring.** Several mechanisms are candidates for this function (BIP, HEC, idle cells, etc.).
- **Performance reporting.** This function reports at the upstream the results of bit error monitoring carried by the downstream equipment (FEBE).

7.2.1.2 Defect detection and report

- **Loss of signal:** This state is detected when no valid signal is received.
- **Loss Of cell Delineation (LOD).** This state is provided by the cell delineation algorithm.
- **Defect Indication signal** : It is provided by the Alarm Indication Signal (AIS) which is used to alert the downstream equipment that an upstream defect has been detected and that the support of the service no longer is provided.
- **Far End Receive Failure (FERF):** It is provided to alert the upstream equipment that a AIS signal or the conditions to set this signal have been detected along the downstream section.

7.2.2 Operation functions

The following functions are proposed as a preliminary approach.

- **Transmission Quality monitoring.** Three states are defined: Normal (NPS), Degraded (DPS), Unacceptable (UPS) Performance State. The criteria to define these grades are to be defined. They are derived from previous error information.
- **Link Load.** This informaton is provided by the number of idle cells inserted by the transmission end between two OAM cells. This information is useful to improve the behaviour of the ATM network.
- **Activation/deactivation.** If needed.
- **Loss of main power feeding.** When it has been detected that the main power feeding has failed, means must be provided (for example by short term backup battery) to allow to send a message to the management plane and a downstream defect indication signal.

7.2.3 F3 information protection

In case the F3 flow is provided by OAM cells and considering that the performance monitoring informations are used for a further performance calculation on a basis of a long period of time (for example a second) errors may also affect the OAM cells and, it would be useful, to add a CRC to protect the whole information in the cell payload. Whether if this code has to be used for error detection and/or correction needs further study.

7.3 Monitoring mechanisms.

7.3.1 SDH transmission systems

In SDH transmission systems, with their external frame, a monitoring mechanism is defined using part of the frame overhead to determine the presence of at least one error over such a frame ("block"). This mechanism allows a coarse measurment of BER performance.

7.3.2 Cell based transmission systems

Several cell based TC sublayer alternatives for cell based transmission system are under discussion, both framed and not framed. The monitoring mechanism is very much dependent on the TC sublayer. Some mechanisms and the field of applicability are summed underneath.

7.3.2.1 Error measurment by means of idle cell

Provided that the idle cell information field content is fully defined, the receive side can detect all errored bits in the information field of these idle cells, either in detail, or as error events (bit error, octet error, cell error). As in ATM streams, idle cells are expected to be available in large volume on links (on average more than 20%), the idle cels are sufficiently representative for error monitoring on the link basis. Since the contents is fully known, errors can be counted very precisely. Over a certain interval both the idle cells and errors can be counted, which allows BER to be calculated on the link or compared to a threshold value.

At the same time, the average link load can be determined as well.

7.3.2.2 Header error detection by means of HEC

By means of the HEC mechanism, single bit eror in the header can be detected, as well as multiple errors leading to cell discarding. This mechanism allows the determination of corrected and uncorrected header errors, and the cell loss ratio due to bit erors. Since headers are interpreted (and corrected) over sections, this mechanism can be used for section maintenance. Illustration of the performance provided by such a mechanism is given in Annex A.

7.3.2.3 Error detection per block of cells

In this mechanim an error detetion is performed for a block of cells. errors can be detected by means of CRC, parity bit or BIP (Bit interleaved parity, e.g. BIP8) over a block of cells. This block can be either of fixed or variable length ; the length is function of the monitoring performance wanted. The blocks are delimited by specific PL-OAM cells.

7.3.3 PDH transmision system

The alternatives for error monitoring outlined in sections 3.3.2 are applicable.

8. Physical Layer cells

In order to differentiate cells for the use at the ATM Layer from cells for the use at the Physical Layer some values of the cell header are pre-assigned for the PL only. The PL cells are used to perform the cell rate decoupling function and to carry the PL-OAM functions.

The pre-assigned header values to be used at the UNI and at the NNI interfaces are given in the CCITT Recommendation I.361 and are reported here in Table I for convenience.

Table I
Cell headers reserved for use of the Physical Layer

	octet 1 87654321	octet 2 87654321	octet 3 87654321	octet 4 87654321	octet 5 87654321
UNI	PPPP0000	00000000	00000000	0000PPP1	valid HEC
NNI	00000000	00000000	00000000	0000PPP1	valid HEC

The numbering reported in Table I is in line with the CCITT Recommendation I.361 and the bits are sent in line from the left to the right. First bit 8 of the octet numberf 1, last bit 1 of the octet 5.

The Physical Layer cells already defined and the relevant header values, are reported in the following.

8.1 Idle cell

The idle cells are inserted and extracted at the Physical Layer in order to adapt the cell flow rate at the boundary between the ATM Layer and the Physical Layer to the available payload capacity of the transmission used.

The idle cells cause no action at the receiving side except for cell delineation. They are inserted and discarded for cell rate decoupling.

Idle cell is identified by the standardized cell header pattern shown below. The idle cells are not passed to the ATM layer.

	octet 1 87654321	octet 2 87654321	octet 3 87654321	octet 4 87654321	octet 5 87654321
Header Pattern	00000000	00000000	0000000	000000001	valid HEC (*) (01010010)

* The information field is filled with a fixed pattern obtained by the repetition (48 times) of the following octet: 01101010

8.2 PL-OAM cells

The PL-OAM cells are inserted and extracted at the Physical Layer to perform PL-OAM functions primarly for cell based transmission systems.

Each PL-OAM cell has a unique header so that it can be identified by the Physical Layer at the receiver.

The PL-OAM cells are identified by the standardized cell header patterns shown below.

	octet 1 87654321	octet 2 87654321	octet 3 87654321	octet 4 87654321	octet 5 87654321
1)	00000000	00000000	00000000	00000011	valid HEC (*) (010111000)
2)	00000000	00000000	00000000	00001001	valid HEC (*) (01101010)

Note : 1) to be used at the regenerator section level (F1)
2) to be used at the digital section level and at the transmission path level (F3)

The PL-OAM cells are not passed to the ATM layer.

8.2.1 Allocation of OAM functions in information field

A provisional octet allocation for the F1 and F3 PL-OAM cells is shown in figure 1.

octet	allocation
1	R
2	AIS
3	R
4	R
5	R
6	R
7	R
8	R
9	R
10	R
11	R
12	R
13	R
14	R
15	R
16	R
17	R
18	R
19	R
20	R
21	R
22	R
23	R
24	R
25	R
26	R
27	R
28	R
29	R
30	R
31	R
32	R
33	R
34	R
35	R
36	FERF (1)
37	R
38	R
39	R
40	R
41	R
42	R
43	R
44	R
45	R
46	R
47	R
48	R

F1 cell

octet	allocation
1	R
2	AIS
3	PSN
4–5	NIC (10)
6	MBS
7	NMB_EDC
8	EDC_B1
9	EDC_B2
10	EDC_B3
11	EDC_B4
12	EDC_B5
13	EDC_B6
14	EDC_B7
15	EDC_B8
16	R
17	R
18	R
19	R
20	R
21	R
22	R
23	R
24	R
25	R
26	R
27	R
28	R
29	R
30	R
31	NMB_EB
32	EB2 / EB1
33	EB4 / EB3
34	EB6 / EB5
35	EB8 / EB7
36	FERF (1)
37	R
38	R
39	R
40	R
41	R
42	R
43	R
44	R
45	R
46	R
47–48	CEC (10)

F3 cell

Figure 1

Allocation of OAM functions in information field

8.2.1.1 Field allocation and functions for the F3 flow

The following fields are identified for the F3 flow:

- **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.
- **Number of included cells (NIC)**: gives the number of cells included between the previous and the present F3 PL-OAM cell. The length of this field is proposed to monitor 512 cells (provisionnally). It includes the number of ATM cells and idle cells but not the PL-OAM cells.

- Transmission Path error monitoring and reporting includes the fields defined below :
  + **Monitoring block size (MBS):** It is selected by balancing efficiency and monitoring accuracy. MBS = 64 cells is proposed as an upper limit, but the entire byte is allocated.
  + **Number of monitored blocks (NMB):** gives the number of blocks included between this cell and the previous F3 OAM cell. NMB = 8 is proposed. The entire byte is allocated.
  + **Error detection code (EDC)**: this code is a BIP-8 calculated on a block of MBS cells repeated for each monitored block. A byte is allocated for each block.
  + **Transmission Path Far End Block Error (TP-FEBE),(EB1, EB2,...,EB8)**: this reports the number of parity violations in each block. Four bits are necessary to indicate the number of parity violations in a BIP8. With NMB = 8, a total of 4 bytes are necessary.
- **Transmission Path Alarm Indication Signal (TP-AIS)** : one byte is allocated (the proposed coding is all "1").
- **Transmission Path Far End Received Failure (TP-FERF)** : a bit is allocated. It is set when one of the defects (LOC, LOM) or AIS (see § 4.2.1.3.4) is detected.
- **Cell Error Control (CEC)** is used to detect errors in the cell payload. A CRC 10 is proposed1).
- **Reserved Field (R)** contains the pattern of the octet of the idle cells (see § 4.4).

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

8.2.1.1.1 Maintenance signals

The following maintenance signals are defined :

- **Transmission Path Alarm Indication Signal (TP-AIS)** : it is used to alert associated downstream termination point and connection point that an upstream failure has been detected and alarmed.
- **Transmission Path Far End Received Failure (TP-FERF)** : it is provided to alert the upstream equipment that a defect has been detected along the downstream path. It is set when a LOC, LOM or a AIS signal has been detected at the path level. The time to set this signal must be as short as possible but long enough to filter intermittent defect informations. This time has to be defined. Loss Of Cell Delineation (LOC) is provided by the cell delineation algorithm. The time to indicate this state has to be defined. Loss of OAM cell (LOM) is detected when no F3 OAM cell is received when the maximum space between two F3 OAM cells is exceeded. This defect is declared when n (n to be defined) successive anomalies are detected. The method of detection of the AIS condition is for further study.

8.2.1.1.2 Transmission performance monitoring

Transmission performance monitoring across the UNI is performed to detect and report transmission errors. This function is performed on the ATM layer cells and idle cells, not on the PL-OAM cells. It is calculated on a block of cells. A F3 OAM cell carries the result for the monitoring of a certain number of blocks

-**Error Performance reporting.** This function reports at the upstream equipment, the results of the path error monitoring carried by the downstream equipment (FEBE) ; for a BIP it gives the number of parity violations in each block, calculated at the receiving end by comparison with the result carried

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1) It should be the same as in F4/F5 flows.

by the downstream cell.

8.2.1.1.3 Control communication

The provision for a capacity for a data communication channel is for further study.

8.2.1.2 Field allocation and functions for the F1 flow

The following fields are identified for the F1 flow.

- **Section Alarm Indication Signal (Section AIS)** : one byte is allocated (the provisional coding is all "1s"). it is set when failure is detected on the incoming stream (LOC, LOM, Unacceptable error performance).

- **Section Far End Received Failure (Section FERF)** : a bit is allocated. It is set when one detects LOC, LOM or Unacceptable error performance.

The other fields are for further study.

9. Framed structure

The existing digital transmission systems using the plesiochronous hierarchy (PDH) or the synchronous hierarchy (SDH) should be used for the ATM cell transport. While the frame is compulsory for the SDH systems it is desirable for the PDH systems especially when considering that PDH frames will enable some network elements to use their error detecting and maintenace facilities (e.g. protection switching). The key parameters are summarized in Annex B.

9.1 Plesiochronous Hierarchical Systems

In the case of the existing Plesiochronous Hierarchy the different levels are defined by a frame structure and by the relevant bit rate.

Each level of the PDH must be considered separately in order to optimize the ATM cell mapping.

9.1.1 Mapping of ATM cell into 2.048 Mbit/s

The clock frequency accuracy of the 2.048 Mbit/s signal must be in according with CCITT Recommendation G.703.

9.1.1.1 Transmission Convergence sublayer functions

9.1.1.1.1 Transmission frame generation and recovery

The frame of the 2.048 Mbit/s must be generated and recovered according to the CCITT Recommendations G.704 and G.706. The frame is composed of 256 bits, numbered from 1 to 256. The frame repetition is 8000 Hz. In each frame there are 32 time slots of eight bits numbered from 0 to 31.

9.1.1.1.2 Transmission frame adaptation

The ATM cell mapping is performed aligning the octet structure of the cell with the octet structure of the 2.048 Mbit/s frame.

The payload capacity is limited to 1.920 Mbit/s as in some cases the time slot 16 is used for signalling while time slot 0 is always used for frame alignment.

9.1.1.1.3 Cell delineation

At the receiving side the cell delineation is performed using the Header Error Control (HEC) mechanism.

9.1.1.1.4 HEC sequence generation and verification

The Header Error Control (HEC) value is generated and inserted in the appropriate field according to the section 4.3.2 of the Recommendation I.432.

The header verification is performed at the receiver side according to the section 4.3.1 of the Recommendation I.432.

9.1.1.1.5 Cell rate decoupling

The cell rate decoupling is performed by the insertion of idle cell when no valid cell are available from the ATM layer.

9.1.1.1.6 Physical Layer OAM functions insertion and extraction

In the 2.048 Mbit/s framed signal, defined according the CCITT Recommendation G.704, the bit error rate monitoring is done by a crc procedure (G.706) and reporting of far end bit errors (block errors) as well as far end receive failures is performed by dedicated bits in the time slot zero of the frame structure.

These functions represent some of the OAM flows defined in the Recommendation I.610.

9.1.1.2 Physical Medium sublayer functions

The Physical Medium sublayer functions must be according to CCITT Reccomendation G.703

9.1.2 Mapping of ATM cell into 34.368 Mbit/s

9.1.2.1 Transmission Convergence sublayer functions

9.1.2.1.1 Transmission frame generation and recovery

The frame of the 34.368 Mbit/s must be generated and recovered according to the CCITT Recommendation G.751. The frame is composed by 1536 bits, numbered from 1 to 1536. The frame repetition is 22375 Hz.

9.1.2.1.2 Transmission frame adaptation

The ATM cell mapping is performed aligning the bit structure of the cell with the bit structure of the 34.368 Mbit/s frame. A four bit structure could be used for mapping.

The payload is of 34.099 Mbit/s as the first 12 bits are always used for frame alignment signal and OAM.

9.1.2.1.3 Cell delineation

At the receiving side the cell delineation is performed using the Header Error Control (HEC) mechanism.

9.1.2.1.4 HEC sequence generation and verification

The Header Error Control (HEC) value is generated and inserted in the appropriate field according to the section 4.3.2 of the Recommendation I.432.

The header verification is performed at the receiver side according to the section 4.3.1 of the Recommendation I.432.

9.1.2.1.5 Cell rate decoupling

The cell rate decoupling is performed by the insertion of idle cell when no valid cell, coming from the ATM layer, are avilable.

9.1.2.1.6 Physical Layer OAM functions insertion and extraction

The F1 and F2 flows are performed by the frame structure and the F3 flow is performed by a F3 PL-OAM cell.

9.1.2.2 Physical Medium sublayer functions

The Physical Medium sublayer functions must be according to CCITT Reccomendation G.703

9.1.3 Mapping of ATM cell into 139.264 Mbit/s

9.1.3.1 Transmission Convergence sublayer functions

9.1.3.1.1 Transmission frame generation and recovery

The frame of the 139.264 Mbit/s must be generated and recovered according to the CCITT Recommendation G.751. The frame is composed by 2928 bits, numbered from 1 to 2928. The frame repetition is 47562.842 Hz.

9.1.3.1.2 Transmission frame adaptation

The ATM cell mapping is performed aligning the bit structure of the cell with the bit structure of the 139.264 Mbit/s frame. Either a four bit and octet structure could be used for the mapping.

The payload is of 138.502 Mbit/s as the first 16 bits are always used for frame alignment signal and OAM.

9.1.3.1.3 Cell delineation

At the receiving side the cell delineation is performed using the Header Error Control (HEC) mechanism.

9.1.3.1.4 HEC sequence generation and verification

The Header Error Control (HEC) value is generated and inserted in the appropriate field according to the section 4.3.2 of the Recommendation I.432.

The header verification is performed at the receiver side according to the section 4.3.1 of the Recommendation I.432.

9.1.3.1.5 Cell rate decoupling

The cell rate decoupling is performed by the insertion of Idle cell when no valid cell, coming from the ATM layer, are avilable.

9.1.3.1.6 Physical Layer OAM functions insertion and extraction

The F1 and F2 flows are performed by the frame structure and the F3 flow is performed by a F3 PL-OAM cell.

9.1.3.2 Physical Medium sublayer functions

The Physical Medium sublayer functions must be according to CCITT Reccomendation G.703

9.2 Synchronous Hierarchical Systems

9.2.1 Transmission Convergence sublayer functions

9.2.1.1 Transmission frame generation and recovery

At each level of the SDH the Synchronous Transport Module (STM) consists of information payload and Section Overhead (SOH) information fields organized in a block frame structure which repeats every 125 microseconds. The frame alignment of a STM-N (N>1) is performed using the Frame Alignment Signal (FAS) defined in the Recommandation G.708.

The available payload information depends on the Container (C-n; n=1-4) used or by the capacity obtained with the concatenation of a multiplicity of Virtual Containers. Alignment information to identify VC frame start is provided by specific pointers.

9.2.1.2 Transmission frame adaptation

The mapping of ATM cells is performed by aligning the byte structure of every cell with the byte structure of the virtual container used including the concatened structure (VC-x or VC-x-mc, x>1). Since the relevant C-x capacity may not be an integer multiple of the ATM cell length (53 octets), a cell is allowed to cross the C-x boundary.

9.2.1.3 Cell delineation

The cell delination is performed using the HEC method described in section 4.5.1.1 of the Recommendation I.432. When the ATM stream is mapped into a VC-4 the H4 pointer provides a cell boundary indication which may optionally be used to supplement the mandatory HEC cell delination mechanism.

The ATM cell information field (48 bytes) shall be scrambled before mapping into the VC-x or VC-x-mc signal. In the reverse operation, following termination of the VC-x or VC-x-mc signal, the ATM cell information field will be descrambled before passing to the ATM layer. A self-synchronizing scrambler with generator polynomial $X^{43}+1$ shall be used as described in section 4.5.3 of the Recommendation I.432.

9.2.1.4 HEC sequence generation and verification

The Header Error Control (HEC) value is generated and inserted in the appropriate field according to the section 4.3.2 of the Recommendation I.432.

The header verification is performed at the receiver side according to the section 4.3.1 of the Recommendation I.432.

9.2.1.5 Cell rate decoupling

The cell rate decoupling is performed by the insertion of idle cells when no valid cells are available from the ATM layer.

9.2.1.6 Physical Layer OAM functions insertion and extraction

The Physical layer OAM functions are carried into the relevant overhead octets defined in the frame structure of the STM-N.

9.2.2 Physical Medium sublayer functions

The Physical Medium sublayer functions must be according to CCITT Reccomendation G.703

10. Unframed structure

A Cell based transmission system is a transmission system built by a continuous flow of cells, in which some are dedicated to transport Operation And Maintenance (OAM) functions related to the Physical Layer (PL).

These transmission systems may have gross bit rates either equal to the bit rates defined in the Recommendation G.703 or they may be defined according to the application needs.

In any case the Cell based transmission system should be optimized for a high degree of commonality with the transmission systems defined for the interfaces at the S_B and T_B reference points for the User

Network Access (UNA), and reported in CCITT Recommendation I.432, and with the transmission systems to be used at the Network Node Interface (NNI).

10.1 Transmission Convergence sublayer functions

10.1.1 Transmission frame generation and recovery

No actions are required.

10.1.2 Transmission frame adaptation

No actions are required.

10.1.3 Cell delineation

The cell delination is performed using the HEC method described in section 4.5.1.1 of the Recommendation I.432.

The distributed sample scrambler ($x^{31}+x^{28}+1$) described in § 4.5.3.2 of the Recommendation I.432, is used.

10.1.4 HEC sequence generation and verification

The Header Error Control (HEC) value is generated and inserted in the appropriate field according to the section 4.3.2 of the Recommendation I.432.

The header verification is performed at the receiver side according to the section 4.3.1 of the Recommendation I.432.

10.1.5 Cell rate decoupling

The cell rate decoupling is performed by the insertion of idle cells when valid cell, coming from the ATM layer, are not available.

10.1.6 Physical Layer OAM functions insertion and extraction

The Physical Layer OAM functions are performed by the insertion and extraction of specific PL-OAM cells.

10.2 Physical Medium sublayer functions

The Physical Medium sublayer functions must be according to CCITT Reccomendation G.703

11. Burst ATM transmission systems

In burst mode transmission, there is no continuous flow of cells. Cells are transmitted in burst, only when necessary. Two consecutive bursts are separated by a gap of variable length, where nothing is transmitted.

11.1 Definition of Burst ATM Transmission

Burst ATM transmission is an asynchronous transmission technique (start-stop operation), whereby cells are transmitted in "strings", preceded by a suitable transmission preamble. The function of the burst transmission option is located in the Transmission Convergence Sublayer. The ATM layer is not affected.

Compared to continuous transmission, the new elements are "strings" and "preamble". The mechanism is further described below. Burst ATM transmission can be used to transmit either

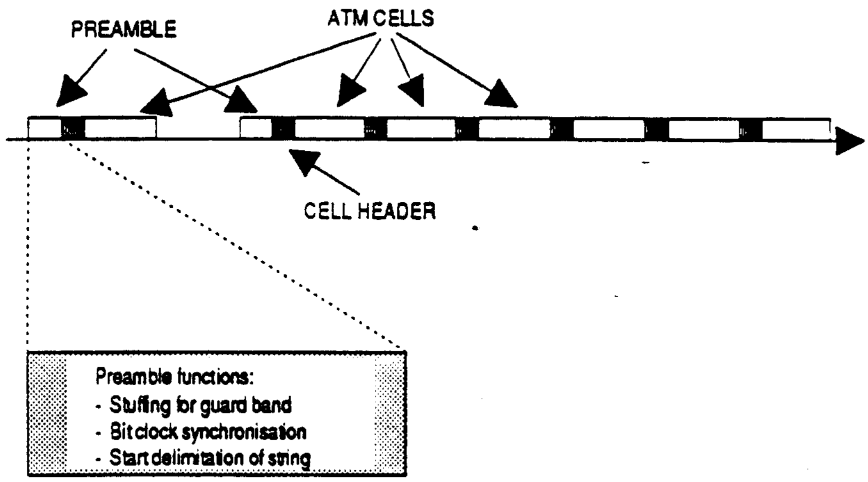
- Single ATM cells (string = 1 cell long)
- Short strings of ATM cells (string = several cells long)

- Long strings of ATM cells, or at the extreme a continuous ATM cell stream

Specific for burst transmission is that every string of ATM cells is preceded by a transmission preamble, which should be following functions: stuffing for guard band, bit clock synchronization, start delimitation of the string.

After the preamble a string of any length of ATM cells is transmitted, without any explicit cell delimiter. The HEC mechanism is used for cell boundary alignment. In case of long strings or a continuous ATM cell stream, the cell synchronization mechanism, as adopted by CCITT SG XVIII, is applicable. At the end of the last cell of string, no specific trailer is required, since cells have a fixed length.

Activation/deactivation as well as emergency mode are embedded features of the burst transmission. The power saving can be very significant.



As can be seen, the Burst ATM transmission is comparable to normal ATM transmission methods under discussion so far, but with the specific Burst option, allowing short strings of cells to be transmitted. It is especially this feature which makes it useful at various points in the network, including PONs.

As such the Burst transmission option can be used in combination with the cell oriented mechanism, which is actually being defined in ETSI NA-5/BNI. From this analysis it is important that the Burst ATM transmission is defined as an option for the cell oriented method. Hence, compatibility must be obtained.

11.2 Physical medium sublayer

11.2.1 Bit rate

105.52 Mbit/s and 622.08 Mbit/s may be considered

11.2.2 Timing

At the receiver side the timing is locally provided by the clock of the receiver equipment

11.2.3 Physical characteristics

The burst ATM transmission can either be used on optical and coaxial transmission media.

11.2.4 Transmission range

F.F.S

11.2.5 Transmission code

CMI or NRZ according to I.432

11.3 Transmission Convergence sublayer

11.3.1 Transfer capability

In order to enable full integration with framed and unframed transmission systems, the transfer capability for an interface at:

- 155.520 Mbit/s is 149.760 Mbit/s
- 622.080 Mbit/s is 599.040 Mbit/s

11.3.2 Transmission frame adaptation

11.3.3 Interface structure

Every string consists of a preamble, followed by one or more ATM cells. The transmission preamble can vary up to 8 octets. With current technology this is an achievable value. The precise value is for further study.

The preamble supports the following functions:

- Stuffing for guard band. Between consecutive strings a guard band may have to be provided. This may be especially occur in PONs, where cells may come from various sources. In case a source wants to send several cells in a string, no guard band is required. The cells are adjacent. The length of the guard band is for further study.
- Bit clock synchronization. For this purpose a predetermined fixed pattern is suggested. The length and value are for further study.
- Start delimitation of the string. This function enables the precise start position of the payload, in this case the first ATM cell of the string.
- Whether or not an End of Burst detection is necessary is still for further study. Methods already identified for End of Burst detection are:
  - last cell is a PL_OAM cell;
  - use of a cell delimiter at the end of the string;
  - indication of the last cell in GFC field. In this case there is no need for a trailer, since the length of the last cell is well known.

11.3.4 OAM implementation

F.F.S.

11.3.5 ATM cell Header Error Control

The ATM cell header error control (HEC) value is generated and inserted in the appropriate field, according to the section 4.3.2 of the Recommendation I.432.

The ATM cell header verification is performed at the receiver side according to section 4.3.1 of the Recommendation I.432.

11.3.6 Cell Rate Decoupling

As in the Burst ATM transmission technique there is no need for a continuous cell flow, stuffing with physical layer idle cell is not mandatory. Instead Burst ATM foresees pauses in between strings. However insertion of idle cell is allowed, whenever necessary.

11.3.7 Cell delineation

For strings of ATM cells, the following procedure is proposed. After the bit synchronization is accomplished, CELL DELINEATION is assumed. The first ATM cell header is then verified by means of the HEC mechanism, as a CONFIRMATION. If valid, cells are accepted. During the string, or during continuous cell transmission, observation of the HEC remains active, in order to detect the Out of Cell Delineation condition. A flow diagram as for continuous operations needs to be defined.

11.3.8 Scrambling

As the burst transmission should be fully compatible with continuous transmission, the same scrambler remains active, as defined in the Cell based option, being the Distributed Sample Scrambler of 31st order. Therefore, the scrambler should be PRESET for every string at a predefined value at the start of the payload (first ATM cell of the string). Presetting the scrambler is advantageous for the following reasons:

- in case a string is missed, the scrambler is always immediately in synchronization again;
- compatibility in case of multiple sources, i.e. for PONs.

The robustness for the first few cells is equivalent to the operation of a reset scrambler. For longer strings the robustness is equivalent to the cell based transmission.

Annex A

Use of the HEC to evaluate the error performance

A.1 Description of the method

The Header Error Control (HEC) is used both for the protection of the header field of each cell and for the cell delineation. The error correction code adopted (generator polynomial: x8+x2+x+1) is able to correct all single errors, and to detect all double errors.

In particular, all single errors are corrected, all double errors are detected, and all odd errors are either corrected or detected, depending on the error pattern configuration. In any case the odd errors are "seen" by the code.

Figure 1 shows the theoretical relation between the error detection probability (pd) of the HEC code and the bit error probability (p) on the link, assuming a Poisson distribution of errors.

The error detection probability (pd) is defined as the probability of either correction or detection in the header.

At the receiver, counting the number of corrections and detections for a certain number of cells, it is possible to evaluate the error detection rate and then obtain the bit error rate using the relation shown in Figure 1.

For example when the ratio between the errored headers and the received headers is 1/100 (pd=10-2) the theoretical bit error rate is about 2.5 10-4.

Obviously the precision of the measure depends on the length of the observation period. Figure 2 shows the measurement time, expressed in number of cell (Nc), versus the bit error rate (p) for a fixed measurement relative uncertainty (e=Dp/p=10%), with confidence level of the 99%. In particular curve A is obtained checking all the bits of a sequence of known cells (e.g. idle cells). Curve B is obtained checking bit by bit only the header of the cells.

Curve C shows the number of cells (Nc) to be observed when only the HEC law is checked for every cell. After 105 cells a bit error rate in the range between 2 10-4 and 1.5 10-1 (2 10-4 < p < 1.5 10-1) can be evaluated with an uncertainty lower than 10% in the 99% of the cases.

The relation between the theoretical uncertainty (e=Dp/p) and the length of the measure is shown in Figure 3 for a fixed value of bit error rate (p=10-4) and for a confidence level of 99%. Some measures, done in a real receiver using an emulated channel with a fixed error rate (p=10-4), are indicated in Figure 3 by stars (*).

Figure 4 shows the theoretical uncertainty (e=Dp/p) introduced in the measure versus the bit error rate (p) after 105 cells (Nc=105) with the same confidence level. The stars are the result of some simulations checking the HEC code property.

The method could be improved using two counter, one counting the correction events and the other one the detection events. After a certain period the counter values will be differently weighted considering that all single error are corrected, all double errors are detected, and all odd errors are either corrected or detected.

A simplified version could be obtained considering that the detection event is mainly due to a double error condition. The correctness of this approximation is also proved by a field observation carried on a fiber optic system showing that the 99.64% of the errored second (ES) had one bit error while only 0.12% of the ES had four or more bit errors. In any case in the 99.88% of the ES there are less than 4 errors.

A.2. Comparison with other methods

The line Bit Error Rate (BER) is one of the performance parameter to be evaluated at the receiving side of every transmission system. This function is generally performed by checking either the violations of the line code used or CRC bits.

In principle an ideal error monitoring algorithm should be able to calculate the exact line bit error rate. The performance of such theoretical mechanism is reported in Figure 5. Obviously real other mechanism will be able to provide an evaluation of the true error rate.

In the particular case of the Synchronous Digital Hierarchy the line BER monitoring is performed by using the Bit Interleaved Parity N (BIP-N) code with even parity. In Figure 5 the Error Detection Rate (EDR), i.e. the number of errored bits in the measured BIP, versus the theoretical Bit Error Rate is reported for both BIP-8 and BIP-24. The curves of Figure 5 are obtained assuming a Poisson distribution of errors.

In a Cell based transmission system the error performance can be evaluated using the informations extracted during the header correction/detection function. The HEC detects all single, double and odd numbers of errors within the header. Assuming a Poisson distribution of errors the HEC is able to give an evaluation of the performances of the link as reported in Figure 5.

The curves derived with the BIP and the HEC are parallel to the theoretical one when the Bit Error Rate is low. This means that a constant value must be added to the evaluated EDR in order to obtain the theoretical BER. For example an EDR of 10-3 evaluated with the BIP-8 implies a BER of about 0.59 10-6 and an EDR of 10-5, evaluated with the HEC, implies a BER of about 0.41 10-6.

All described methods have an upper bound. To read such bound, the slope decreases, and the BER evaluation becomes unreliable because an increase in the line BER causes only a little variation in the EDR. For the BIP-8 and BIP-24 methods this value applies when the BER is about 10-4 and 8 10-4 respectively while the boundary is higher of 10-3 (about 10-2) for the HEC method. The boundary for the described methods is more observable in Figure 6.

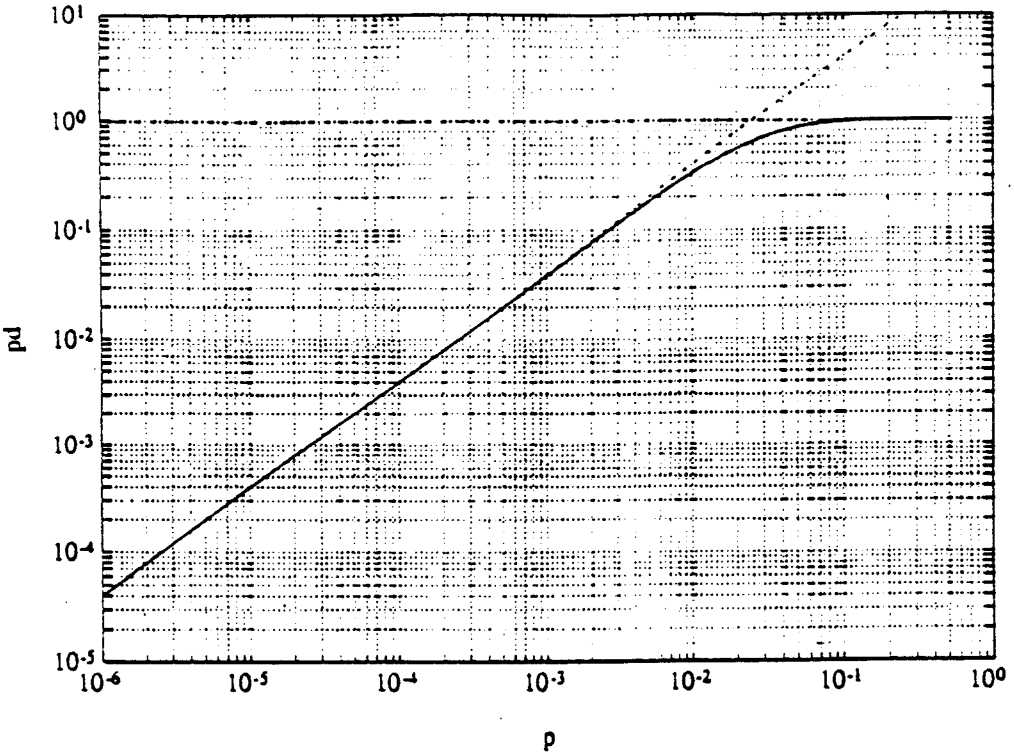


Figure 1

Error detection probability (pd) versus the bit error probability (p)

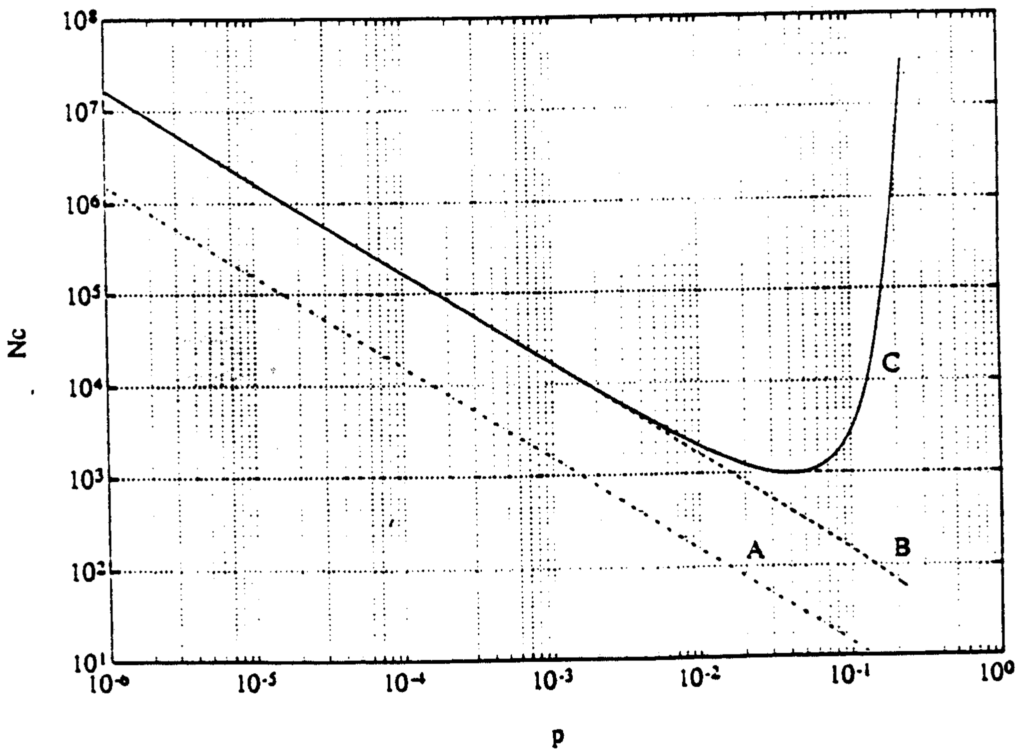


Figure 2

**Measurement time, in number of cell (Nc), versus the bit error rate (p)
(e=10% and confidence level = 99%)**

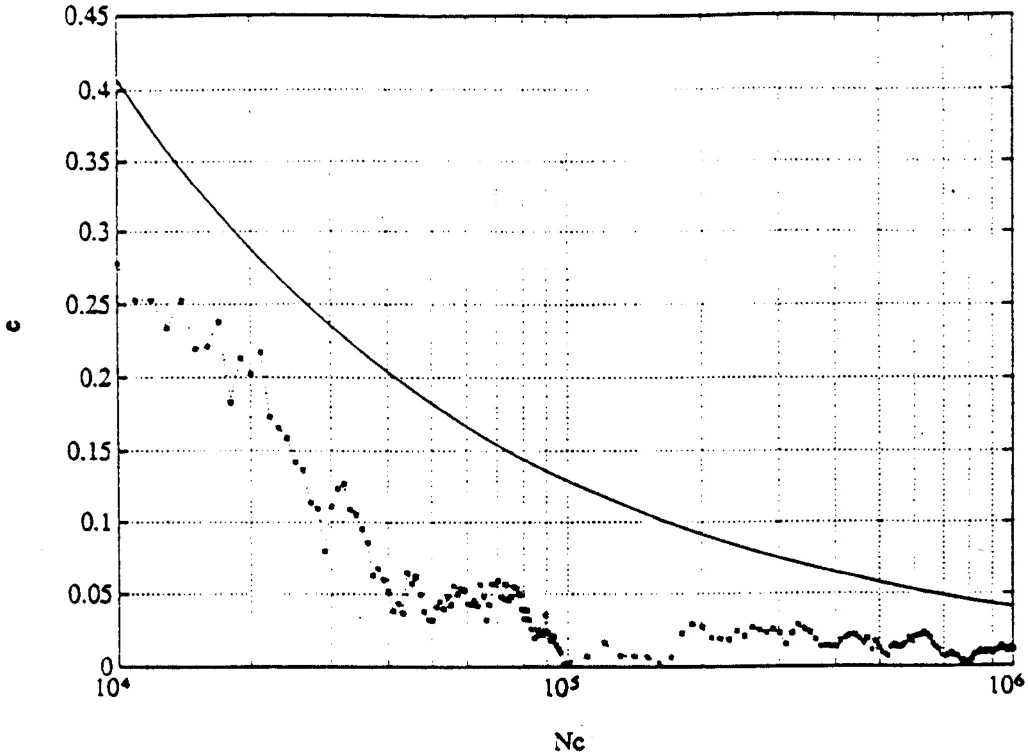


Figure 3

Uncertainty (e=Dp/p) versus the length of the measure (Nc) (p=10-4 and confidence level = 99%)

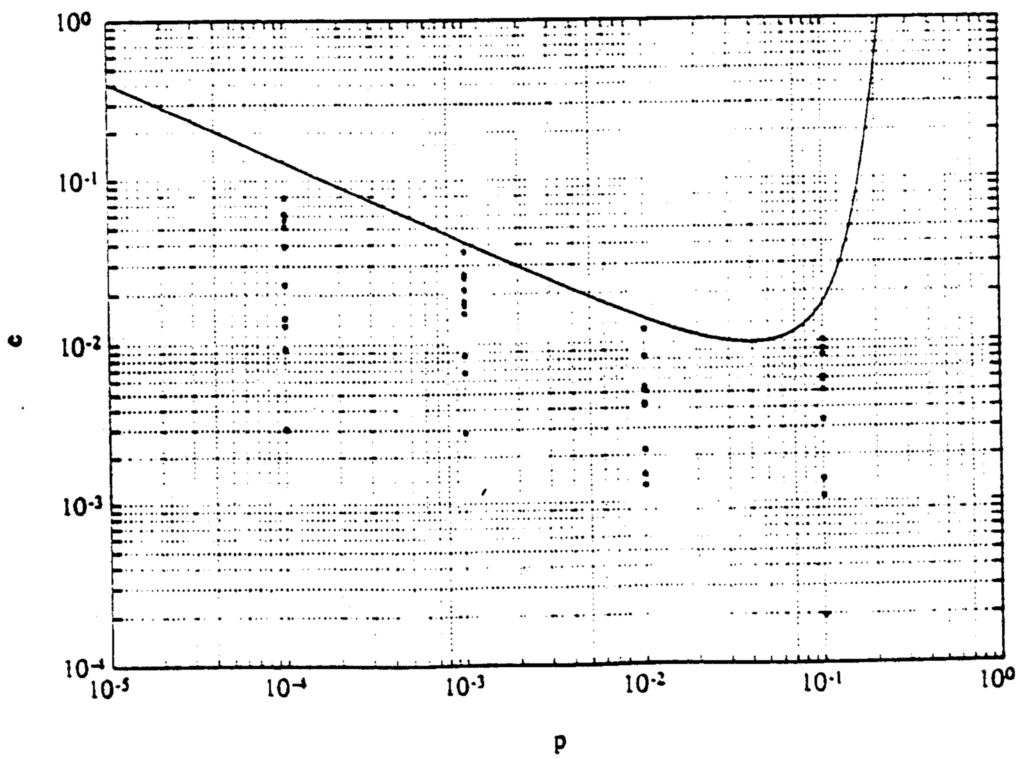


Figure 4

Uncertainty (e=Dp/p) versus the bit error rate (p) (Nc=105 and confidence level = 99%)

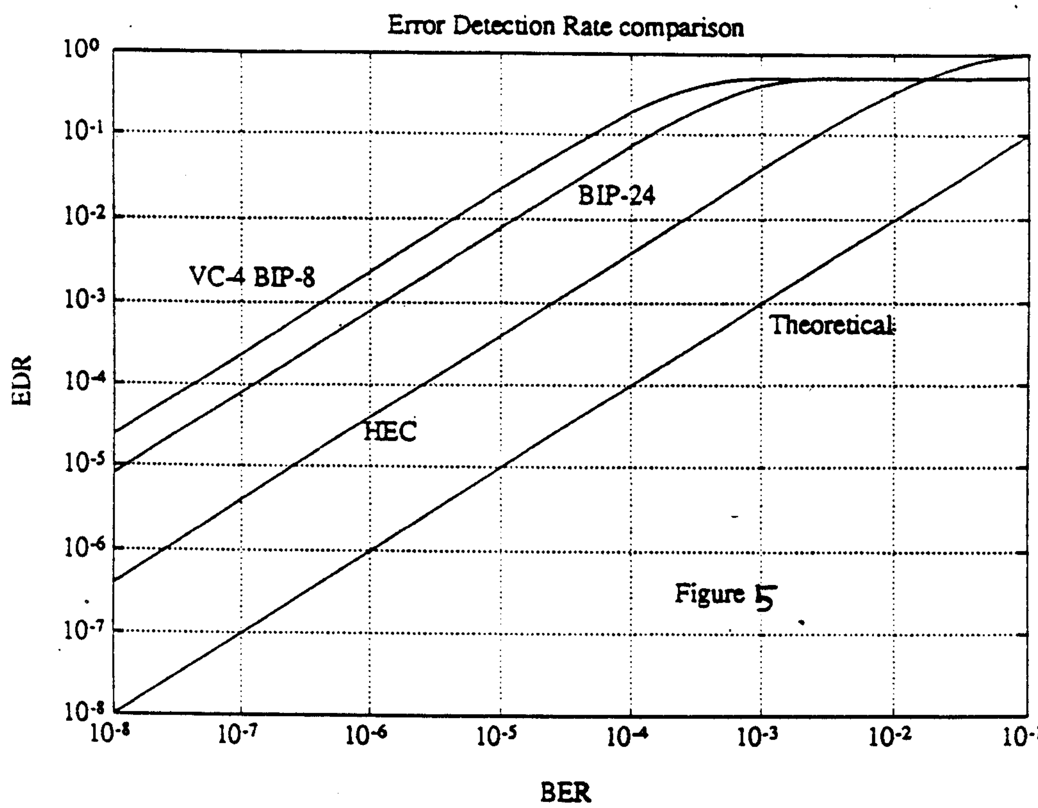


Figure 5

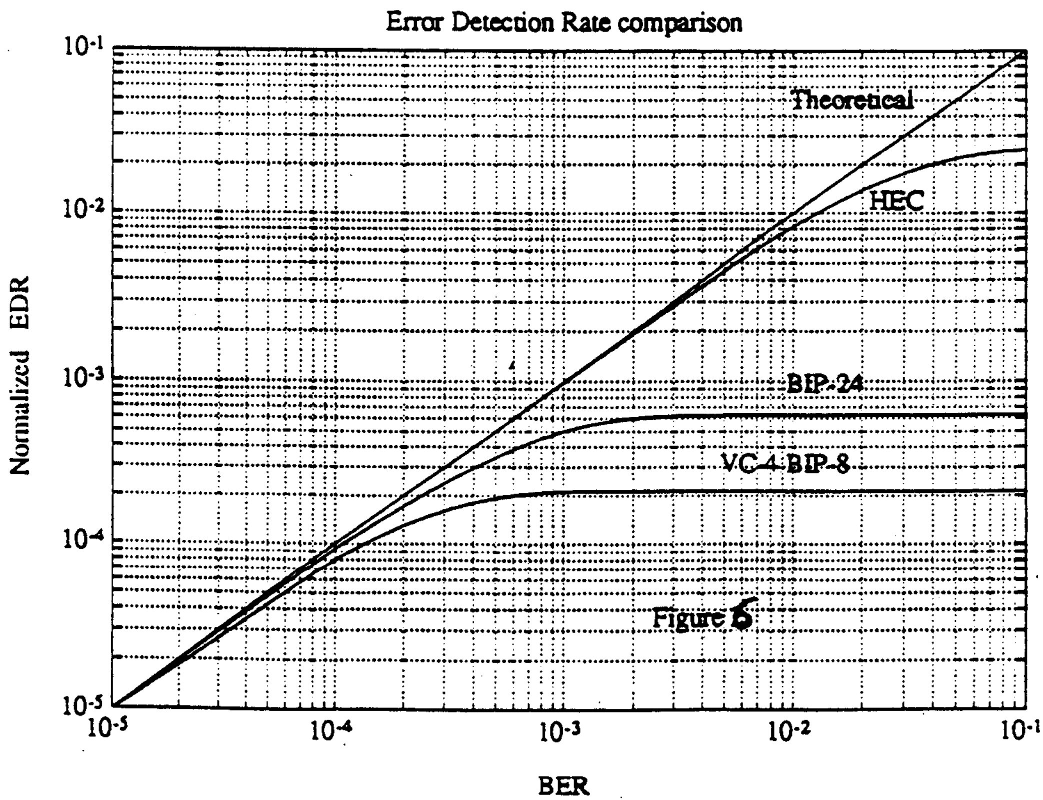
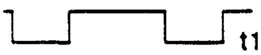


Figure 6

Annex B

Key parameters for cell mapping on different transmission systems

G.703					
	2/34/140 Mbits Transparent	G.704 2 Mbit/s	G.751 34 Mbit/s	G.751 140 Mbit/s	G.707 155 Mbit/s
Average bit rate available at the ATM layer	<2/34/140	<1920 kbit/s	<34099kbit/s	<138502 kbit/s	<149,76 Mbit/s
Cell delineation number of bits to detect /loss \Recovery of cell delineation (BER)	HEC + $x^{31} + x^{28} + 1$ (1 + X^{43})				HEC +
External framing  t1 >t1< t2 < t2	empty	8 bits 15x8 bits	12 bits 1524 bits	16 bits 2912 bits	8x10 bits 8x260 bits
Number of bits to detect /loss	empty	3x256 bits (BER > 10-3)	3x1536 bits	3x2928 bits	4x2430 bytes
\Recovery of framing (BER)	empty	2x256 bits (BER < 10-4)	2x1536 bits	2x2928 bits	2x2430 bytes

History

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