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SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

International telephone connections and circuits – Transmission plan aspects of special circuits and connections using the international telephone connection network

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Planning guidelines for the integration of ATM technology into networks supporting voiceband services

ITU-T Recommendation G.176

(Previously CCITT Recommendation)

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ITU-T RECOMMENDATION G.176

PLANNING GUIDELINES FOR THE INTEGRATION OF ATM TECHNOLOGY INTO NETWORKS SUPPORTING VOICEBAND SERVICES

Summary

This Recommendation provides transmission performance planning guidance to network and service planners who are responsible for the integration of ATM technology, e.g. digital processing equipment, multiplexers, and switches, into the PSTN. This Recommendation recognizes and addresses: the interconnection of other networks, e.g. Private Networks and Digital Cellular Networks, with the PSTN, and the continued need to support existing voiceband services.

Source

ITU-T Recommendation G.176 was prepared by ITU-T Study Group 12 (1997-2000) and was approved under the WTSC Resolution No. 1 procedure on the 18th of April 1997.

FOREWORD

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The approval of Recommendations by the Members of the ITU-T is covered by the procedure laid down in WTSC Resolution No. 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

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

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As of the date of approval of this Recommendation, the ITU had/had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

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Recommendation G.176

PLANNING GUIDELINES FOR THE INTEGRATION OF ATM TECHNOLOGY INTO NETWORKS SUPPORTING VOICEBAND SERVICES

(Geneva, 1997)

1 Preamble

This Recommendation is intended to provide transmission performance planning guidance to network and service planners who are responsible for the integration of ATM technology into networks. This Recommendation assumes that ATM will always ride on a standard physical layer transmission system, e.g. SONET (Synchronous Optical NETwork), Synchronous Digital Hierarchy (SDH).

The current regulatory operating environment in certain countries has made allowance for other networks to interconnect with the PSTN. Thus, this Recommendation also addresses the interconnection of other networks, e.g. Private Networks and Digital Cellular Networks, with the PSTN and it is consistent with the concept that customers may provision their own terminal equipment. The information in this Recommendation is intended to provide guidance consistent with this operating environment.

2 Scope

This Recommendation deals with the subject of planning the integration of ATM technology into networks. The introduction of ATM technology into the PSTN will make it more difficult to convey in a unique fashion what is meant by the term "digital PSTN" and in some instances will require an ability to uniquely reference the portion of technology within it that is ATM or non-ATM in character. To overcome this hurdle, the term "Plesiochronous Digital Hierarchy/Synchronous Digital Hierarchy (PDH/SDH) oriented networks" will be used, the intention being that these networks represent the byte domain while ATM networks represent the cell domain. To work between these domains, viz. between the PDH/SDH and the ATM cell domain, it is understood that an interworking function must exist and while it may physically occur in the PDH/SDH or the ATM cell-oriented hardware, it is always deemed to occur at the boundaries of the PDH/SDH and ATM cell networks.

A number of existing Recommendations deal with the subject of transmission impairments that affect modern telephone connections with regards to the quality of speech communications, and to some extent, data transmission in a generic sense, and are not intended to be tied to the technology used for the transmission medium. Thus, although they do not include explicit statements to say that they are intended to provide guidance on the integration of ATM technology into the PSTN, they can and should be used for guidance, e.g. Recommendations G.113, G.114 and G.131. Planning rules associated with the initial creation of ATM islands and planning rules for the introduction of additional ATM technology within each of these islands will be presented.

3 Normative 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.

– ITU-T Recommendation G.101 (1996), *The transmission plan*.

– ITU-T Recommendation G.113 (1996), *Transmission impairments*.

– ITU-T Recommendation G.114 (1996), *One-way transmission time*.

– ITU-T Recommendation G.122 (1993), *Influence of national systems on stability talker echo in international connections*.

– ITU-T Recommendation G.126 (1993), *Listener echo in telephone networks.*

– ITU-T Recommendation G.131 (1996), *Control of talker echo*.

– CCITT Recommendation G.132 (1988), *Attenuation distortion*.

– ITU-T Recommendation I.361 (1995), *B-ISDN ATM Layer Specification.*

– ITU-T Recommendation Q.552 (1996), *Transmission characteristics at 2-wire analogue interfaces of digital exchanges.*

– ITU-T Recommendation G.712 (1996), *Transmission performance characteristics of pulse code modulation channels.*

– ITU-T Recommendation I.731 (1996), *Types and general characteristics of ATM equipment.*

– ITU-T Recommendation I.732 (1996), *Functional characteristics of ATM equipment.*

4 Terms and definitions

This Recommendation defines the following terms:

4.1 asynchronous transfer mode (ATM): The term applied to a technology that is based on the premise that information is transported in cells. Specifically, in this Recommendation ATM is used to apply to technology that uses Recommendation I.361 B-ISDN ATM Layer Specification for ATM cell size and makeup, viz. 53 octets per cell with 5 octets allocated for the header and 48 octets allocated to carry payload information.

Additionally, the ATM technology is expected to be designed consistent with Recommendation I.731 and operate consistent with the functional characteristics defined in Recommendation I.732.

4.2 ATM digital signal processing function (see Figure 2): The term applied to ATM technology that operates with cell-based signals operating over standard line rates on both the inputs and the outputs, e.g. E3 on the input and E3 on the output, and which modifies the payload contents of the cells as they pass through in some prescribed manner. This device may modify none, some, or all of the cells that pass through it. This cell modification is intended to change the transmission characteristics of the signals in the virtual connections, e.g. this device may perform echo cancellation or speech compression on some or all the virtual connections that pass through it.

4.3 ATM multiplexer/crossconnect (see Figure 3): The term applied to a cell-multiplexing device that operates with cell-based signals and over standard line rates on all interfaces, e.g. T1 and T3, and which passes the cells received on an input to an output. The relationship between input and output, i.e. the virtual circuits routing, does not change on a per call basis, i.e. only permanent virtual circuits are supported. This device does not allow blocking or signal compression.

4.4 ATM transport system (see Figure 4): The term applied to a transport system that is composed of a carrier system terminated by an ATM multiplexer at each end. The relationship between input and output, i.e. virtual circuits, cannot change on a per call basis, i.e. permanent virtual circuits only are supported. This device does not allow blocking or signal compression.

4.5 ATM switch (digital interfaces only) (see Figure 5): The term applied to ATM technology that operates with cell-based signals and over standard line rates on both the inputs and the outputs, e.g. T1 or E1 on the input and T3 or E3 on the output, and which passes the cells received on the input to the output. The relationship between input and output, can change on a per call basis, i.e. switched virtual circuits must be supported and permanent virtual circuits may be supported. This device allows blocking and performs concentration.

4.6 ATM switch (analogue and digital interfaces) (see Figure 6): The term applied to ATM technology that operates with analogue 2-wire interfaces[1] and standard digital line rates on both the inputs and the outputs, e.g. T1 on the input and T3 on the output, and which passes the cells received on the input to the output. The relationship between input and output, can change on a per call basis, i.e. switched virtual circuits must be supported and permanent virtual circuits may be supported. (For the purposes of this Recommendation it is assumed that the cell formation function associated with an analogue input is performed before the switch function occurs. However, this definition is not intended to constrain technical implementations.) This device allows blocking and concentration. The switch function is also required to perform 2-wire to 4-wire conversion as well as A/D conversion.

4.7 ATM interworking function (with narrowband services in the PDH/SDH byte-oriented domain) (see Figure 7): The term applied to a technology device that allows ATM systems, i.e. cell-oriented systems, to interwork with narrowband, byte-oriented systems. Although interworking will have to occur in both the transmission plane and the signalling plane, this Recommendation will restrict itself to the transmission plane.

4.8 DS1 signal: The term used to apply to a primary rate line signal. The signal at an interface can be specified as either E1 or T1.

4.9 DS3 signal:The term used to apply to a line signal operating at the 3rd level in the transmission hierarchy. The signal at an interface can be specified as either E3 or T3.

4.10 equipment impairment factor: A number allocated to a network element, in units of "eif", that indicates the anticipated incremental level of impairment that would result when this element is inserted into a connection. See Recommendation G.113.

4.11 equipment impairment factor unit: The unit "eif" (Equipment Impairment Factor) is used to specify the impairment associated with a particular network element, e.g. transmission circuit or digital signal processing unit. See Recommendation G.113.

4.12 guidance not required (GNR): The term GNR is used in Table 1 and is used to indicate that the associated parameter should have negligible or no impact on the ATM functionality under consideration (This is because approved ATM or SDH objectives for these parameters are sufficiently stringent so as not to affect the performance of the derived voiceband channels.) It is the responsibility of the network planner to ensure that this assumption is not invalidated by selection of inappropriate equipment.

4.13 preliminary guidance available (PGA): The term "PGA" is used in Table 1 and is used to indicate that the associated parameter must be considered in the context of transmission performance for end-to-end connections and that preliminary guidance is available. (Sources where guidance information can be found is provided within square brackets within Table 1.)

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[1] This configuration is not intended to exclude analogue 4-wire interfaces. However, the intended focus is on the 2-wire interface. For convenience, this 2-wire interface is assumed to occur in a 2-wire line card. However, use of this term is not intended to constrain technical implementations.

4.14 requires further study (RFS): The term "RFS" is used in Table 1 and is used to indicate that a reference cannot be made to a Recommendation that provides guidance needed in this area. Further, it is recognized that this guidance should be available and is urgently required.

4.15 total impairment value: A numerical value, obtained by summing up all of the element impairment factors of the end-to-end connection and which provides an indication of the expected quality of speech communication of the particular telephone connection. The Total Impairment Value consists of the sum of several Impairment Factors and is expressed in units of "eif".

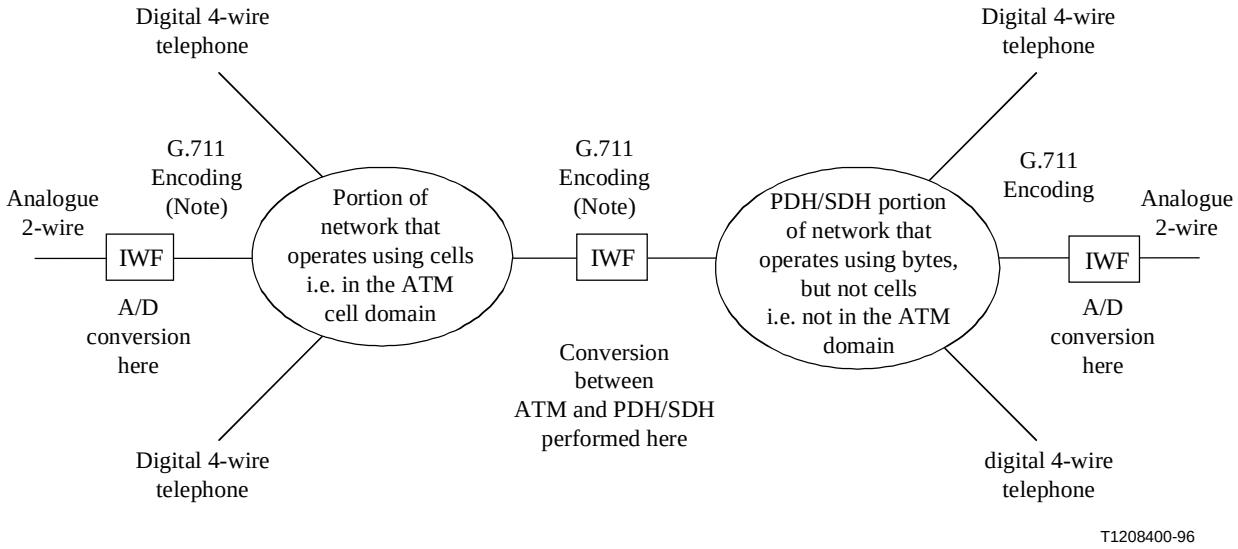
5 Abbreviations

This Recommendation uses the following abbreviations:

ATM	Asynchronous Transfer Mode
eif	equipment impairment factor
IWF	Interworking Function
OC3	Optical Carrier System Operating at the 3rd Hierarchical Level
PBX	Private Automatic Branch Exchange
PDH	Plesiochronous Digital Hierarchy
PSTN	Public Switched Telecommunications Network
SDH	Synchronous Digital Hierarchy
SONET	Synchronous Optical Network

6 Assumed network operating configuration

This Recommendation assumes a generic network operating configuration as shown in Figure 1. In this figure it can be seen that there are three interworking functions considered. The first one to consider is shown on the right and deals with A/D conversions as per Recommendation G.711 and typically would exist as a function built within a subscriber line interface of a PDH/SDH local exchange or PBX, e.g. Recommendation Q.552. This interworking function will not be addressed further as it has been added for completeness only and does not impact on our planning guideline discussions. The second interworking unit is on the left and deals with A/D conversions as per Recommendation G.711 and typically would exist as a function built within a line card of an ATM local exchange or PBX. A Recommendation covering this configuration is currently under development in ITU-T Study Group 15. Note that A/D conversions to other data rates may be performed at this physical point; however, such conversions are not contained within the current set of Recommendations and while it may be performed within a particular network, it is assumed that the G.711 signal format will be the normal signal carried across network boundaries. The use of other rates is an item for further study. The third interworking unit is shown between the ATM and PDH/SDH networks. The signals on the PDH/SDH and the ATM side are assumed to be G.711 compliant signals. While this unit could perform conversions between data rates, it is currently agreed that the G.711 signal format will be the normal signal carried across network boundaries. The use of other rates is an item for further study.



IWF Interworking Function
NOTE – G.711 coding is shown. Other rates are for further study.

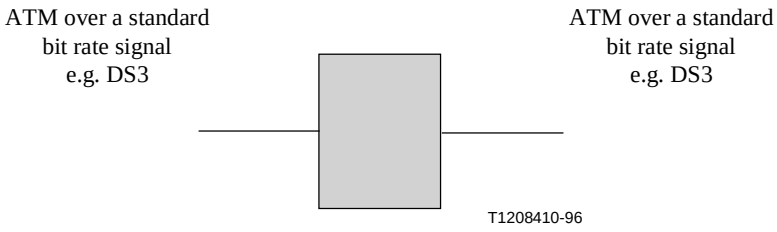
Figure 1/G.176 – Assumed operating configuration

7 ATM technology functions

In the definition clause a number of ATM network element functions were identified, e.g. digital signal processing function and a multiplexer function. In this clause, these functions are considered packaged on a one per black box basis. As a result, the function is deemed to operate on a standalone basis and this is the way they are treated in a table in clause 8. However, in practice, more than one function could appear in a device. For these cases, the appropriate columns from the matrix table in clause 8 should be used. The reason for identifying the function of ATM as a digital signal processing unit is to focus discussion on the interfaces which exist on both sides of this ATM device.

7.1 ATM technology as a digital signal processing unit

An illustration of ATM technology acting as a digital signal processing unit is shown in Figure 2.



NOTE – This device may have more hant one input and one output and the input and output rates can be different.

Figure 2/G.176 – ATM technology operating as a digital signal processor

7.2 ATM technology as a multiplexer

An illustration of ATM technology acting as a multiplexer is shown in Figure 3. The reason for identifying the function of ATM as a multiplexing system is to focus discussion on the interfaces

which exist on both sides of the ATM device. This category is intended to include devices which may be used to perform a digital cross-connect function.

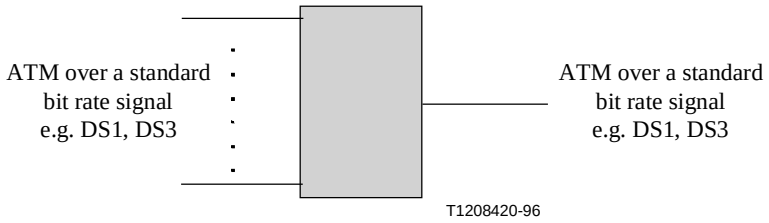


Figure 3/G.176 – ATM technology operating as a multiplexer

7.3 ATM technology as a transport system

An illustration of ATM technology acting as a transport entity is shown in Figure 4. This is intended to address the situation where ATM multiplexers are used in conjunction with a transport system, e.g. when ATM multiplexers are combined with SONET/SDH to provide a transport function which has DS1 interfaces. Note that the supported service can be any rate below the T1 or E1 rate. In this configuration, the ATM multiplexer uses permanent virtual circuits which have constant bit rate channels and thus a signal compression function is not performed. For the purposes of this Recommendation, a multiplexer is defined as a device whose payload output is equal to the sum of the inputs plus overhead.

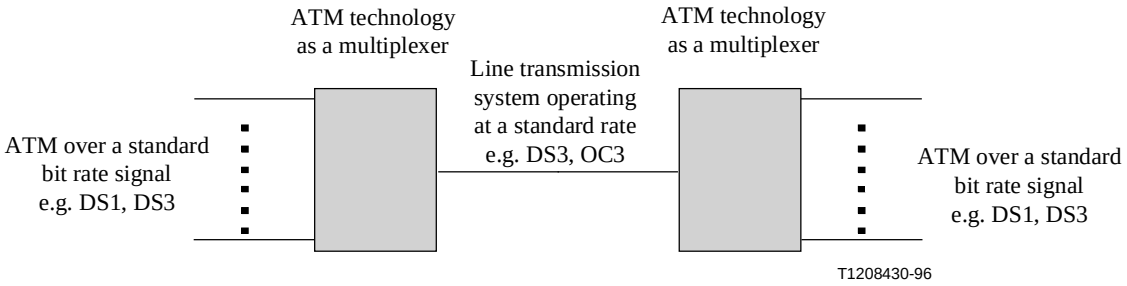


Figure 4/G.176 – ATM technology operating as a transport system

7.4 ATM as a switched network function

ATM technology can operate as a switch. Figure 5 shows this switch configured with digital interfaces only. This figure is intended to apply to switches that could assume the functions of a PBX, an end office, or a tandem office.

Figure 6 shows the switch with 2-wire analogue interfaces, intended to terminate a standard 2-wire telephone set on a loop access facility in the PBX or Local Exchange environment. This figure is also intended to apply to those cases where the ATM switch could terminate a digital loop subscriber carrier system.

This Recommendation is not intended to promote particular operating configurations, but rather is focused on determining if standards exist for all operating arrangements.

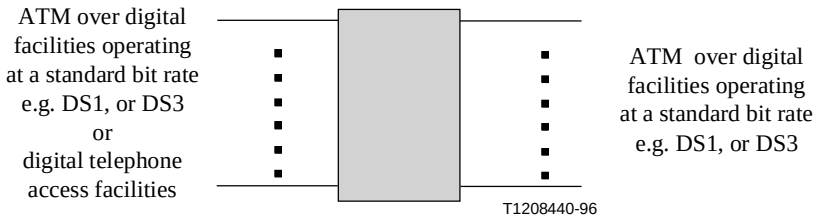


Figure 5/G.176 – ATM technology as a switch – digital interfaces only (PBX, local exchange, tandem)

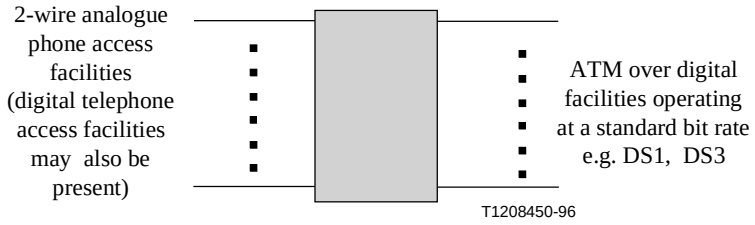


Figure 6/G.176 – ATM technology as a switch – 2-wire analogue and digital interfaces (PBX, local exchange)

7.5 ATM interworking function (ATM cell – PDH/SDH interworking function)

ATM systems will have to interwork with narrowband systems if ATM is to be integrated into current byte oriented networks, see Figure 7. The interworking function will have to occur in both the transmission plane and the signalling plane. This Recommendation will restrict itself to the transmission plane.

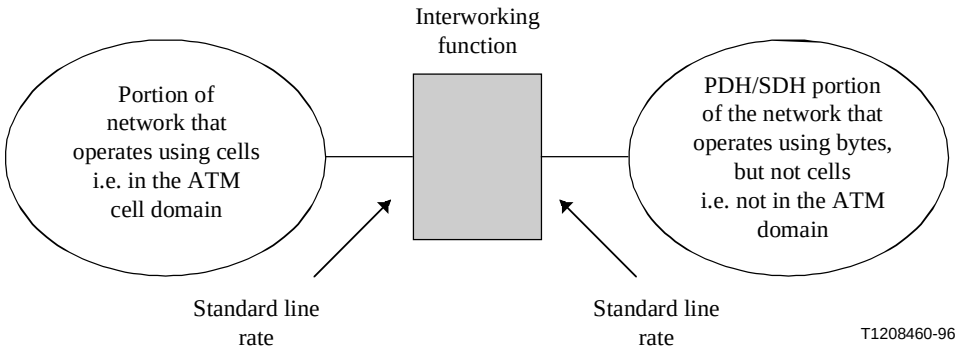


Figure 7/G.176 – ATM technology operating as an interworking unit

8 Planning guidelines

The guidelines developed in this clause are intended for use by a network or service planner who intends to either generate a new ATM domain, or an ATM island, within the PSTN or to add incremental ATM technology to an already existing ATM domain. These guidelines follow:

1) The number of ATM islands in a connection should be minimized. While it is recognized that ATM islands will occur in the early stages of evolution of the PDH/SDH PSTN to an ATM PSTN, the total delay should be limited, see Recommendation G.114.

2) The overall quality of a connection (see Recommendation G.101), depends upon the total equipment impairment factor units, viz. *Itot*, (see Recommendation G.113).

3) It is the responsibility of the ATM domain provider to provide echo control or ensure that echo control is provided when:

   - the one-way delay caused by an all ATM network domain exceeds G.131 requirements when completing connections between analogue terminals, terminated on it;
   - the incremental additional delay caused by insertion of the ATM domain causes delay on connections to exceed the guidelines of G.131;
   - the incremental one-way delay caused by the ATM delay exceeds 5 ms and there is uncertainty as to whether the requirements of Recommendation G.131 will be met for connections routed through the ATM domain.

4) Unless there is a bilateral agreement to do otherwise, the ATM network implementor is expected to transmit a G.711 compliant signal across both ATM and PDH/SDH network boundaries and should expect to receive G.711 signals across both ATM and PDH/SDH network boundaries. It is also assumed that these G.711 compliant signals were generated using a G.712 or Q.552 compliant interface converter.

5) The ATM network implementor should take into consideration the technical performance aspects associated with connections through the ATM domain. Table 1 below provides direction as to where guidance information may be obtained.

In summary, Table 1 makes it clear that:

- for the parameter of delay, all ATM functions are affected;
- except for the ATM functions of ATM Digital Signal Processing and ATM Switching, all other ATM functions have little impact on embedded analogue signal performance parameters. Special attention should be given to the ATM Digital Signal Processing and ATM Switch functions, because many of the embedded analogue signal performance parameters can be affected.

Table 1 provides network planners responsible for the integration of ATM technology into the PSTN with recommended sources for transmission performance planning guidance information.

In Table 1, when standards appear in brackets within a cell, it means that these standards represent a valid provisional source of basic information and guidance until such time as definitive Recommendations associated with ATM can be generated. See clause 4 for the definitions and clause 5 for the abbreviations used in this table.

Table 1/G.176

	Parameter (Note 1)	ATM digital processing function (Figure 2)	ATM multiplex function (Digital interfaces) Figure 3)	ATM transport function (Digital interfaces) (Figure 4)	ATM switch function [PBX, local exchange & transit] (Digital interfaces) (Figure 5)	ATM switch function [PBX & local exchange] (Digital trunk & 2-wire analogue line interfaces) (Figure 6)	ATM Interworking unit function to narrowband PSTN (Figure 7) (Analogue interface in ATM and digital interface at the point of connection to the PSTN)
Embedded analogue signals & analogue interface parameters	Attenuation distortion	GNR (Note 3)	GNR	GNR	GNR	PGA (Notes 4, 5) [G.113, G.132, Q.552]	GNR
	Crosstalk	GNR	GNR	GNR	GNR	PGA (Note 5) [Q.552]	GNR
	Delay (Steady state)	PGA [G.114]	PGA [G.114]	PGA [G.114]	PGA [G.114]	PGA (Note 5) [G.113, G.114]	PGA [G.114]
	Delay (Variation)	RFS (Note 6)	RFS	RFS	RFS	RFS (Note 5)	RFS
	Dropout	GNR	GNR	GNR	GNR	GNR	GNR
	Echo return loss	PGA [G.131]	GNR	GNR	GNR	PGA (Note 5) [G.113, G.131]	PGA [G.131]
	Group delay	GNR	GNR	GNR	GNR	PGA (Note 5) [Q.552]	GNR
	Gain hits	GNR	GNR	GNR	GNR	GNR	GNR
	Listener echo	GNR	GNR	GNR	GNR	PGA (Note 5) [G.113, G.126]	GNR
	Loss (Single frequency)	GNR (Note 7)	GNR (Note 7)	GNR (Note 7)	GNR (Note 7)	PGA (Note 5) [G.113]	GNR (Note 7)
	Noise (impulse)	GNR	GNR	GNR	GNR	RFS (Note 5)	GNR
	Noise (Quantization, including total distortion)	PGA [G.113]	GNR	GNR	GNR (Note 8)	PGA (Notes 5, 8) [G.113, Q.552]	GNR
	Noise (Steady state)	GNR	GNR	GNR	GNR	PGA (Note 5) [G.113]	GNR
	Phase hit (Analogue)	GNR	GNR	GNR	GNR	RFS	RFS
	Phase jitter (Analogue)	GNR	GNR	GNR	GNR	RFS (Note 5)	RFS
	Relative Level – Input	GNR	GNR	GNR	GNR	PGA (Note 5) [G.552]	GNR
	Relative Level – Output	GNR	GNR	GNR	GNR	PGA (Note 5) [G.552]	GNR
	Return loss [Looking into the port(s)]	GNR	GNR	GNR	GNR	PGA (Note 5) [G.113, G.131]	GNR
	Signal clipping (Power)	PGA [G.712]	GNR	GNR	GNR	PGA (Note 5) [G.552]	GNR

Table 1/G.176 (*concluded*)

	Parameter (Note 1)	ATM digital processing function (Figure 2)	ATM multiplex function (Digital interfaces) Figure 3)	ATM transport function (Digital interfaces) (Figure 4)	ATM switch function [PBX, local exchange & transit] (Digital interfaces) (Figure 5)	ATM switch function [PBX & local exchange] (Digital trunk & 2-wire analogue line interfaces) (Figure 6)	ATM Interworking unit function to narrowband PSTN (Figure 7) / (Analogue interface in ATM and digital interface at the point of connection to the PSTN)
	Signal clipping (Speech burst)	PGA [G.174]	GNR	GNR	GNR (Note 9)	PGA (G.174]	GNR
	Singing return loss	PGA [G.122]	GNR	GNR	GNR	PGA (Notes 5, 10) [G.113]	GNR
	Talker echo path loss	PGA [G.131]	GNR	GNR	GNR	PGA (Notes 5, 10) [G.113]	GNR

NOTE 1 – See Recommendation G.100 for parameter definitions.

NOTE 2 – This column applies only to the analogue interfaces of an ATM switch which has 2-wire analogue line side and 4-wire digital trunk interfaces. The digital line side interface requirements are addressed in the column labelled ATM switch function (Digital interfaces).

NOTE 3 – GNR: Guidance Not Required. The term used in Table 1 to indicate that the associated parameter should have negligible or no impact on the ATM functionality under consideration

NOTE 4 – PGA: Provisional Guidance Available. The term used in Table 1 to indicate that the associated parameter must be considered in the context of transmission performance for end-to-end connections and that preliminary guidance is available.

NOTE 5 – Note that this requirement is part of a line card specification and when a parameter value is developed it should appear in an ATM switch (including PBX) standard.

NOTE 6 – RFS: Requires Further Study. The term used in Table 1 to indicate that the associated parameter must be considered in the context of transmission performance for end-to-end connections and that preliminary guidance is not currently available.

NOTE 7 – While, strictly speaking, this entry could have been labelled RFS, there is a general underlying agreement that digital networks will not insert loss/gain unless it is part of a network element that is implementing this function as part of the loss transmission plan.

NOTE 8 – This is not applicable unless the device performs transcoding.

NOTE 9 – This is not applicable unless the device performs compression.

NOTE 10 – This parameter will depend upon the assumptions made about how echo control will be handled in the ATM network. For example, echo control could be assumed to be totally controlled by: an active hybrid in a line card; an echo canceller in a line card; an echo canceller situated after the analogue signal is digitized but before the cells are generated; or by a digital speech processing device which operates on a cell stream and which may reside within or external to the terminating ATM local exchange or PBX. If industry agreement cannot be obtained to limit the number of operating configurations, then industry should agree upon appropriate values for each operating configuration.

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Series K	Protection against interference
Series L	Construction, installation and protection of cables and other elements of outside plant
Series M	TMN and network maintenance: international transmission systems, telephone circuits, telegraphy, facsimile and leased circuits
Series N	Maintenance: international sound programme and television transmission circuits
Series O	Specifications of measuring equipment
Series P	Telephone transmission quality, telephone installations, local line networks
Series Q	Switching and signalling
Series R	Telegraph transmission
Series S	Telegraph services terminal equipment
Series T	Terminals for telematic services
Series U	Telegraph switching
Series V	Data communication over the telephone network
Series X	Data networks and open system communication
Series Z	Programming languages