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BLUE BOOK

VOLUME III – FASCICLE III.8

INTEGRATED SERVICES DIGITAL NETWORK (ISDN)

OVERALL NETWORK ASPECTS AND FUNCTIONS, ISDN USER-NETWORK INTERFACES

RECOMMENDATIONS I.310-I.470

IXTH PLENARY ASSEMBLY
MELBOURNE, 14-25 NOVEMBER 1988

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PRELIMINARY NOTE

In this Volume, the expression “Administration” is used for shortness to indicate both a telecommunication Administration and a recognized operating agency.

PART III

I.300-Series Recommendations

OVERALL NETWORK ASPECTS AND FUNCTIONS

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SECTION 1

NETWORK FUNCTIONAL PRINCIPLES

Recommendation I.310

ISDN – NETWORK FUNCTIONAL PRINCIPLES

(Malaga-Torremolinos, 1984; amended at Melbourne, 1988)

1 General

1.1 *Basic philosophy of the functional description*

The objective of this Recommendation is to provide a common understanding of the ISDN capabilities, including terminal, network and specialized service centre aspects.

A functional description of ISDN capabilities must allow a clear distinction between definition/specification aspects of services provided by the ISDN and the actual specification of the equipment utilized to support those services. Therefore, an implementation-independent approach should be adopted.

Moreover in the context of this Recommendation the adjective "functional" is used in the sense of an implementation-independent approach. The noun "function" itself has a specific meaning which is explained below.

The description of network capabilities is consistent with the protocol reference mode, e.g.:

- the layering structure of all systems involved in a communication process, i.e. partitioning the required functions between different layers;
- the clear discrimination between layer service concept, layer function concept and layer protocol concept.

Furthermore, the three following distinctions apply:

- distinction between basic services and supplementary services;
- distinction between ISDN capabilities and services offered to the customer;
- distinction between static and dynamic aspects of the description.

1.2 *Services supported by an ISDN*

The concepts and the principles of an ISDN are described in Recommendation I.120. The services supported by an ISDN are given in the I.200-Series of Recommendations. A classification and the tools for the description of telecommunication services are specified in Recommendation I.210 according to the description method as given in Recommendation I.130. The network capabilities to support these services are defined in the I.300-Series of Recommendations. The relationship between these Recommendations and some other relevant I-Series Recommendations is shown in Figure 1/I.310.

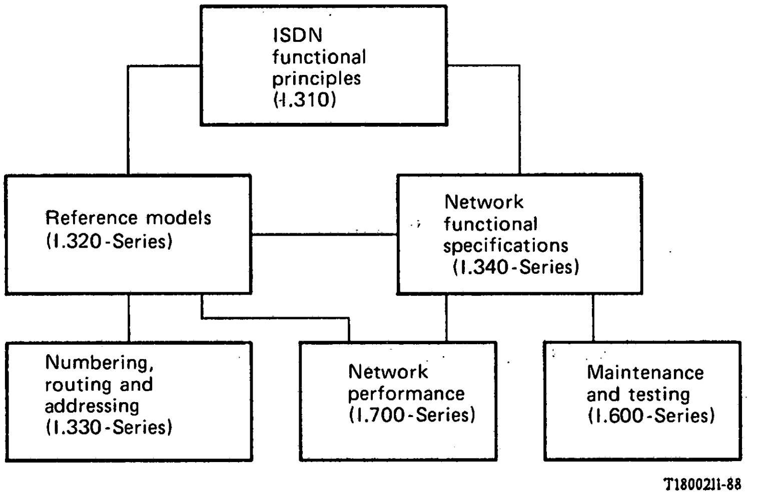


FIGURE 1/I.310

ISDN network series of Recommendations

It should be noted that the service concept defined in Recommendation I.210 is different from the layer service concept of the OSI model. The telecommunication service concept in Recommendation I.210 corresponds to the services offered to users by the network. Besides operational and commercial aspects, the provision of these telecommunication services (bearer and teleservices) and associated supplementary services requires the availability of appropriate capabilities:

- network capabilities, in various network equipments (exchanges etc.);
- terminal capabilities;
- specialized service centre capabilities, when required.

1.3 *Generic description of required capabilities*

ISDN capabilities are the total sum of the functions required to support all basic and supplementary services offered by the ISDN.

1.3.1 *Static description*

The identification and characterization of these functions, which are related to the specification and analysis of these basic and supplementary services, form the first step of the generic description. This part of the generic description is intrinsically static.

1.3.2 *Dynamic description*

The use of a basic or supplementary service generally requires cooperation between functions located in different equipment.

The static description of the ISDN capabilities, which will be a list of functions, is not sufficient. It is necessary, in addition, to depict the sequence of events and the activation of functions coordinated by suitable inter-equipment signals. This second step is the dynamic aspect of the description. This involves firstly an identification and characterization of the functions and then a method of showing the dynamic interaction between functions.

2 Objectives of the functional description of the ISDN

As described in Recommendation I.120, an Integrated Services Digital Network (ISDN) is a network providing end-to-end digital connectivity to support a wide range of telecommunication services.

The characterization of ISDN is centered on three main areas:

a) the standardization of services offered to users, so as to enable services to be internationally compatible;

b) the stadardization of user-network interfaces, so as to enable terminal equipment to be portable [and to assist in a)];

c) the standardization of ISDN capabilities to the degree necesary to allow user-network and network-network interworking, and thus achieve a) and b) above.

The I.200-Series of Recommendations identifies the range of telecommunication services to be offered in an ISDN, namely bearer services, teleservices, and associated supplementary services and the attributes characterizing those services. The I.400-Series of Recommendations describes both the functional and technical aspects of user-network interfaces. This Recommendation defines the ISDN capabilities to support services via interfaces in terms of functions. A functional description enables a decoupling of services and ISDN capabilities, and therefore allows an implementation-independent approach.

The principal objectives of the ISDN functional method are:

1) to define the ISDN capabilities, by building up a harmonized set of functions that are necessary and sufficient to support telecommunication services by their static and dynamic description;

2) to aid the evolution of ISDN capabilities (modifications, addition of capabilities to support new basic or supplementary services), by organizing this set of functions in an open-ended and modular structure;

3) to aid the standardization of system-independent switching functions between exchanges of differing designs and manufacture;

4) to aid the standardization of interworking standards between switching systems located in different countries;

5) to provide information for the preparation of functional specifications for new telecommunication services;

6) to maximize the exploitation of functions provided and available in switching systems.

The transition from an existing network to a comprehensive ISDN may require a period of time extending over one or more decades. Therefore the design of an ISDN will be revolutionary, adding capabilities in a flexible and modular manner. An ISDN may therefore be expected to provide an open-ended set of functional capabilities able to accommodate new needs as they arise at acceptable cost.

During a long intermediate period, some functions may not be implemented within a given ISDN. Also, specific arrangements should be used to ensure compatibility with existing networks and services. An ISDN should also give access to existing services and interwork with existing networks and terminals.

3 Generic description model

3.1 *General concepts*

The ISDN functional description defines a set of capabilities which enable bearer and teleservices to be offered to users (see Recommendation I.210). The services require two different levels of ISDN capabilities viz.:

- the low-layer functions (LLF) relate to the bearer services;
- the high-layer functions (HLF) together with the lower layer functions relate to the teleservices.

In addition, operation and maintenance capabilities are required to support both bearer and teleservices (see Figure 2/I.310).

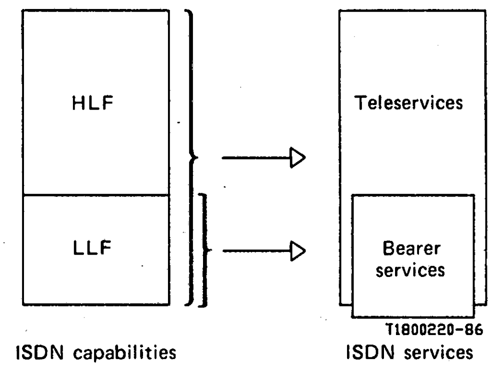


FIGURE 2/I.310

Relationship between telecommunication services and network capabilities

The capabilities of the ISDN need a detailed and rigorous characterization because there is a wide range of standardization issues involved.

To achieve the functional objectives described in § 2, the ISDN functional description has been designed to:

- define the overall functional characteristics of the ISDN;
- be implementation-independent and place no constraints on national network architectures beyond the network and interface standards given in the I-Series of Recommendations;
- take full account of the constraints of existing dedicated networks;
- support the layering protocol concepts defined in Recommendation I.320.

For this purpose the concept of an ISDN function is used, which is defined as:

"A distiguishing characteristic which describes functional capabilities of a given equipment, or system, or network, as seen from the designer point of view."

As far as possible, the number of functions should be limited.

3.2 *Static description model*

3.2.1 *Global functions (GF)*

The description of ISDN capabilities concerns the low layers (1-3) in a global context (see Note), i.e. taking into account all the equipment involved in the communication, according to the protocol reference model. In this context, a global function is defined as:

- referring to the ISDN capabilities;
- having a global significance in the lower layers.

The set of all GFs leads to the description of the total ISDN low layer capabilities.

Note – This concept of global function may be extended to describe the higher layer capabilities of ISDN terminals (and network capabilities, where these exist). In this case the GF has a global significance inside the higher layers.

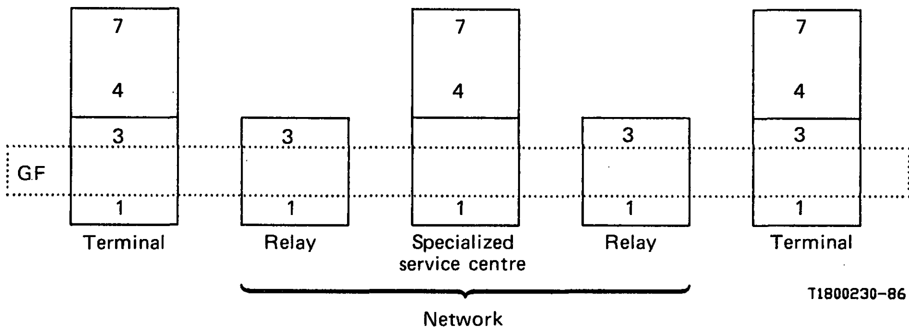


FIGURE 3/I.310

Global function concept

There are two kinds of GFs:

– the Basic Global Functions (BGF), are those global functions needed to support ISDN basic services. The BGFs are related to ISDN connection types, as indicated in Table 1/I.310;

– the Additional Global Functions (AGF), are related to the ISDN capability to support supplementary services. Details of the relationship between AGFs and the ISDN capability to support supplementary services are given in § 4.1.2.

3.2.2 *Elementary functions (EF)*

The introduction of the GF concept allows a general description of low layer capabilities.

The following is a more detailed description: for each GF, a set of elementary functions is identified as the set of basic elements which are then *allocated* to different functional entities involved in the communication.

GF = (EF1, EF2, EF3, ... EFn)

An EF within this Recommendation is the lowest level of functionality. It is allocated to a functional entity involved in supporting a telecommunication service. An EF is an intrinsically static description of the capability of performing an action on a resource when defined conditions are met.

For building up a GF, each associated EF must be present in one or more functional entities of the ISDN. (In this context the ISDN may include the terminals, the network or specialized service centres.) But in a specific functional entity the complete set of associated EFs need not be present (see for example Figure 4/I.310).

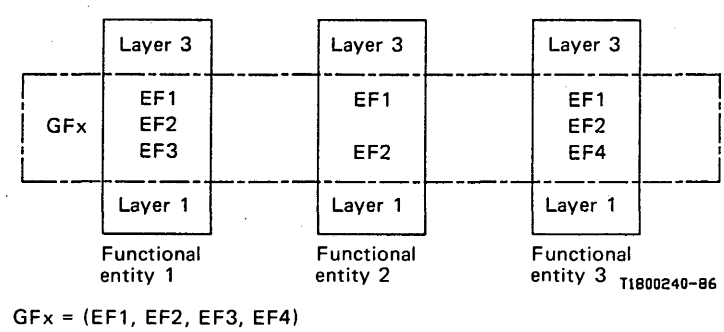


FIGURE 4/I.310

EFs associated with a GFx

3.2.3 *Allocation of EFs*

This flexibility in construction of EFs allows a specialization of the functions to be allocated to particular functional entities. Because the Recommendations on the architecture of the ISDN (Recommendation I.324) will only specify a functional approach to standardization, the relationship between functional entities and specific equipment is, in general, a national matter. However an important first step in allocation of functions will be the distinction between terminal equipment and the network equipment involved.

Recommendation I.324 introduces the functional grouping CRF (connection related functions). The CRF can be local, national transit or international transit. EFs can be associated with each of these.

3.3 *Dynamic description model*

The complete description of ISDN capabilities must include dynamic aspects involved in the process of a call.

This association of functional and protocol aspects leads to the use of the following dynamic description method:

3.3.1 *Information flow diagrams*

The operation of basic and supplementary services are described and characterized, as seen from a network point of view, by using information flow diagrams which show the sequence of events occurring in the course of the call.

3.3.2 *Executive processes*

An executive process (EP) corresponds to the particular use of one or more elementary functions within a particular functional entity which always yields specific results. Therefore an EP is characterized by input information it needs for execution and by output information or actions resulting from execution.

Executive processes involve (see Figure 5/I.310):

a) sequences that link together events producing the activation of an EP, by means of signalling information passed between the function entities;
b) the information (or data) actually used:
   - protocol information (signalling information sent or received by the component);
   - component information ("network information");
   - static information (description of available resources, environment, services, etc.)
   - dynamic information (elaborated and used during the call handling).

The dynamic description of each basic or supplementary service as required in stage 2 of the description method given in Recommendation I.130, based on the above elements, results in a chart showing functional entities involved (e.g. associated with originating and destination exchanges, specialized service centres when required), the signalling information flow passed between them, and the executive processes used inside them.

4 Use of generic description model

The analysis of telecommunication services and technological development leads to the identification of the range of required functions.

The analysis of all the basic and supplementary services provided by the ISDN will lead to the establishment of a set of elementary functions which can be allocated to different functional entities.

The design of a new basic or supplementary service should maximize the use of the set of existing EFs available to existing systems. This will minimize changes to the systems necessary for introducing these new services. The specifications for new equipment designed for providing particular services will have to comply with the set of EFs required for these services.

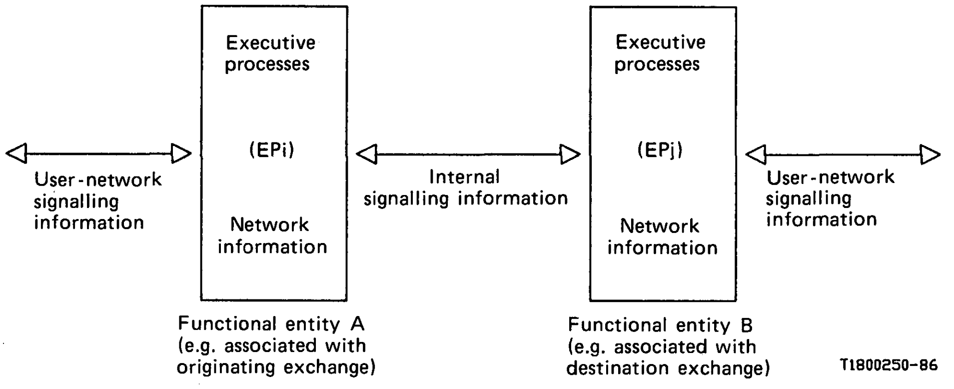


FIGURE 5/I.310

Basic functional allocation and executive processes

4.1 *Identification of ISDN global functions*

4.1.1 *Basic global functions (BGF)*

The basic global functions correspond to the ISDN capability to provide the various connection types that support telecommunication services.

The functions implemented to support telecommunication services can be classified into the following categories:

- *Connection handling:* functions which enable the establishment (set-up), holding and release of connections (e.g. user-to-network signalling).
- *Routing:* functions that determine a suitable connection for a particular service (call) request, i.e. suitable paths between the various equipments and inside the switching systems to establish end-to-end connections (e.g. called number analysis).
- *Resources handling:* functions that enable the control of the resources necesary for the use of connections (e.g. transmission equipment, switching resources, data storage equipment).
- *Supervision:* functions that check the resources used to support the connections, to detect and signal possible problems and to solve them if possible (e.g. transmission error detection and correction).
- *Operation and maintenance:* functions providing the capability to control the correct working of the services/network as well for the subscribers as for the Administration.
- *Charging:* functions providing the capability to the Administration to charge the subscribers.
- *Interworking:* functions providing the capability for both service and network interworking.
- *Layer 2 and 3 data unit handling:* functions providing handling of layers 2 and 3 data units during the information transfer phase for the case of packet mode connections.

According to this classification, a basic global function is defined as:

- referring to an ISDN connection type;
- belonging to one of the above categories.

Table 1/I.310 shows the total set of BGFs.

TABLE 1/I.310

ISDN basic global functions

Category \ Connection type	CT_1	CT_2	...	CT_n
Connection handling	1 BGF_1	2 BGF_1		n BGF_1
Routing	1 BGF_2	2 BGF_2		n BGF_2
Resources handling	1 BGF_3	2 BGF_3		n BGF_3
Supervision	1 BGF_4	2 BGF_4		n BGF_4
Operation and maintenance	1 BGF_5	2 BGF_5		n BGF_5
Charging	1 BGF_6	2 BGF_6		n BGF_6
Interworking	1 BGF_7	2 BGF_7		n BGF_7
Layer 2 and 3 data unit handling	1 BGF_8	2 BGF_8		n BGF_8

4.1.2 *Additional global functions (AGF)*

The additional global functions corresponds to the ISDN capability to support supplementary services.

The classification of AGFs is based on the principle that the support of a supplementary service is considered as being realized by a number of functions distributed throughout the ISDN. The definition of AGFs needs further study.

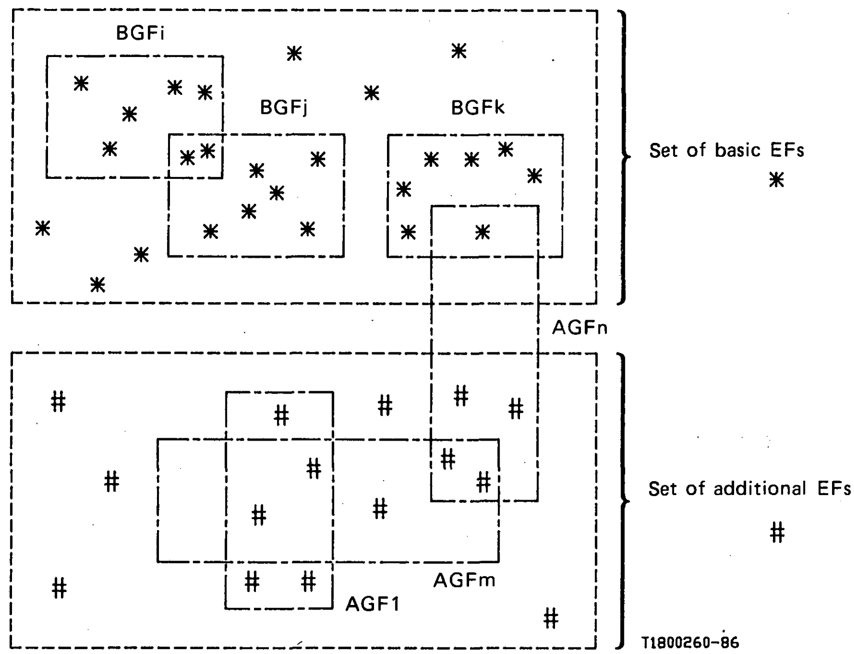
4.2 *Identification of ISDN elementary functions*

Like GFs, there are two kinds of elementary functions: the basic EFs (i.e. components of BGFs, and possibly AGFs) and the additional EFs (i.e. components of AGFs). Therefore, identification of basic EFs requires a detailed analysis of connection types. Implementation and identification of additional EFs requires a detailed analysis of supplementary services implementation.

- *Basic EFs:* for each connection type, there are up to 8 BGFs to implement (see Table 1/I.310). Therefore each BGF is composed of basic EFs related to this connection type. However some basic EFs may be common to several connection types (e.g. "called number analysis" belonging to the BGF "routing").
- *Additional EFs:* additional EFs form a common set of functional elements available to build up the various AGFs, and thus to implement supplementary services.

This grouping of EFs into sets of BGFs and AGFs is illustrated in Figure 6/I.310.

The list of EFs so far identified is contained in Annex A, together with a preliminary set of definitions.



BGFi Basic global function related to connection type CTi (see Table 1/I.310).
AGF1 Additional global function related to supplementary service 1.

FIGURE 6/I.310

EFs association principles for building up GFs

4.3 *Identification of ISDN executive processes*

A possible use of the concept of an Executive Process (EP) is the definition of Functional Components (FC) as executive processes that can be invoked by the network to realize a telecommunication service.

According to this an FC is a specific example of how to use the EP concept.

A functional component is a set of elementary functions performed in an order that yields a specified result. An FC always has an invoking and a responding entity. The invoking entity is the entity which acts in response to an FC request from an invoking entity.

In defining an FC, the following guidelines should be considered:

- FCs are used as building blocks and may be invoked in order to realize a telecommunication service. FCs will have signalling impact and should be structured in such a way that several telecommunication services can use them. In particular, the definition of an FC should as far as possible be independent of any connection type.
- A new FC should not be defined if its functionality can be provided by one or more existing FCs. As an objective, an FC will not invoke another FC.

The relationship between an FC and EFs is shown in Figure 7/I.310.

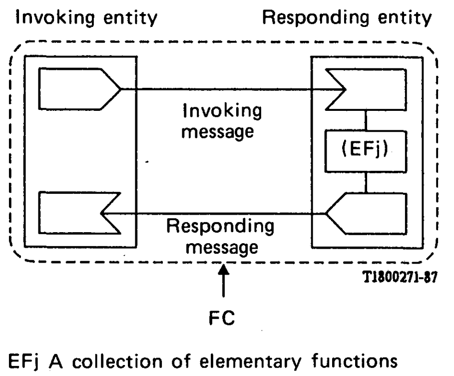


FIGURE 7/I.310

Relationship between an FC and EFs

Once invoked, the responding entity will not be affected by unsolicited inputs from the invoking entity. However, the request for execution of an FC may be cancelled by the invoking entity if the request was received.

It should also be noted that the functionality of an FC could be invoked by a user equipment, i.e. the invoking entity of an FC could be allocated to user equipment. When an FC affects the user-network interface a service description is needed. Figure 8/I.310 illustrates FCs affecting different interfaces, FC1 affecting the user-network interface, FC2 affecting an internal network interface. It also illustrates that the invoking and responding entities of different FCs may appear in the same functional entity.

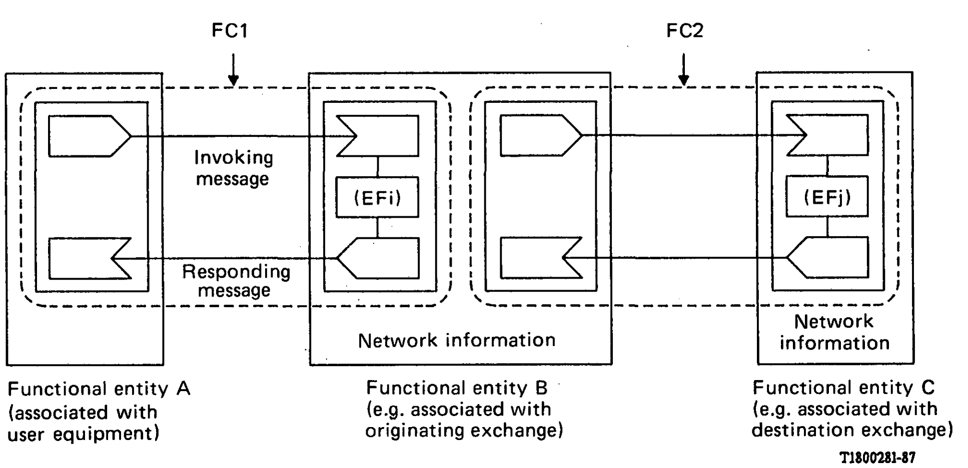


FIGURE 8/I.310

Illustration of multiple FCs affecting different interfaces: FC1 affecting the user-network interface and FC2 affecting the internal network interface

FCs are building blocks, which by themselves are not sufficient to provide a service. There is a need for some logic reflecting how FCs are coordinated in order to support a given service: this logic is termed service control. Service control is an example of the application process concept which can be found in other Recommendations.

Annex B gives descriptions of FCs so far identified for the ISDN.

5 Functional realization of basic service requests

From the functional point of view, the process involved in satisfying a basic service request in the ISDN can be described as follows:

a) A basic service request contains a set of attribute values. The appropriate connection type(s) to support the service must be identified.

   Service request examination:

   – input: service request containing a set of attribute values;
   – process: examine service request and determine appropriate connection type(s);
   – output: connection type(s).

b) Once selected, the connection type (which has end-to-end significance) can be further broken down into one or more smaller functional components called "connection elements" (see Recommendation I.324).

   Connection element selection:

   – input: connection type;
   – process: determine connection element(s) to form the connection type;
   – output: connection element(s).

c) Each connection element would require a set of functions in order to be established.

   Function set determination:

   – input: connection element;
   – process: select appropriate functions to establish connection element;
   – output: set of functions.

ANNEX A

(to Recommendation I.310)

A.1 *List of identified basic elementary functions and additional elementary functions (EFs) for the ISDN*

A.1.1 *BASIC EFs related to connection types*

Connection handling

BEF100	Characteristics of service requested examination
BEF101	Connection elements type determination
BEF102	User-network access resources reservation (channels)
BEF103	Transit resources reservation
BEF104	Communication references handling
104 E:	Establish call reference
104 C:	Clear call reference
BEF105	Establishment control
105 R:	Establish connection-return path only
105 F:	Establish connection-forward path
150 B:	Establish connection-both directions
BEF106	Release control
BEF107	Service related authorizations examination
BEF108	User-network signalling handling (layer 3)
BEF109	Inter-exchange signalling handling (user part)
BEF110	Supplementary services compatibility checking
BEF111	Building up of and maintaining dynamic information relating to the call/connection
BEF112	Signalling interworking
BEF113	Priority
BEF114	Queue handling

Routing

BEF200	ISDN number identification
BEF201	Called number analysis (address analysis)
BEF202	Routing information examination (if provided)
BEF203	Predetermined specific routing
BEF204	Connection path selection
BEF205	Rerouting

Resources handling

BEF300	Hold and release of user-network access resources (channels)
300 H:	Hold user-network access resources
300 R:	Release user-network access resource
BEF301	Hold and release of transit resources (circuits)
301 H:	Hold transit resources
301 R:	Release transit resources
BEF302	Insertion and suppression of specific equipment
BEF303	Tones, announcements and display information
BEF304	User-network signalling handling (layer 1-2)
BEF305	Inter-exchange signalling handling (message transfer)
BEF306	Path search inside switching unit
BEF307	Synchronization handling
BEF308	Timing handling
BEF309	Line service marking
BEF310	Real time clock

Supervision

BEF400	User-network access resources monitoring
BEF401	Transit resources monitoring
BEF402	Continuity checking
BEF403	Detection of congestion
BEF404	Semi-permanent connection checking

Operation and maintenance

BEF500	Management of subscriber data
BEF501	Fault report

Charging

BEF600	Charging management
600 I:	Initiate charging
600 C:	Cease charging
BEF601	Charging registering
BEF602	Charging recording
BEF603	Billing
BEF604	Accounting
BEF605	Charging information

Interworking

BEF700	Rate adaption
BEF701	Protocol conversion
BEF702	Handling of signalling for interworking
BEF703	Numbering interworking
BEF704	Special routing algorithms
BEF705	Negotiation
BEF706	Notification
BEF707	Charging for interworking
BEF708	Mapping of lower layer comparability

A.1.2 *AEFs relating to supplementary services*

AEF00	Insertion and suppression of additional resources (tones etc.)
AEF01	Line hunting
AEF02	Direct dialling-in
AEF03	Address determination
AEF04	Subscriber's dedicated storage
AEF05	Bridge
AEF06	User-network access resource hold
AEF07	Hold of communication
AEF08	Additional subscriber signalling
AEF09	Additional inter-exchange signalling
AEF10	Multi-call handling
AEF11	Internal call initialization
AEF12	Access/route restriction
AEF13	Subscriber call data registration
AEF14	Data display option

A.2 *Short description of elementary functions*

A.2.1 *Basic EFs related to connection types*

A.2.1.1 *Connection handling*

100 *Characteristics of service requested examination*

Function of a functional entity to determine the required service characteristics (certain attributes of the bearer service and optional supplementary services) of a call by means of examination of information set by calling terminal.

101 *Connection elements type determination*

Function of a functional entity to determine connection types and connection elements necessary to provide the requested service.

102 *User access resources reservation*

Function of a functional entity to determine the type of user-network access (basic, primary), the state of the resources (channels availability) and to reserve the channel(s) needed for establishing the access connection element.

103 *Transit resources reservation*

Function of a functional entity to reserve the transit connection element, based on the state of resources.

104 *Communication references handling*

Function of a functional entity to assign a local reference (at the access interface) to the call and an internal reference (at the internal interface) to the connection, and to clear these references when the call/connection is cleared/released.

104 E Establish call reference. (For further study.)

104 C Clear call reference. (For further study.)

105 *Establishment control*

Function of a functional entity to set up a connection through the functional entity.

105 R Establish connection-return path only. (For further study.)

105 F Establish connection-forward path. (For further study.)

105 B Establish connection-both direction. (For further study.)

106 *Release control*

Function of a functional entity to release a connection through the functional entity.

107 *Service related authorization examination*

Function of a functional entity to determine the authorization (calling or called user) relating to basic and supplementary services that have been subscribed to.

108 *User-network signalling handling (layer 3)*

Function of a functional entity to support the layer 3 protocol of the user-network signalling system.

Note – For layers 1 and 2, see § A.2.1.3, Resources handling.

109 *Inter-exchange signalling handling (user part)*

Function of a functional entity to support the user part of the inter-exchange signalling system.

110 *Supplementary services compatibility checking*

Function of the network to check the compatibility of requested supplementary services, e.g.:

- with requested bearer service to teleservice;
- with other requested supplementary services;

and to verify coherence between parameters that may be associated.

111 *Building-up of and maintaining dynamic information related to the call/connection*

Function of a functional entity to compile information related to the call/connection, e.g.:

- resources needed (connection type, connection elements, channels, circuits);
- details of call in progress;
- supplementary services effected and associated parameters.

112 *Signalling interworking*

Function of a functional entity to support interworking functions between signalling systems.

113 *Priority*

Function of a functional entity to handle specific calls with priority (e.g. in the case of overload or degraded mode of operation).

114 *Queue handling*

Function of a functional entity to store requests in a queue, in order to handle this information later in a predefined order.

A.2.1.2 *Routing*

200 *ISDN number identification*

Function of a functional entity to identify the ISDN number of the user-network interface. This information is limited to that included within the ISDN numbering plan.

201 *Called number analysis*

Function of a functional entity to analyse called ISDN number sent by the calling terminal in the call set-up phase.

202 *Routing information examination*

Function of a functional entity to analyse routing information that may be sent by the calling terminal and that has an effect on path selection.

203 *Predetermined specific routing*

Function of an exchange to select a specific routing according to the information received from the calling terminal (for example routing towards operators, access points, an interworking unit, an operational or maintenance unit, etc.).

204 *Connection path selection*

Function of a functional entity to select the transit outgoing part relating to connection types to be used, and the overall path through the network.

205 *Rerouting*

Function of a functional entity to select a new connection path through the network depending on changed conditions during call set-up or information transfer phases.

A.2.1.3 *Resources handling*

300 *Hold and release of user-network access resources (channels)*

Function of a functional entity to hold the access channel(s) reserved to support the communication, and to release it at the end of this communication.

300 H Hold user-network access resource. (For further study.)

300 R Release user-network access resource. (For further study.)

301 *Hold and release of transit resources (circuits)*

Function of a functional entity to hold the circuit(s) reserved to support the communication at the transit connection element and to release it at the end of this communication.

301 H Hold transit resources. (For further study.)

301 R Release transit resources. (For further study.)

302 *Insertion and suppresion of specific equipment*

Function of a functional entity to insert or remove specific equipments particularly to satisfy the service request invoked by the user. Examples of such equipment include:

- echo suppressers;
- A-μ law conversion units (change of A/D conversion);
- interworking unit;
- storage unit.

303 *Tones, announcements and display information*

Function of a functional entity to provide call progress information in one or more of the following ways:

- a tone is an audible (call progress) indication comprising one or more discrete frequencies but excluding speech;
- a recorded announcement is an audible indication in the form of speech or music;
- display information is (call progress) information set to the user which is displayed visually.

Definitions of the other topics are not yet available.

304 *User-network signalling handling (layers 1-2)*

Functions of a functional entity to support layers 1 and 2 of the user-network signalling system.

305 *Inter-exchange signalling handling (message transfer)*

Function of a functional entity to support the messages transfer part of the inter-exchange signalling systems.

306 *Path search inside switching unit*

Function of a functional entity to select an internal connection inside the switching unit.

307 *Synchronization handling*

Function of a functional entity to provide synchronization between different functional entities; and

Function of a functional entity to provide its own internal synchronization functional entity.

308 *Timing handling*

Function of a functional entity to provide timing between time instances involved in calls.

309 *Line service marking*

Functions of a functional entity to store for each customer the data on the parameters of the bearer and teleservices that are subscribed to. The store also contains the data on the parameters of the basic bearer and teleservices that are subscribed to by the customer. In addition, it contains the binary information (i.e. subscribed to or not) for a range of supplementary services which the subscriber can use. In general this data does *not* contain information on the type of subscriber terminal, but it may contain information on the type of access (basic, primary rate, etc.), the type of NT2 (simple, intelligent, etc.) and the attributes of the services subscribed to.

310 *Real time clock*

Function of a functional entity to provide real time information.

A.2.1.4 *Supervision*

400 *User-network access resources monitoring*

Function of a functional entity to check the correct operation of subscriber access resources.

401 *Transit resources monitoring*

Function of a functional entity to check the correct operation of the transit resources.

402 *Continuity checking*

Function of a functional entity to control the checking operations relating to the continuity of a connection.

403 *Detection of congestion*

Function of a functional entity to detect congestion during the selection of a connection path.

404 *Semi-permanent connection checking*

Function of a functional entity to check the availability of a given semi-permanent connection (e.g. passive continuity checking).

A.2.1.5 *Operation and maintenance*

500 *Management of subscriber data*

Function of a functional entity to manage subscriber data related to services. Examples include:

- in/out of service
- number translation
- changing of subscriber data.

501 *Fault report*

Function of a functional entity to register the cause if an attempt to set up a call fails.

A.2.1.6 *Charging* (the groupings below require further study)

Function of the network to determine, collect and store the charging information. The following features are involved in this process:

600 *Charging management*

Function of a functional entity to determine by means of certain parameters the charging mode (free of charge, ordinary, peak, reduced rate charge, etc.). These parameters include service type, class of customer, time information, distance, etc.

600 I Initiate charging. (For further study.)

600 C Cease charging. (For further study.)

601 *Charging registering*

Function of a functional entity to register the details of the call (both short- and long-term storage).

602 *Charging recording*

Function of a functional entity to format the charging details in a standardized way.

603 *Billing*

Function of functional entity to calculate the variable charges to the customer which depend on the use of a service and on the fixed costs of the subscription. Both of these are accumulated over a fixed period of time. This billing is associated with the subscriber and not with a user-network interface, a terminal, etc.

604 *Accounting*

Function of a functional entity to analyse, store and forward information relating to the use of inter-network resources between the different Administrations involved in a call.

605 *Charging information*

Function of the network to indicate the user the amount of the charge involved in the (current) use of the service.

A.2.1.7 *Interworking*

Functions that permit the establishment of end-to-end connections when an ISDN and a dedicated network are involved. This requires the provision of the basic elementary features (BEFs) which are described below and others that have been defined already (service request examination, signalling interworking, called number analysis, routing information examination, insertion and suppresion of interworking units, etc.).

700 *Rate adaption*

Function of a functional entity to adapt, according to a certain method, the user/dedicated network bit rates to the ISDN bit rates.

701 *Protocol conversion*

Function of a functional entity to support mapping functions between interfaces.

702 *Handling of signalling for interworking*

Function of a functional entity to handle signalling information for interworking (interpretation, termination, generation).

703 *Numbering interworking*

Function of a functional entity to support interworking functions between numbering plans.

704 *Special routing algorithms* (For further study)

705 *Negotiation* (For further study)

706 *Notification* (For further study)

707 *Charging for interworking* (For further study)

708 *Mapping of lower layer comparability (LLC) lists* (For further study)

A.2.2 *Additional EFs relating to supplementary services*

AEF00 *Insertion and suppression of additional resources (tone, etc.)*

Note – A definition has already been proposed for a basic EF. It needs to be considered if this feature should also be regarded as an additional feature. With respect to supplementary services a proposed description is:

Function of an exchange to manage (reserve, insert, release) additional resources related to the handling of supplementary services.

AEF01 *Line hunting*

Function of a functional entity to select, on receipt of a certain terminal address, one free line in a multi-line group corresponding to that number.

AEF02 *Direction dialling-in*

Function of a functional entity to transfer address and other appropriate call handling information to a PABX for the purpose of setting up a call to its extensions without assistance of the PABX operator.

AEF03 *Address determination*

Function of a functional entity to determine the destination number(s) called by means of short-long number conversion or of association between one code and one list of numbers.

AEF04 *Subscriber's dedicated storage*

Function of a functional entity to store details in addition to the LSM (line service marking) for each customer and which contains the registration data for supplementary services that have been subscribed to (i.e. listed in the LSM as binary 1). For example, it would contain a list of abbreviated numbers.

AEF05 *Bridge*

Functions of a functional entity to allow more than two individual participants on the same call.

AEF06 *User-network access resource hold*

Function of a functional entity to hold the user-network access resources (channel) involved in a communication in a waiting condition and, at the same time, to release the network connection. The call reference information is maintained.

AEF07 *Hold of communication*

Function of a functional entity to initiate the function to hold one, or more, of the other parties engaged in an established call in a waiting condition without the disestablishment of the call, and at the same time to release the initiating user-network access resource.

AEF08 *Additional subcriber signalling*

Functions of an exchange to send or receive specific signalling information to or from the user, related to the handling of supplementary services. (Additional signalling to the subscriber signalling for basic calls.)

AEF09 *Additional inter-exchange signalling*

Function of a functional entity to send or receive specific signalling information to or from another component, related to the handling of supplementary services. (Additional signalling to the inter-exchange signalling for basic calls.)

AEF10 *Multi-call handling*

Function of a functional entity to set up and manage several connections by means of a single procedure. (In response to only one call request.)

AEF11 *Internal call initialization*

Functions of a functional entity to initiate the setting-up of a connection without receiving a call request from the user [e.g. used for Completion of Call to Busy Subscribers (CCBS) supplementary service and alarm call services].

AEF12 *Access/route restriction*

Function of a functional entity to reject incoming or outgoing calls, either:

- totally for all services, or
- for one type of service (e.g. telephony).

AEF13 *Subscriber call data registration*

Function of a functional entity to register and display or print subscriber call data. Subscriber call data is information related to specific calls. This data is collected by the same functional entity as that which contains the EF "subscriber call data registration".

AEF14 *Data display option*

Functions of a terminal to display information to the user.

ANNEX B

(to Recommendation I.310)

Descriptions of identified functional components (FCs) for the ISDN

B.1 *Hold invocation*

This FC allows to invoke the disconnection of an established communication channel between the initiating and responding entities and its resevation for subsequent reuse for another (or the previous) communication. This implies the interruption of the communication for an existing connection.

The initiating entity provides the information required to identify the connection to be interrupted.

The successful application of this FC results in:

- the disconnection of the communication channel between the initiating and the responding entities;
- the reservation of the disconnected communication channel for the initiating entity (for originating or terminating connections);
- an indication of successful completion from the responding entity.

The unsuccessful application of this FC results in a response containing the failure details.

Note – The exact definition of communication channel is for further study.

B.2 *Retrieve*

This FC allows the initiating entity to request the reconnection of a communication channel between the initiating and responding entities in order to re-establish a previously held connection.

The initiating entity provides the information required to identify the connection to be re-established over the reserved communication channel.

The successful completion of this FC results in:

- the re-establishment of the connection. The communication channel will be the reserved channel whenever possible. If exceptionally an alternate channel had to be allocated, the responding entity will indicate its identity;
- an indication of succesful completion from the responding entity.

The unsuccessful application of the FC results in a response containing the failure details.

The possible re-establishment of a connection over another communication channel than the reserved one is for further study.

B.3 *Join*

This FC allows to invoke the addition of a connection in order to form, or to add to, a multiparty connection of the same connection type.

The initiating entity provides all information required to identify the connection to be joined to the multi-party connection. The responding entity executes the functions to join the connection and provides the initiating entity with the information of the result of the execution.

Upon successful completion, all connections involved are connected together. A successful indication is returned to the initiating entity.

Upon unsuccessful completion, the status of last connection remains unchanged and an unsuccessful indication is returned to the initiating party with failure cause(s).

B.4 *Split*

This FC allows the initiating entity to separate a connection from a multiparty connection.

The initiating entity provides the identities of the multiparty connection and the connection to be separated. The responding entity executes the functions to separate the designated connection from the multiparty connection.

Upon successful completion the designated connection is separated from the multiparty connection. The separated connection is put on hold; the remainder of the multiparty connection remains unchanged. A successful indication is returned to the initiating entity.

Upon unsuccessful completion, the status of the multiparty connection remains unchanged and an unsuccessful indication is returned to the initiating party with failure cause(s).

B.5 *Transfer*

This FC allows the initiating entity to reassign the ownership of a call to an elected subscriber.

The initiating entity provides the identity of the connection to be transferred and the identity of the elected subscriber.

Successful completion of this FC results in:

- the elected subscriber assumes the subsequent charges;
- the initiating entity receives a successful confirmation from the responding entity;
- the initiating entity is disconnected from the transferred connection.

Upon unsuccessful completion, the status of the connection remains unchanged and an unsuccessful indication is returned to the initiating party with failure cause(s).

Note – The concept of ownership requires further investigation in relation to control and charging aspects.

B.6 *Notify*

This FC provides the capability for one entity to inform another entity of some action or condition without requiring a response from the receiving entity.

Note – A more precise definition of this FC is required.

B.7 *Enquire*

This FC provides the capability for the initiating entity to request information from another entity, without changing that information.

The initiating entity provides to the responding entity what information is requested and other information the responding entity needs to respond successfully. For example, in requesting information from the responding entity about busy/idle status of an interface, the initiating entity provides information uniquely identifying that interface.

Upon successful completion, the responding entity returns to the initiating entity the requested information.

Upon unsuccessful completion, the responding entity returns an unsuccessful indication including failure cause(s).

B.8 *Adjourn*

This FC provides the capability for the initiating and responding entities to retain knowledge of a call (or call attempt) sufficient for subsequent re-establishment.

The initiating entity provides to the responding entity the identity of the call to be adjourned.

Upon successful completion, all channels previously allocated for the call (or call attempt) are released and the knowledge of the call is retained.

Upon unsuccessful completion, the status of the call remains unchanged and an unsuccessful completion indication with failure cause(s) is returned to the initiating entity.

B.9 *Restart*

This FC provides the capability for the initiating entity to allocate resources to restore an adjourned call.

The initiating entity provides the identity of the adjourned call to be restored.

Upon successful completion, the necessary resources to re-establish the call are restored and the call set-up process resumes.

Upon unsuccessful completion, the adjourned call is released and a failure indication returned to the initiating entity including failure cause(s).

B.10 *Monitor*

This FC allows the initiating entity to watch for an event (e.g. transition to idle, transition to busy) on a resource. The resource being monitored may be a network resource or a user resource.

The initiating entity provides the identity of the resource to be monitored, the event to be reported, and optionally the period of the monitor function. If the event to be monitored is the availability of a resource, the initiating entity may also request the resource be reserved when it becomes available. The responding entity will indicate acceptance or rejection of the monitor request immediately and subsequently check the states of the resource during the period specified.

Upon successful completion, the responding entity will notify the intiating entity if the period expired before the monitored event occured.

Upon unsuccessful completion, an unsuccessful indication is returned to the initiating entity with failure cause(s).

B.11 *Reroute*

The FC allows the initiating entity to redirect an incoming call to an alternate address before the call is established.

The initiating entity provides the identity of the incoming call and the aternate address to where the incoming call is to be redirected.

Upon successful completion, the incoming call is connected to the alternate address.

Upon unsuccessful completion, the responding entity provides to the initiating entity the cause of failure and the call processing of the incoming call is resumed.

SECTION 2

REFERENCE MODELS

Recommendation I.320

ISDN PROTOCOL REFERENCE MODEL

(Malaga-Torremolinos, 1984; amended at Melbourne, 1988)

1 Introduction

The objective of the ISDN Protocol Reference Model (ISDN PRM) is to model the interconnection and exchange of information – including user information and control information – to, through or inside an ISDN.

Communicating entities may be:

- ISDN users;
- an ISDN user and a functional entity within an ISDN, e.g. network control facilities;
- an ISDN user and a functional entity inside or outside an ISDN, e.g. an information storage/processing/messaging facility;
- various functional entities in an ISDN, e.g. a network management facility and a switching facility;
- an ISDN functional entity and an entity located in or attached to a non-ISDN network.

The purpose of communications between these functional entities is to support the telecommunication services introduced in Recommendations I.211 and I.212, by providing ISDN capabilities as defined in Recommendation I.310. Examples of these capabilities are:

- circuit-switched connection under the control of common channel signalling;
- packet-switched communication over B-, D- and H-channels;
- signalling between users and network-based facilities (e.g. information retrieval systems such as Videotex, operations data bases such as directory);
- end-to-end signalling between users (e.g. to change mode of communication over an already established connection);
- combinations of the above as in multi-media communication, whereby several simultaneous modes of communication can take place under common signalling control.

With such diversity of ISDN capabilities (in terms of information flows and modes of communication), there is a need to model all these capabilities within a common framework (i.e. reference model). This would enable the critical protocol architectural issues to be readily identified and facilitate the development of ISDN protocols and associated features. It is not intended as a definition of any specific implementation of an ISDN or of any systems or equipment in, or connected to, an ISDN.

Examples of applications of this model are included in this Recommendation.

2 Modelling concepts

2.1 *Relationship with the X.200-Series*

The ISDN Protocol Reference Model (ISDN PRM) and the Open Systems Interconnection Reference Model (OSI RM) for CCITT Applications, defined by Recommendation X.200, have both commonalities and differences.

Both the ISDN PRM and the OSI RM organize communications functions into layers and describe the relation of these layers with respect to each other. However, the scope of the ISDN PRM is different from the scope of the OSI RM.

The scope of the ISDN PRM is to model information flows across the range of telecommunication services defined in the I.200-Series. These are bearer services, teleservices and supplementary services. This description necessarily incorporates ISDN-specific characteristics not encountered in other network types. Among these characteristics are multi-service types of communications which include voice, video, data and multi-media communications.

The scope of the OSI RM is not associated with any particular network type[1]. In that sense it is less specific than the ISDN PRM. Further, the scope of the OSI PRM is tied to data communications and so, in this respect, its scope is more specific than the ISDN PRM. The OSI is used to model data communications between open systems in an ISDN environment.

The relative scopes of the two models are illustrated by Figure 1/I.320. The existence of a common intersection shows that these models coexist and overlap.

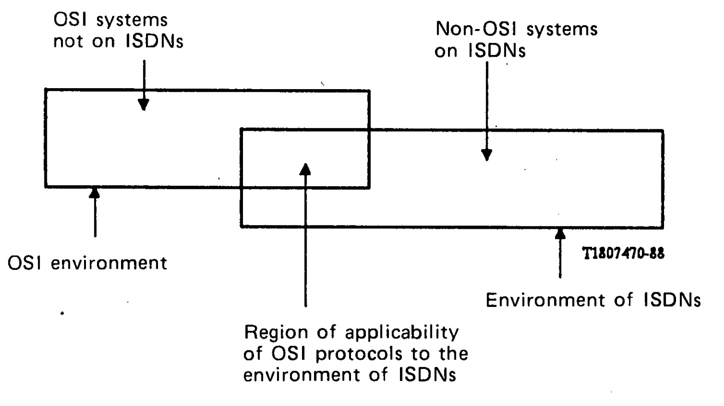


FIGURE 1/I.320

Applicability of OSI protocols to ISDN

However, in spite of these differences in scope, a number of concepts and the associated terminology which have been introduced in Recommendations X.200 and X.210 are fully applicable to the ISDN PRM. They include the concept of layer, layer service (Recommendation X.200), and the notions of service primitive, peer entity and peer protocol (Recommendation X.210).

Note – The relation between service primitives and functional components introduced in Recommendation I.310 requires further study.

The layer identification used in Recommendation X.200 is limited in this Recommendation to the use of layer numbers. Layer titles (e.g. network layer) as used in Recommendation X.200 are sometimes misleading in the ISDN context, and have not been used here.

[1] Note that the term "network" in the ISDN corresponds to "sub-network" in the OSI terminology.

The following ISDN needs have to be specifically catered for in Recommendation I.320:

- information flows for out-of-band call control processes, or more generally, information flows among multiple related protocols;
- information flows for selection of connection characteristics;
- information flows for re-negotiation of connection characteristics of calls;
- information flows for suspension of connections;
- information flows for overlap sending ;
- information flows for multi-media calls;
- information flows for asymmetric connections;
- information flows for network management (e.g. change over and change back) and for maintenance functions (e.g test loops);
- information flows for power activation/deactivation;
- interworking;
- switching of information flows;
- new layer service definitions for non-data services;
- application to other than end-systems, e.g. signal transfer points (STPs) and interworking points;
- information flows for multi-point connections;
- information flows for applications such as:
  - i) voice (including A/μ law conversion),
  - ii) full motion video,
  - iii) transparent flow,
  - IV telex.

2.2 *Control and user planes*

The support of out-of-band signalling and the ability to activate supplementary services during the active phase of the call imply a separation between control information and user information.

The notion of plane – control plane, or C-plane, and user plane, or U-plane – is introduced to reflect this.

The main rationale for protocols within the user plane is the transfer of information among user applications, e.g. digitized voice, data and information transmitted between users. This information may be transmitted transparently through an ISDN, or it may be processed or manipulated, e.g. A/μ law conversion.

The main rationale for protocols within the control plane is the transfer of information for the control of user plane connections, e.g. in:

- controlling a network connection (such as establishing and clearing down);
- controlling the use of an already established network connection (e.g. change in service characteristics during a call such as alternate speech/unrestricted 64 kbit/s);
- providing supplementary services.

In addition to user information, any information which controls the exchange of data within a connection, but otherwise does not alter the state of this connection (e.g. flow control), pertains to the U-plane. All control information which involves resource allocation/deallocation by the ISDN pertains to the C-plane.

2.3 *Local and global significance*

A key characteristic of the ISDN is that, due to the integration of telecommunication services, the facilities to be provided depend on whether the adjacent entity, or a remote entity, is involved: different services, possibly using different routes, may have to be provided accordingly. An example is a telecommunication service, which can be supported by various network capabilities, (e.g. a telematic service supported either by circuit or packet facilities), or an ISDN connection based on various types of basic connection components (e.g. analogue and digital circuits for a speech connection).

As a consequence, the control information handled by an entity may concern:

- an adjacent functional entity, in which case it is said to have local significance;
- a remote (non-adjacent) functional entity, in which case it has global significance.

The significance concept is illustrated by Figure 2/I.320

The notion of significance applies to control plane information only. As an example from the ISDN user's point of view:

- the overall service to be provided to users has a global significance;
- the control of any resources to be used at the user-network interface has local significance;

and, from the network's point of view:

- the overall service to be provided by the ISDN (ISDN connection types, as introduced in Recommendation I.340) has a global significance;
- the handling of connection elements has local significance.

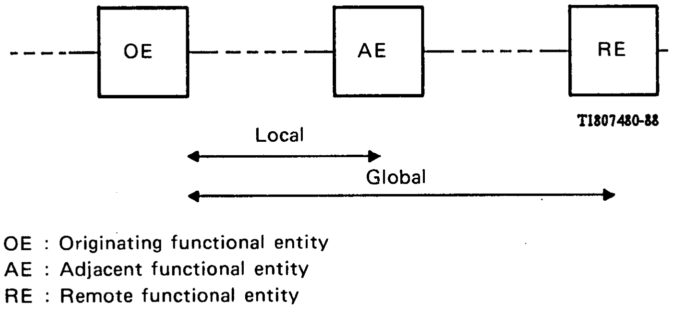


FIGURE 2/I.320

Concept of local and global significance

Depending on their functional requirements, supplementary services relate to either the local, or global perspective. For example:

- completion of calls to busy subscribers (CCBS) or user-to-user signalling (UUS) have global significance;
- call waiting has local significance.

Global information falls into three classes:

1) the information is transported transparently;
2) the information may be processed, but remains unchanged (e.g. teleservice);
3) the information may be altered (e.g. destination number in relation with freephone or call forwarding supplementary services).

3 Model

The ISDN PRM is represented by a protocol block which incorporates the concepts of layer, significance and plane described above.

Such a protocol block can be used to describe various elements in the ISDN user premises and the network [e.g. terminal equipment (TE), ISPBX network termination (NT), exchange termination (ET), signalling point (SP) and signalling transfer point (STP), etc.].

3.1 *Generic protocol block*

The considerations above lead to the introduction of the concept of significance in combination with planes; the result is a splitting of the control plane into two parts: a local control (LC) plane, and a global control (GC) plane, in addition to the user (U) plane.

The layering principles apply in each of these planes: each plane can potentially accommodate a 7-layer stack of protocols. A plane management function is required to allow coordination between the activities in the different planes. Examples of plane management function are:

- the decision on whether an incoming information is relevant to the LC- or GC-plane,
- allowing communication between C- and U-planes, for synchronization purposes.

The Generic protocol block is represented in Figure 3/I.320.

Note – The plane management function should not be confused with the system management as introduced to model OSI management.

The following remarks apply:

1) Some layers may be empty, i.e. they provide no functionality. For example, it is likely that not all seven layers are required to serve the LC-plane requirements; however, entities communicating in this plane are application layer entities. Note that this is not in contradiction with the OSI RM.
2) An element (either in the network, or in user premises) does not have to support in all cases protocols of LC-, GC- and U-planes: some may ignore one or even two of these planes. For example, a network service centre accessed to provide a supplementary service (e.g. freephone) will be concerned by the LC plane only, and will have no knowledge of the other two planes.
3) A network element – unless it provides a high layer function (HLF) – will generally not support any U-plane protocol above layer 3.
4) The need for application processes specific to each plane, or for application processes able to access several planes, is for further study.

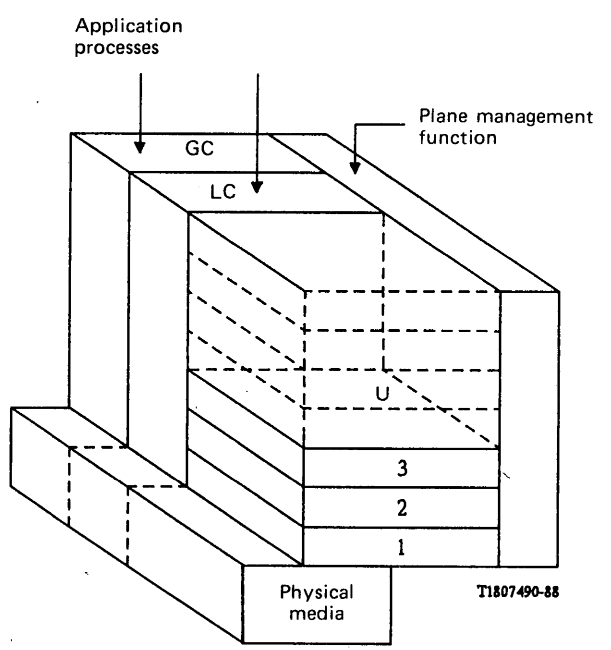


FIGURE 3/I.320

Generic protocol block

3.2 *Relations between layers in one plane*

Adjacent layers within a plane communicate using service primitives. If a layer is empty the primitive is mapped directly onto a primitive to the next layer.

Further study is required on which layer services have to be specified in order to describe a telecommunication service.

3.3 *Relations between planes*

Starting from GC-plane requirements, an entity will derive the LC-plane requirements, and the facilities that have to be provided for the support of U-plane lower layers. For example, in order to provide an ISDN connection (GC-plane), an exchange will have to identify the required basic connection component (LC-plane).

This relation is made via the plane management function.

Informations in different planes need not be carried by distinct physical/logical means in all cases. For example:

- control and user information may use the same support, e.g. when in-band signalling is used, or when user information is carried on a D-channel;
- LC and GC information share the same support when the LC-plane pass-along facility is used;
- ISPBX-to-ISPBX control information appears as U-plane information to the ISDN.

3.4 *Data flow modelling*

For further study.

4 ISDN management

For further study.

5 Interworking

A number of particular interworking situations should be considered:

- internetworking with an OSI network;
- interworking with an non-ISDN terminal;
- interworking between two ISDNs which do not provide the same set of facilities;
- interworking involving a network-provided interworking function to support high-layer and/or low-layer facilities.

5.1 *General*

All the interworking situations mentioned above are covered by the model illustrated by Figure 4/I.320.

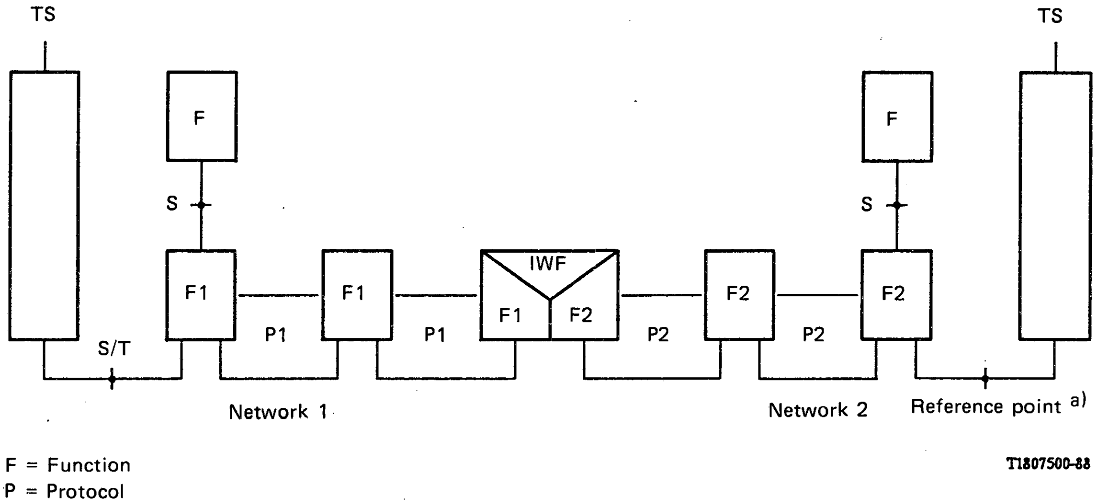
The service S may be:

- the initially required telecommunication service (TS), if both networks are able to provide it (F is then empty);
- a telecommunication service resulting from a negotiation process, which both networks are able to provide (F is then empty);
- a service which is required to support the telecommunication service to be provided, which is offered by both networks, but by means of different capabilities in the two networks.

The service S is provided:

- by means of functions F1 and protocol(s) P1 in network 1;
- by means of functions F2 and protocol(s) P2 in network 2.

The interworking function (IWF) maps the facilities offered by F1 and F2.



a) This reference point is an S/T reference point when considering interworking between ISDNs, or service interworking within an ISDN.

FIGURE 4/I.320

Interworking model

Two kinds of interworking can take place:

1) a one-stage interworking, where the calling user is not explicitly aware that an interworking function is required;

2) a two-stage interworking, where the calling user has a dialogue with the interworking function prior to exchanging control information with the destination user.

The model applies to both cases.

Interworking may involve the GC-plane, and/or the U-plane.

In an interworking situation, the GC-plane has to:

- determine the telecommunication service to be provided (agreed telecommunication service): this may imply service negotiation;
- identify the interworking situation, i.e. the fact that more than one network is involved, and that for some service S required to support the telecommunication service, two adjacent networks do not use the same underlying facilities;
- locate and invoke an IWF capable of mapping the facilities in the two networks.

In each network, the GC-plane facilities will provide the functions and protocols (Fi and Pi) required to support service S; this will result in different (and independent) requirements on the LC-plane in each network.

In the two-stage interworking case, the GC-plane information is "consumed" by the IWF during the first phase, and is forwarded (with or without modification) during the second phase.

Whenever interworking in the U-plane is involved, the following differences apply in the two cases:

- one-stage interworking: in this case only the first three layers (at most) may be involved for the provision of the requested end-to-end service. No HLF is required.
- two-stage interworking: in this case the first stage is the establishment of the U-plane facilities between the calling user and the IWF. High layer functions (HLF) and protocols may be involved, in which case the IWF acts as a substitute for the called user.

5.2 *Relationships with the OSI RM*

The OSI RM, seen from the ISDN PRM point of view, appears not to be in contradiction with the latter, but contains some restrictions which stem from the fact that it does not have the same scope:

1) The C- and U-planes are not separated, since the C- and U-plane information in one layer (n) always maps onto the U-plane information of the layer below ($n - 1$).
2) The concept of significance does not explicitly appear; however control informations (e.g. in layer 3) include both "local" informations and informations which are carried end-to-end transparently or take part in the definition of the overall service provided to the user (e.g. throughput).
3) The C- and U-plane informations in one layer (n) map onto the U-plane informations of the layer below ($n - 1$).

Interworking between the OSI RM and ISDN PRM takes place in the following situations:

- internetworking with a specialized network (e.g. PSPDN) which respects the OSI RM: the reference points involved are K/L;
- interworking with an "OSI terminal" via a terminal adaptor: the reference point is then R;
- the interworking of an ISDN terminal on the S reference point which conforms to the OSI reference model is for further study.

In each case, the interworking function (an IWF or a TA) has to map information flows of one model onto information flows of the other.

5.2.1 *Interworking at reference point K/L*

For further study.

5.2.2 *Interworking at reference point R*

In the case when a user application, running an OSI system, requires network services across the ISDN, the originating user application will address the terminating application as a destination user.

In the OSI system, the application is considered as an ISDN user – a communicating functional entity in the PRM.

The GC information pertinent to the higher layer OSI application is carried in the U-plane to the destination application. The GC information pertinent to the network service required is carried in the C-plane with LC information.

The OSI system requests the network service from the ISDN by placing a service request to both the LC-plane and the U-plane (Figure 5/I.320). The distribution of the information to the appropriate planes is made by the plane management function. The plane management function is responsible for providing an OSI service access point to the OSI system.

6 **Examples**

Applications of the PRM to the following examples is for further study.

6.1 *Basic call situations* (no supplementary service, no interworking)

- circuit service (see Figure 6/I.320)
- packet service
- multi-bearer capability
- data base access.

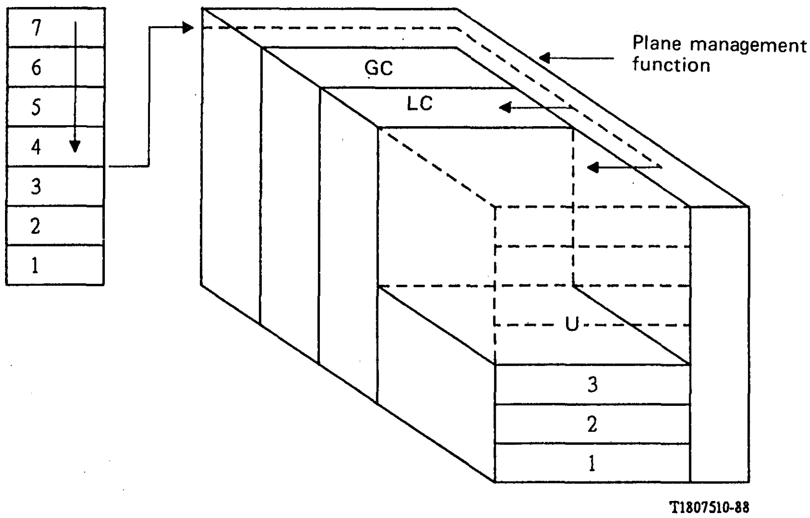


FIGURE 5/I.320

OSI reference model and ISDN protocol reference model

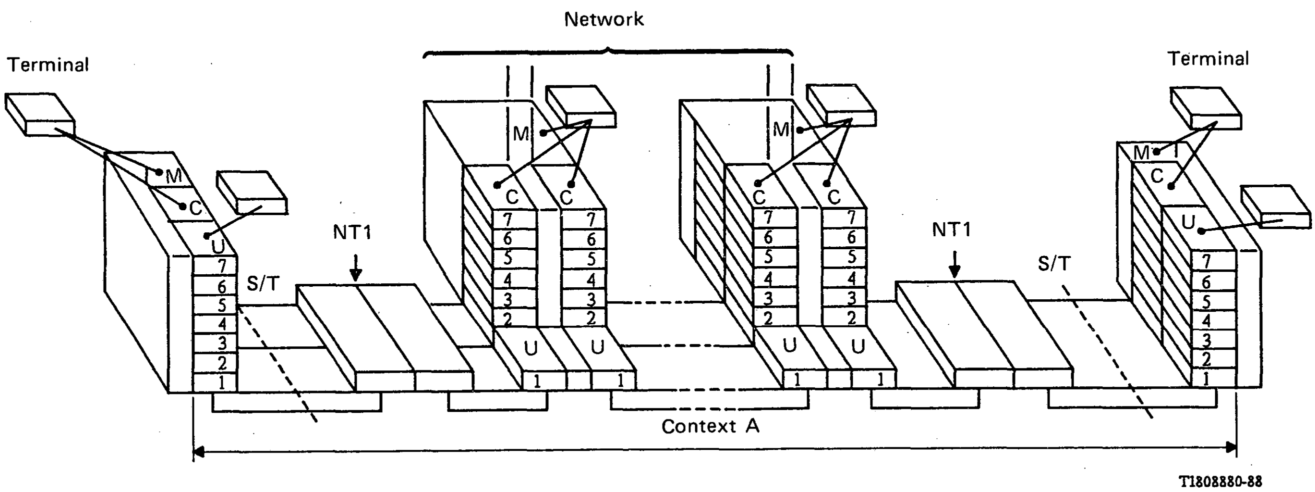


FIGURE 6/I.320

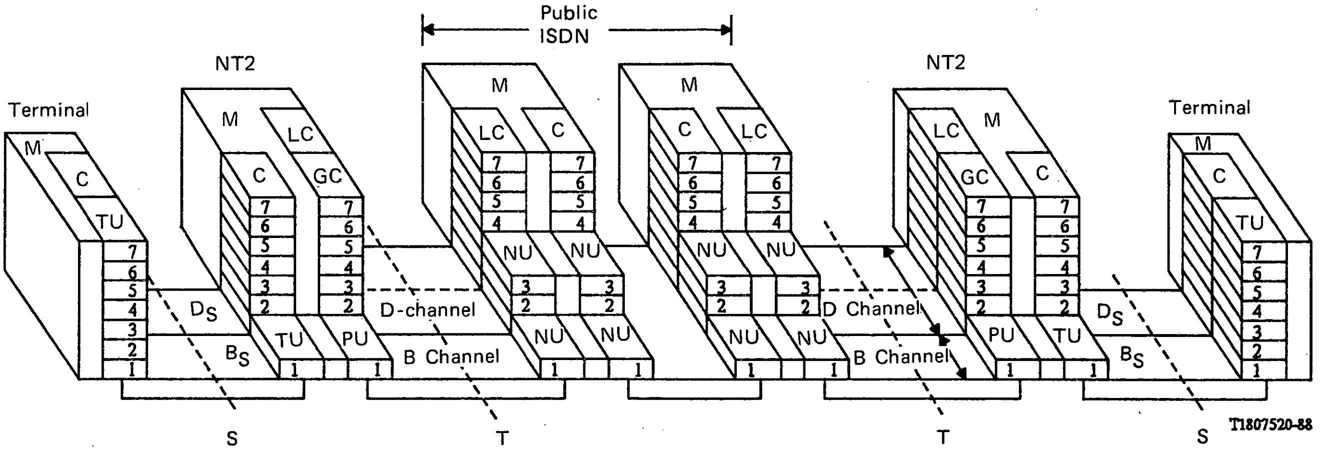
Circuit-switched connections via the B-channel

6.2 *More elaborate situations*

- supplementary services:
  - completion of calls to busy subsribers (CCBS);
  - three-party service;
- PABX facilities;
- OAM (operational, administrative and maintenance) applications.

6.3 *Interworking*

- at reference point R (Teletex terminal):
- with a PSTN;
- with a PSPDN (Videotex);
- inside an ISDN (provision of an HLF by the network);
- of public ISDN with other networks (a possible example is given in Figure 7/I.320).



C : Local or global control depending on the destination functional entity
LC : Local control
GC : Global control
M : Plane management function
NU : Network user plane
PU : PSN user plane
TU : Terminal user plane

Note – For simplicity reasons, NT1 funcional units are not shown.

FIGURE 7/I.320

A protocol reference model example showing the interconnection of public and private ISDNs

Recommendation I.324

ISDN NETWORK ARCHITECTURE

(Melbourne, 1988)

1 General

1.1 *Basic philosophy*

The objective of this Recommendation is to provide a common understanding of the CCITT studies on the general architecture of an ISDN from the functional point of view. The model is not intended to require or exclude any specific implementation of an ISDN, but only to provide a guide for the specification of ISDN capabilities.

1.2 *Definitions*

A number of terms used in this Recommendation are described in more detail in other Recommendations. To assist the understanding of the reader, the following particular definitions apply in this Recommendation:

1) **reference configurations** are conceptual configurations which are useful in identifying various possible arrangements in an ISDN. The reference configurations are based on association rules of functional groupings and reference points. Detailed descriptions of reference configurations for ISDN connection types are given in other I-series Recommendations. For user-to-network access they are defined in Recommendation I.411 and for interworking between networks they are defined in the I.500-series of Recommendations.

2) **functional groupings** are sets of functions which may be needed in ISDN arrangements. The relationship between generic functions and specific functions allocated to particular entities (or functional groupings) in the ISDN are explained in Recommendation I.310.

3) **reference points** are the conceptual points at the conjunction of two functional groupings. In a particular example, a reference point may correspond to a physical interface between pieces of equipment, or in other examples there may not be any physical interface corresponding to the reference point. Interfaces will not be defined by CCITT for an ISDN unless the corresponding reference points have been already specified.

2 General architecture of an ISDN

In practical ISDN implementations some of the ISDN functions will be implemented within the same network elements, whereas other specific ISDN functions will be dedicated to specialized network elements. Various different ISDN implementations are likely to be realized depending on national conditions.

A basic component of an ISDN is a network for circuit switching of end-to-end 64 kbit/s connections. In addition to this connection type, depending on national conditions and evolution strategies, the ISDN will or will not support other connection types, such as packet mode connection types and $n \times 64$ kbit/s circuit mode connection types, and other broadband connection types.

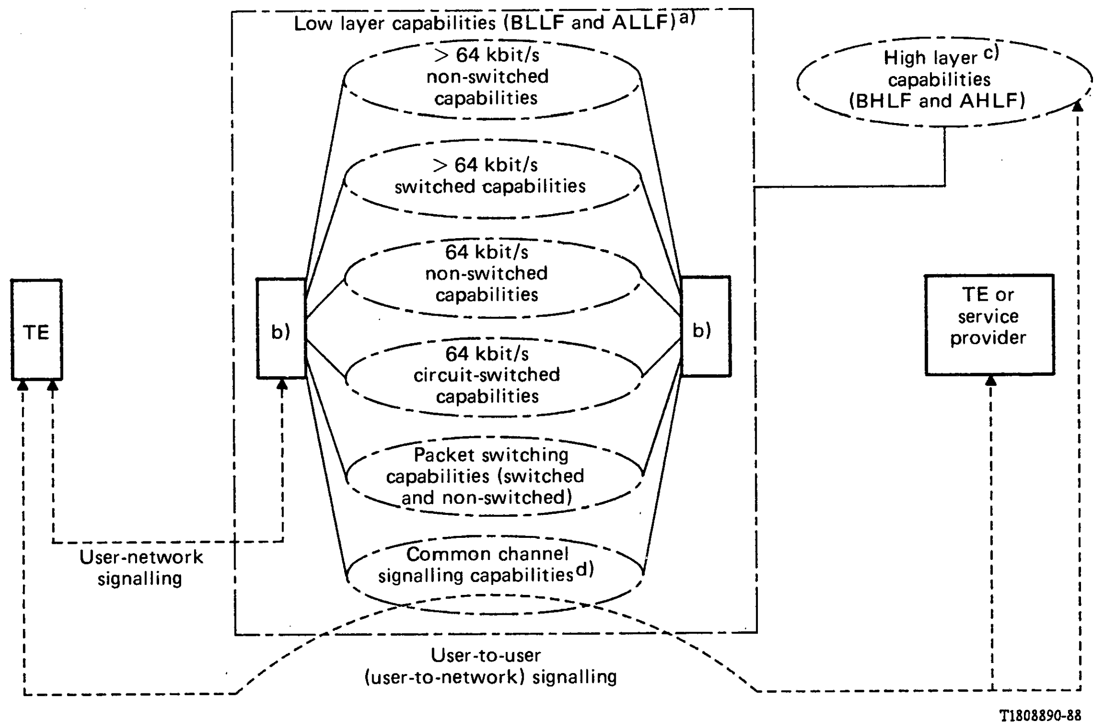
2.1 *Basic architectural model*

A basic architectural model of an ISDN is shown in Figure 1/I.324. This shows the seven main switching and signalling functional capabilities of an ISDN:

- ISDN local Connection Related Functions (CRF), see § 4.2.2.1;
- narrow-band (64 kbit/s) circuit switching functional entities;
- narrow-band (64 kbit/s) circuit non-switched functional entities. (The identification and definition for 8, 16, 32 kbit/s or non-switched functional entities is left for further study.);
- packet switching functional entities;
- common channel inter-exchange signalling functional entities, for example conforming to CCITT Signalling System No. 7;
- switched functional entities at rates greater than 64 kbit/s;
- non-switched functional entities at rates greater than 64 kbit/s.

These components need not be provided by distinct networks, but may be combined as appropriate for a particular implementation.

Higher layer functions (HLF) which may be implemented within (or associated with) an ISDN may be accessed by means of any of the above-mentioned functional entities. Those functional entities could be implemented totally within an ISDN or be provided by dedicated networks or specialized service providers. Both cases may provide the same ISDN teleservices (see Recommendation I.210) from the user's point of view.



BLLF Basic low layer functions
ALLF Additional low layer functions
BHLF Basic high layer functions
AHLF Additional high layer functions

[a] In certain national situations, ALLF may also be implemented outside the ISDN, in special nodes or in certain categories of terminals.

[b] The ISDN local functional capabilities corresponds to functions provided by a local exchange and possibly including other equipments, such as electronic cross connect equipment, muldexes, etc.

[c] These functions may either be implemented within ISDN or be provided by separate networks. Possible applications for basic high layer functions and for additional high layer functions are contained in Recommendation I.210.

[d] For signalling between international ISDNs, CCITT Signalling System No. 7 shall be used.

FIGURE 1/I.324

Basic architectural model of an ISDN

2.2 *Architectural components of the ISDN*

Recommendation I.310 describes the functions of an ISDN. These functions are by their nature static (i.e., time-independent). The relative distribution and allocation of these functions is the subject of the architecture of the ISDN and is described in this Recommendation. The dynamic aspects of these functions are modelled in Recommendation I.310 as Executive Processes.

Therefore the key components in this architectural model are: what functions are contained in the ISDN, where they are located, and what is the relative topology for their distribution in the ISDN.

3 Aspects of the architecture of the ISDN

The architecture of the ISDN includes low layer capabilities and high layer capabilities. These capabilities support services both within the ISDN and via interworking (see § 5) to other networks.

3.1 *Low layer capabilities*

From the main functional capabilities of the ISDN, as shown in Figure 1/I.324, four main functional capabilities require further description.

3.1.1 *Circuit switching capabilities*

Circuit-switched connections with information transfer rates up to 64 kbit/s are carried by B-channels at the ISDN user-network interfaces and switched at 64 kbit/s by the circuit-switching functional entities of the ISDN. Circuit switching can also be applied to information transfer rates greater than 64 kbit/s.

Signalling associated with circuit switched connections is carried by the D-channel at the ISDN user-network interface and processed by the local CRF (see § 4.2.2.1). User-to-user signalling could be carried through the common channel signalling functional entities (in the transit connection elements).

User bit rates of less than 64 kbit/s are rate adapted to 64 kbit/s, as described in Recommendation I.460, before any switching can take place in the ISDN. Multiple information streams from a given user may be multiplexed together in the same B-channel, but for circuit switching an entire B-channel will be switched to a single user-network interface. This multiplexing should be in accordance with Recommendation I.460. Furthermore, circuit switched data services with bit rates less than 64 kbit/s (in accordance with Recommendation X.1 user classes of service) may be handled by a dedicated circuit switched public data network to which the user gains access by means of an ISDN connection.

The narrow-band ISDN circuit switching capabilities are based on 64 kbit/s switching. Connection types at higher bit rates could also be provided on a semi-permanent basis. Switched connections at these bit rates could also be provided by broadband switching functional entities.

3.1.2 *Packet switching capabilities*

A number of packet mode bearer services are described in the I.230-series of Recommendations. Different network solutions and corresponding architectures may be adopted in different countries to support these services.

Recommendations I.310 (functional principles of ISDN), I.462 (definitions of minimum and maximum integration scenarios) and Q.513 (description of exchange connections) constitute the basis for the description of packet switchng functions in an ISDN.

Two types of functional groupings are involved in the provision of packet switched bearer services by an ISDN:

- packet handling functional groupings, which contain functions relating to the handling of packet calls within the ISDN;
- interworking functional groupings, which ensure interworking between ISDN and packet switched data networks.

The solutions which could be used to access packet bearer services are:

- via the B-channel, with the following cases:
  - circuit (switched or semi-permanent) access through ISDN to an interworking function within a PSPDN,
  - circuit (switched or semi-permanent) access associated with packet handling functions and/or interworking functions in the ISDN,
  - circuit (switched or semi-permanent) access associated with packet handling functions within the ISDN;
- via the D-channel, with the following cases:
  - packet handling functions and interworking functions within the ISDN,
  - packet handling functions in the ISDN (without interworking functions).

Note – This classification does not preclude a combination of the solutions described above.

Depending on national considerations, the ISDN packet handling and interworking functions can be centralized or distributed. The following cases may be encountered:

- packet handling and interworking functions are not integrated in the local CRF (e.g., they are located in a transit CRF);
- packet handling functions are integrated in the local CRF;
- packet handling functions and/or interworking functions are integrated in the local CRF.

3.1.3 *Other switching capabilities*

For the support of broadband connections, other switching capabilities in addition to the above-mentioned switching capabilities could be employed.

3.1.4 *Transmission capabilities*

In addition to the normal transmission capabilities of the IDN (Integrated digital network) the following transmission aspects are important when considering the architecture of the ISDN. Services which do not require unrestricted digital information transfer capability, such as telephony, may also employ non-transparent channels (e.g., packetized voice, digital speech interpolation). Channels at 8, 16, 32 kbit/s may be used in the transmission part of the network; they may be used to support some services (e.g., voice-band connection types). They may also be used in cases where a B-channel (at the S or T reference point) carries user data streams at bit rates lower than 8, 16, 32 kbit/s respectively.

3.2 *High layer capabilities*

Normally the high layer functions (HLFs) are involved only in the terminal equipment, but for the support of some services, provision of HLFs could be made via special nodes in the ISDN belonging to the public network or to centres operated by other organizations and accessed via ISDN user-network or inter-network interfaces. Some services such as message handling service (MHS) may be used on a large scale and the relevant functional entities could be provided within the ISDN exchanges. For both cases the protocols used to activate such services should be identical and integrated with the general user procedures defined for the activation of ISDN teleservices.

4 Location of functions in the ISDN

4.1 *Overall*

In considering an ISDN call (i.e. an instance of a telecommunication service) two major functional areas are involved:

i) the customer equipment (TE and optional customer network);

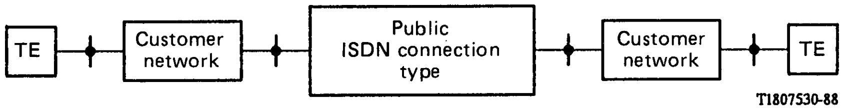
ii) the public ISDN connection type.

Recommendation I.411 describes the functional groupings and reference configurations for the customer network, while Recommendation I.412 describes the channel structures to be used at reference points S and T. The partitioning of the functions involved in ii), the public ISDN connection type, is described in § 4.2 below.

Figure 2/I.234 illustrates this overall division of functions involved in a communication across the ISDN.

4.2 *Partitioning of the ISDN connection type*

The distribution of functions within the ISDN connection type is known as the connection type reference configuration. The partitions of the connection type to allow this distribution are described below. The detailed reference configurations for groups of connection types can be found in Recommendation I.325.



Note 1 — The functional grouping customer network is described in Recommendation I.411.

Note 2 — In the case where the customer network is null (i.e. null NT2), then the ISDN connection type can be considered to end at the S/T reference point.

Note 3 — Other configurations are possible where the call is asymmetrical, or terminates in or involves HLFs.

Note 4 — The terms "customer network" and "Public ISDN connection type" do not presuppose a particular regulatory situation in any country and are used purely for technical reasons. The connection type concept is defined in Recommendation I.340.

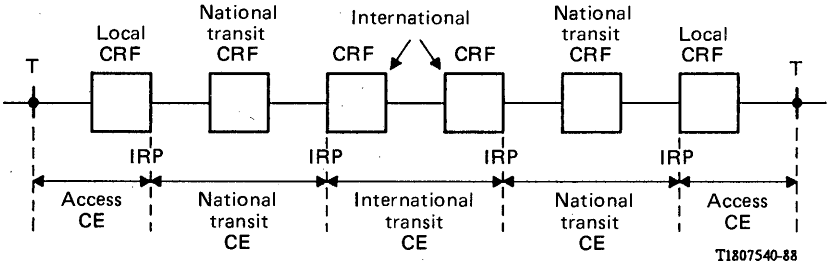
FIGURE 2/I.324

General ISDN reference configuration

4.2.1 *Connection elements*

The first level of partitioning of the ISDN connection type is the connection element. The partitioning is based on the two most critical transitions of a connection: change of signalling system and the international transmission system(s). These two points generate three connection elements: access connection element, national transit connection element, and international transit connection element. These three connection elements allow the description of both the access and transit capabilities to support services. However, in the case of performance allocation, for example, the access connection element and the national transit connection element may be fused into one national connection element. This allows for the variation in the nature of the local plant and regulatory environments in different countries according to national policies.

The partitioning into connection elements is shown in Figure 3/I.234.



IRP National reference point
CRF Connection related functions
CE Connection element

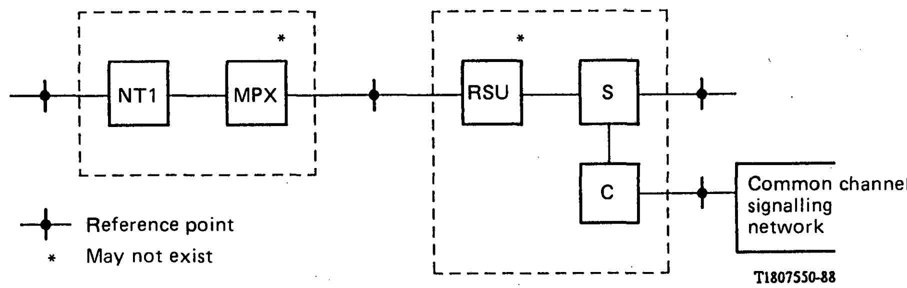
FIGURE 3/I.324

Reference configuration of public ISDN connection type

4.2.1.1 *Access connection element*

The access connection element is bounded by the T reference point at the customer end and the reference point which marks the transition from the access signalling system to the common channel signalling system on the network side.

The model for the access connection element in the case of 64 kbit/s circuit switched is shown in Figure 4/I.234. Depending on the national situations and on the type of access, a number of different possibilities are available for this element, in particular with regard to the use of multiplexer (MPX) or remote switching units (RSU).



S 64 kbit/s circuit switch
C Signalling handling and exchange control functions
MPX Remote multiplex
RSU Remote switching unit and/or concentrator

FIGURE 4/I.324

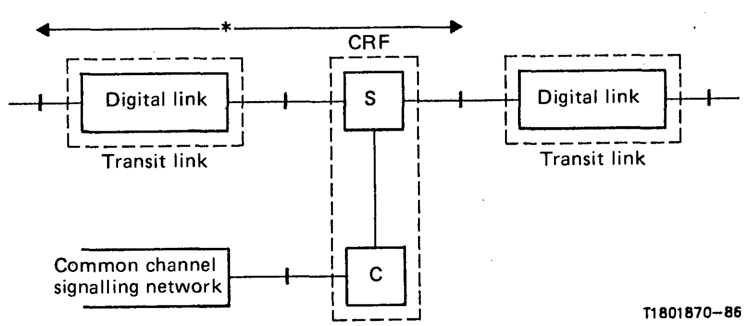
Access connection element model

4.2.1.2 *National transit connection element*

The national transit connection element is bounded by the transition from access signalling system to common channel signalling systems and the *first* international switching centre. In the case of a national connection this would default to a "transit connection element", i.e. between two local CRFs, but could involve network elements from more than one network operator.

In some instances, the first international exchange (and the international CRF) may be in close proximity to the local and national transit CRF. This is a national matter.

The model for the national transit connection is shown in Figure 5/I.324.



Reference point
* This portion may be replicated if more than one transit exchange is involved in the connection

S 64 kbit/s circuit switch
C Signalling handling and exchange control functions
CRF Connection related function

FIGURE 5/I.324

National transit connection element model

4.2.1.3 *International connection element*

The international connection element is bounded by the originating and destination International Switching Centre (ISC). A number of transit international exchanges may be involved to bridge long international connections. With satellite connections, fewer international transits may be required.

Figure 6/I.324 shows an international connection element model. Figure 7/I.324 shows an international connection element model made by a concatenation of several links and exchanges.

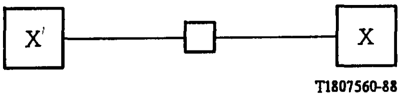


FIGURE 6/I.324

International connection element model

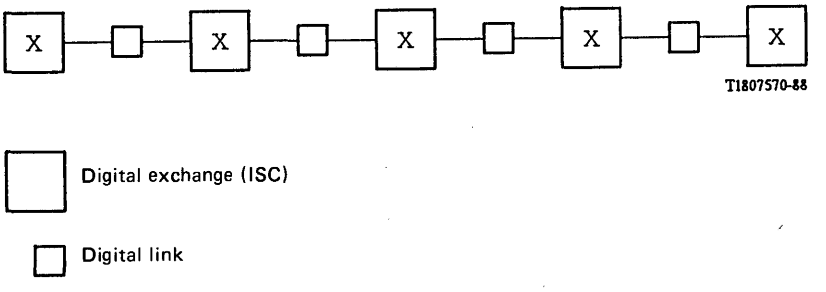


FIGURE 7/I.324

International connection element model making use of several links and exchanges

4.2.1.4 *Future additional connection elements*

Connection elements for interworking and connection to specialized resources and services are also required.

4.2.2 *Basic connection components*

The Basic Connection Components (BCC) allow for the analysis of system performance. There are three forms of BCC: connection related function, access links and transit links. Broadly, CRFs cover switching aspects, and links cover transmission aspects.

4.2.2.1 *Connection related function*

The connection related function includes all aspects involved in establishing and controlling the connections within the particular connection element. This includes functions such as exchange terminations, switching, control, network management, operation and maintenance. The specific capabilities of each CRF are not specified in the general reference model: this is done in the reference configuration for each group of connection types.

4.2.2.2 *Access link*

The access link includes the NT1 and may include a multiplexer, along with the required transmission equipment to link the customer network to the local CRF.

4.2.2.3 *Transit link*

The transit link is a digital link as described in Recommendations G.701 and G.801.

4.2.3 *Functional groupings*

Functional groupings are sets of functions which may be needed in the ISDN. In a particular instance, specific functions in a functional group may or may not be present. Note that specific functions in a functional group may be performed in one or more pieces of equipment. Examples of functional groupings are Line Termination (LT), Exchange Termination (ET), and Packet Handling (PH) function. Further study is required on functional groupings for the public ISDN connection type.

4.2.4 *Reference points*

The other element involved in the description of a reference configuration is the reference point concept. The I-series already identifies reference points S and T (in Recommendation I.411) and K, M, N, P (in the present Recommendation). As can be seen from Figure 4/I.324, some further internal reference points need to be identified. Further study is required to see whether these and any further reference points need to be defined.

In describing the reference configuration for the public ISDN connection types, an important consideration vis-a-vis the reference points is the following. In Figure 3/I.324 the end points of the overall connection is shown as being at the T reference point. The reason for this is as follows. Reference point S is identifical to reference point T when the NT2 function is null (cf Recommendation I.411). When the NT2 function is non-zero, then the performance of the overall connection will be made up of the performance of the ISDN network connection (i.e. between the two interfaces at reference point T) and the sum of the performance of the customer network connections (i.e. between the interfaces at reference points S and T at each end). Recommendation G.801 also uses this approach by defining the areas of the digital hypothetical reference connection (HRX) as being at the T reference point.

5 Architectural relationship between the ISDN and other networks including ISDN

A key element of service integration for an ISDN is the provision of a limited set of standard multi-purpose user-network interfaces.

It is important to note that the introduction of ISDN capabilities into a network requires a massive development effort. Consequently, Administrations will be introducing various ISDN functions successively over a course of time. For example, the 64 kbit/s circuit switched capability may be introduced initially, followed by provision of packet switching features, and so on.

An ISDN will therefore have to interwork with a set of various dedicated networks or terminals in order to:

i) provide ISDN connections to non-ISDN terminal equipments (TE2) through dedicated networks;

ii) provide a non-ISDN terminal equipment (TE2) connected by means of a terminal adaptor (TA) with access to non-ISDN services provided by a dedicated services network;

iii) ensure that an ISDN terminal connected to ISDN interworks with a non-ISDN terminal connected to a dedicated network.

The dedicated networks will offer services (e.g. public data network services) that are either available or not available within an ISDN. Some of the dedicated networks could be integrated into the ISDN in the future, depending on national conditions. Connections have to be allowed between terminals, both connected to an ISDN, or for terminals where one is connected to the ISDN and the other is connected to the dedicated network.

The I.500-series of Recommendations describe the characteristics of interworking.

The I.400-series of Recommendations describe the characteristics of user-network interfaces for the following cases:

1) access of a single ISDN terminal;
2) access of a multiple ISDN terminal installation;
3) access of multiservice PABXs, local area networks or, more generally, private networks;
4) access of non-ISDN terminal;
5) access of specialized storage and information processing centres.

In addition, considering that the evolution to a comprehensive ISDN will take place over a long period of time, the connection of non-ISDN customers to an ISDN via analogue lines as well as interworking with existing networks or other ISDNs will be necessary. These cases include:

1) access to the existing telephone network and to dedicated networks (e.g. packet network, telex network);

2) access to another ISDN;

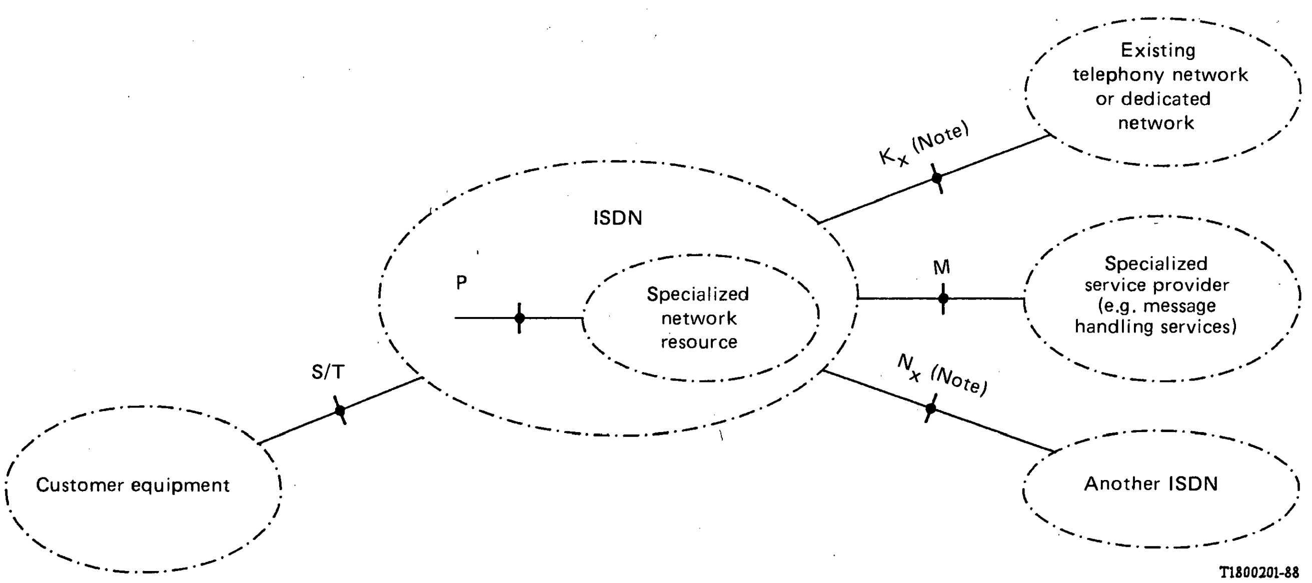
3) access to service providers outside the ISDN.

The ISDN user-network interfaces or internetwork interfaces may be used in the above cases. The definition of internetwork interfaces is necessary for these arrangements for interworking and administrative requirements.

Interworking with other networks or other ISDNs requires in some cases the provision of Interworking Functions (IWF), either within the ISDN or in the other network (see Recommendations of the I.500-series). These functions would ensure interworking between different protocols and user procedures.

Within a country or geographical area, an ISDN connection may be formed across several interconnected networks, each of which is characterized by the attributes of one or more ISDN connection types (as defined in Recommendation I.340).

Figure 8/I.324 depicts the ISDN user-network reference points as defined in the I.400-series of Recommendations, as well as reference points at which internetwork interfaces between an ISDN and other networks (including other ISDNs) may exist. Whether internetwork interfaces at all of these reference points will be defined by CCITT Recommendations is for further study.



Note – x = 1 indicates that interworking functions exist inside ISDN while x = 2 would indicate no such functions are required inside of ISDN. No assumptions are made regarding interworking functions outside of ISDN. Therefore, irrespective of the value of x, the possibility of interworking functions in the other network, between the networks or a combination of these possibilities are kept open.

Preferred solutions within the framework given above will be indicated in other Recommendations dealing with service/network specific cases of interworking.

The case of N_1 covers the situation when interworking functions are split between the two ISDNs involved.

FIGURE 8/I.324

Reference points for interconnection of customer equipment and networks to an ISDN

Examples of possible interworking situations are given in Figures 9/I.324, 10/I.324 and 11/I.324.

Figure 9/I.324 shows cases where some ISDN services are also provided to subscribers connected to dedicated networks. In these circumstances ISDNs have to interwork with such networks.

Figure 10/I.324 primarily shows cases where a dedicated network is used to carry a given class of ISDN services. As an example, a dedicated packet switched network providing X.25 services to its subscribers could be used to set up ISDN packet connections between two ISDN subscribers. From an ISDN services perspective, this could be viewed as a subset of ISDN.

The dedicated network may be composed of dedicated transmission and switching facilities or be restricted to a set of special nodes linked together via connections, provided through the circuit switched part of the ISDN network, as illustrated in Figure 11/I.324, for the example of a packet switched network.

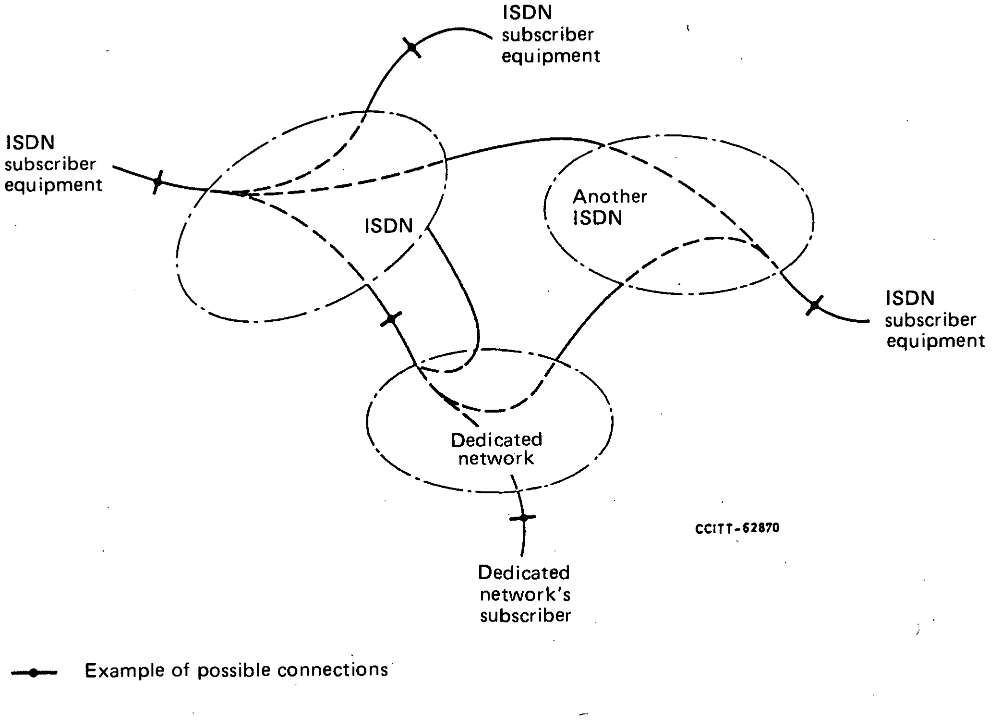
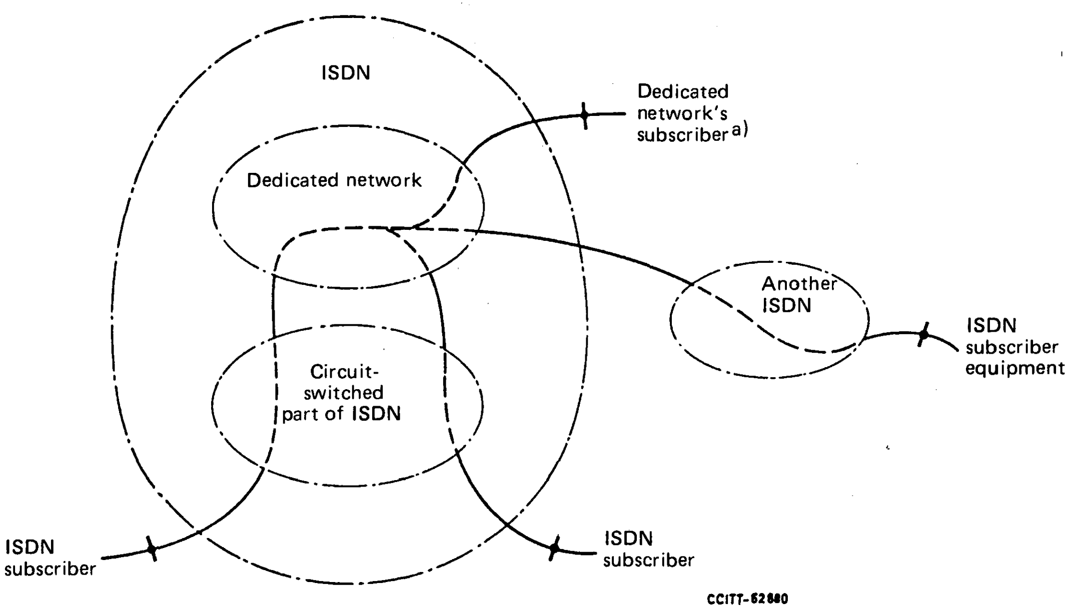


FIGURE 9/I.324

Interworking with a dedicated network



Connection type now provided by the circuit-switched part of ISDN

a) During the interim period, this network could also be a subscriber dedicated network.

FIGURE 10/I.324

Use of a dedicated network for setting up some ISDN connection types

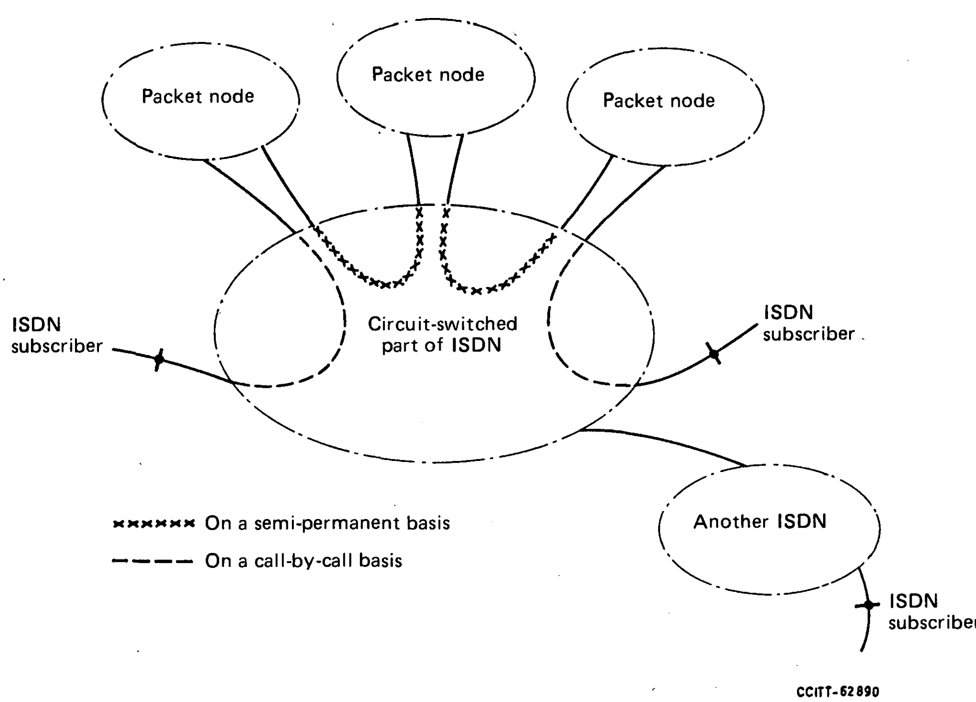


FIGURE 11/I.324

Dedicated logical packet switched network

REFERENCE CONFIGURATIONS FOR ISDN CONNECTION TYPES

(Melbourne, 1988)

1 Summary

In order to apply the network performance parameters to the ISDN, some form of hypothetical reference connections (HRXs) are necessary. These HRXs should be based on appropriate reference configurations for the connection types to which the network performance parameters refer. This Recommendation shows how reference configurations can be developed for the ISDN connection types and what form such reference configurations should take.

2 Introduction

2.1 *Objective*

The general architectural model of the ISDN (see Figure 1/I.325) is given in Recommendation I.324. The detailed network capabilities of the ISDN, as described by connection types in Recommendation I.340, are described topologically by this Recommendation giving reference configurations as appropriate for (an) ISDN connection type(s). These reference configurations do not give details on the number of switching nodes, length of connection, transmission facilities used, etc. However, they do give the details on the reference configuration (or topological configuration) of all matters described by the connection type to which they refer. Therefore they should include details on the signalling, existence of switching functions, channels, etc. Based on these reference configurations, appropriate HRXs should be developed which will be particular to network performance parameters or groups of network performance (NP) parameters. The details on these HRXs will be appropriate for the NP parameters in question.

In order to keep the task of developing reference configurations and the subsequent HRXs, and the allocation of performance values to these HRXs, to manageable proportions, it is necessary to have as limited a set as possible of specific reference configurations. Consequently the ISDN connection types in Recommendation I.340 need to be arranged in different classes which differ significantly from each other such that they require a separate reference configuration model.

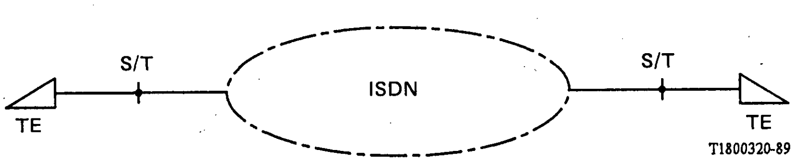


FIGURE 1/I.325

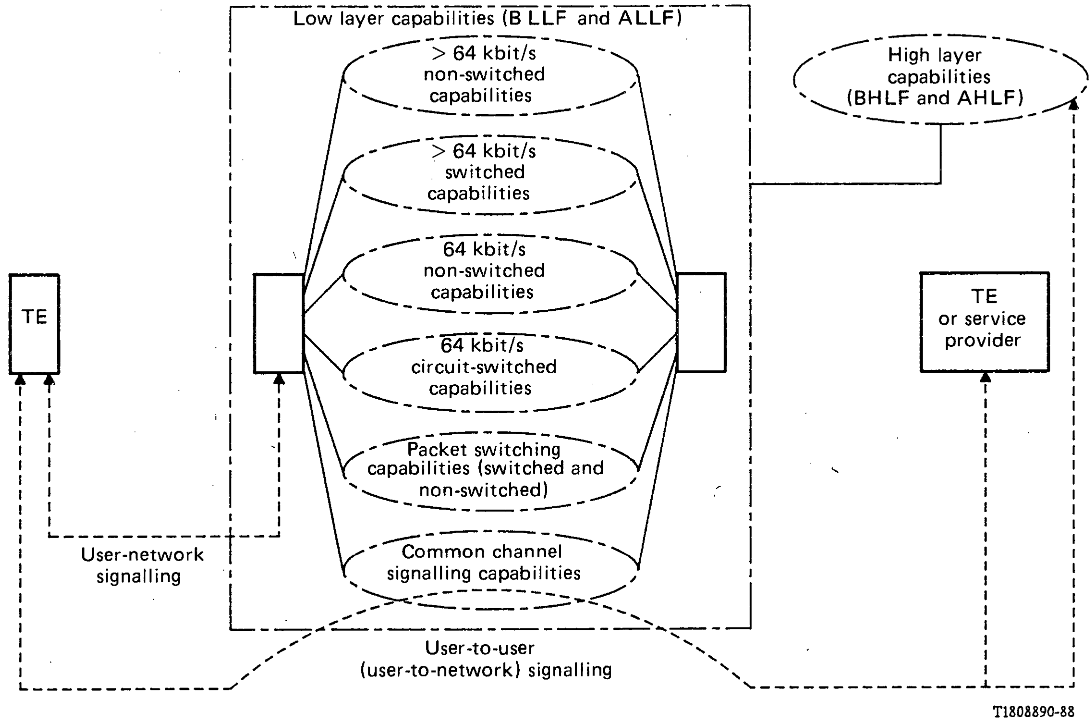
Simple cloud model of the ISDN

2.2 *Relationship to other I-series Recommendations*

The concept of reference configurations has already been used in a number of areas of standardization of the ISDN. It is therefore necessary to consider the concept of connection type reference configurations in the context of these developments.

2.2.1 *ISDN architecturural model*

It should be noted that defining a set of reference configurations presupposes a particular architectural model of an ISDN (see Figure 2/I.325). The architecturural model for the ISDN is contained in Recommendation I.324. In addition, Recommendation I.310 on the ISDN network functional principles, when considered together with Recommendation I.324, gives the general basis of the architecture of the ISDN from which it is possible to develop reference configurations for ISDN connection types.



BLLF Basic low layer functions
ALLF Additional low layer functions
BHLF Basic high layer functions
AHLF Additional high layer functions

FIGURE 2/I.325

Basic architectural model of an ISDN

2.2.2 *ISDN user-network interfaces*

The concept of reference configurations was first used in the ISDN work to describe the topological association of functional groupings at the user-to-network interface points. Recommendation I.411 (ISDN user-network interfaces – Reference configurations) is the complete description of these particular reference configurations. The key factors in the definition of reference configurations in Recommendation I.411 are the concepts of functional groupings and reference points.

2.2.3 *Recommendations X.30 and X.31 (I.461 and I.462)*

Recommendations X.30 and X.32 on the adaption of X.21 and X.25 based DTEs to the ISDN also use the concept of reference configurations to explain the topological configuration of functional groupings involved in these kinds of terminals accessing the ISDN.

3 Development of the concept of reference configurations

3.1 *Definitions*

As can be inferred from Recommendation I.411, a **reference configuration** is defined to be "a conceptual configuration based on association rules of functional groupings and reference points."

3.2 *Principles for developing reference configurations for ISDN connection types*

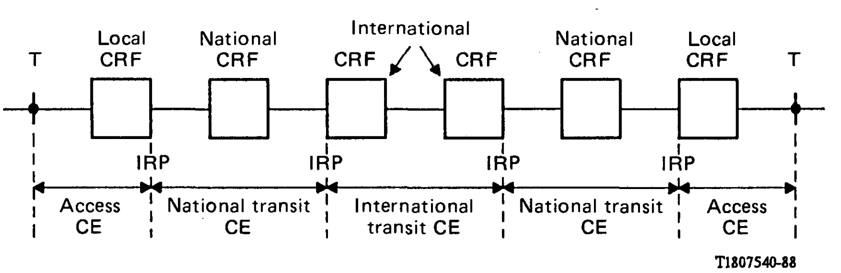
Overall, the concept of the ISDN connection elements, as introduced in Recommendations I.324 and I.340, can be effectively used to demarcate the different sections of the reference configuration. Because of the complicated nature and evolutionary potential of the ISDN, it may not be possible to internationallly specify a detailed end-to-end reference connection (such as Recommendation X.92 for data networks). Consequently a functional approach is adopted to specifying the structure of the ISDN connection types and the associated ISDN reference configurations. In order to keep the number of reference configurations manageable, only a restricted list of connection types and a limited number of models of frequently realized connection topologies are considered.

3.3 *Connection elements*

From the concepts of connection elements introduced in Recommendation I.324 a diagram, as shown in Figure 3/I.325 can be developed which can be considered as the general reference configuration of the ISDN. It is valid for all ISDN connection types. Particular ISDN connections may be local, national transit, international or international transit [i.e. transit switched through intermediate country(ies)]. In each case the appropriate parts of the general reference configuration would be involved.

Recommendation I.324 shows that three types of connection element have been defined (so far):

- access connection element;
- national transit connection element;
- international transit connection element.



IRP Internal reference point
CRF Connection related functions
CE Connection element

FIGURE 3/I.325

Reference configuration of public ISDN connection type

3.4 *Functional groupings*

As stated in the definition in § 3.1 above, in order to define reference configurations, it is necessary to define certain functional groupings and also reference points which are the conceptual points dividing these functional groupings.

In the description of the connection type reference configuration, some of the major functional groupings involved can be considered under the concept of connection related functions (CRF) as described in § 4.2.2.1 of Recommendation I.324. The concept of the CRF includes all the functional groupings involved in establishing and controlling the connections within the particular connection element. In the case of the international transit connection element, two CRFs are shown in Figure 3/I.325 in order to retain the symmetry of the diagram. The specific capabilities of each CRF are not specified in the general reference model, this is done in the reference configuration for each group of connection types. The boundary of the CRF should not be associated with the boundary of an exchange as these may not correspond to each other.

Other functional groupings which are necessary for the complete description of the connection type reference configuration include line termination (LT), digital link, packet handling (PH) function and various functions associated with the signalling network.

3.5 *Reference points*

The other element involved in the description of a reference configuration is the reference point concept. The I-series already identifies reference points S and T (in Recommendation I.411) and K_X, M, N_X and P (in Recommendation I.324). As can be seen from Figure 3/I.325, some further internal reference points need to be identified. Further study is required to see whether these and any further reference points need to be defined.

In describing the reference configuration for the ISDN connection types, an important consideration vis-a-vis the reference points is the following. In Figure 3/I.325, and the following diagrams, the end points of the overall connection is shown as being at the T reference point. The reason for this is as follows. Reference point S is identical to reference point T when the NT2 function is null (cf Recommendation I.411). When the NT2 function is non-zero, then the performance of the overall connection will be made up of the performance of the ISDN network connection (i.e. between the two interfaces at reference point T) and the sum of the performance of the customer network connections (i.e. between the interfaces at reference points S and T at each end). Recommendation G.801 also uses this approach by defining the ends of the digital HRX as being at the T reference point.

4 Specific reference configurations

This general reference model needs now to be associated with specific connection types in order to develop specific reference configurations. However, Recommendation I.340 allows for so many variations in its different attributes, leading to a very large number of potential connection types, that is necessary to consider only certain dominant attributes in order to produce a shorter list of reference configurations. For an initial analysis, only the first two of the four dominant attributes listed in Recommendation I.340 need to be considered. Therefore the "information transfer mode" and "information transfer rate" will lead to three general classes of ISDN connection types, viz:

- circuit:
  - 64 kbit/s,
  - greater than 64 kbit/s (broadband);
- packet.

The other two dominant attributes ("information transfer" and "establishment of connection") do not require separate reference configurations but will manifest themselves by different performance values.

This limited set of connection types is subsequently modelled in the associated reference configurations taking into account a limited number of frequently realized connection topologies.

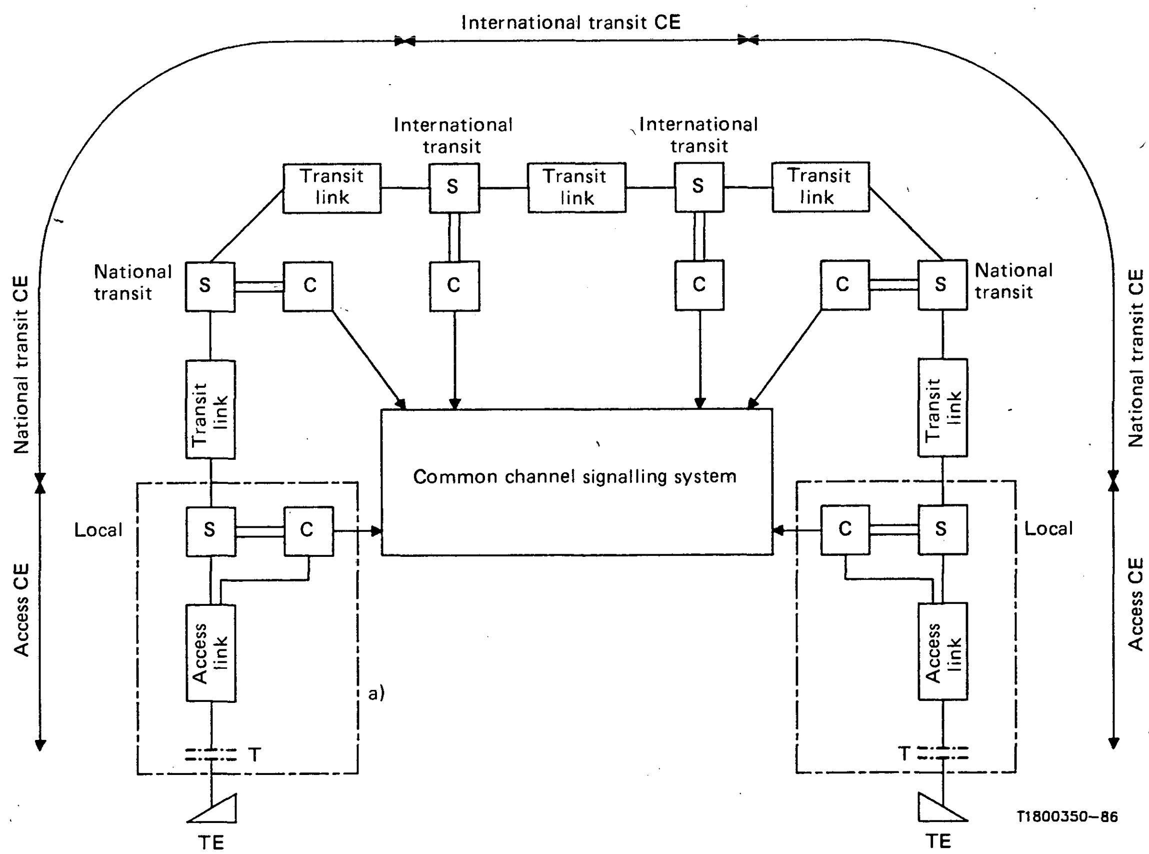
4.1 *64 kbit/s class*

This class includes connection types A1 to A12 of Table 2/I.340, i.e. unrestricted digital, speech and 3.1 kHz audio information transfer susceptances and switched semi-permanent and permanent establishments.

The variation of the information transfer capability is determined by the network performance parameter values allocated to each portion of the connection. For example, use of digital speech interpolation in the international connection element would restrict the connection type to speech or 3.1 kHz audio. Likewise, the differences between permanent connection types and switched connection types would manifest themselves in differences in the value of parameters such as connection establishment time, etc.

This approach means that there is a small number of reference configurations, but that all of the different connection types listed in Recommendation I.340 would need to be tabulated for the allocation of performance values.

Figure 4/I.325 shows the reference configuration that is proposed for this class of ISDN connection types.



S 64 kbit/s circuit switch function

C Signalling handling and exchange control functions

a) See Figure 1/Q.512.

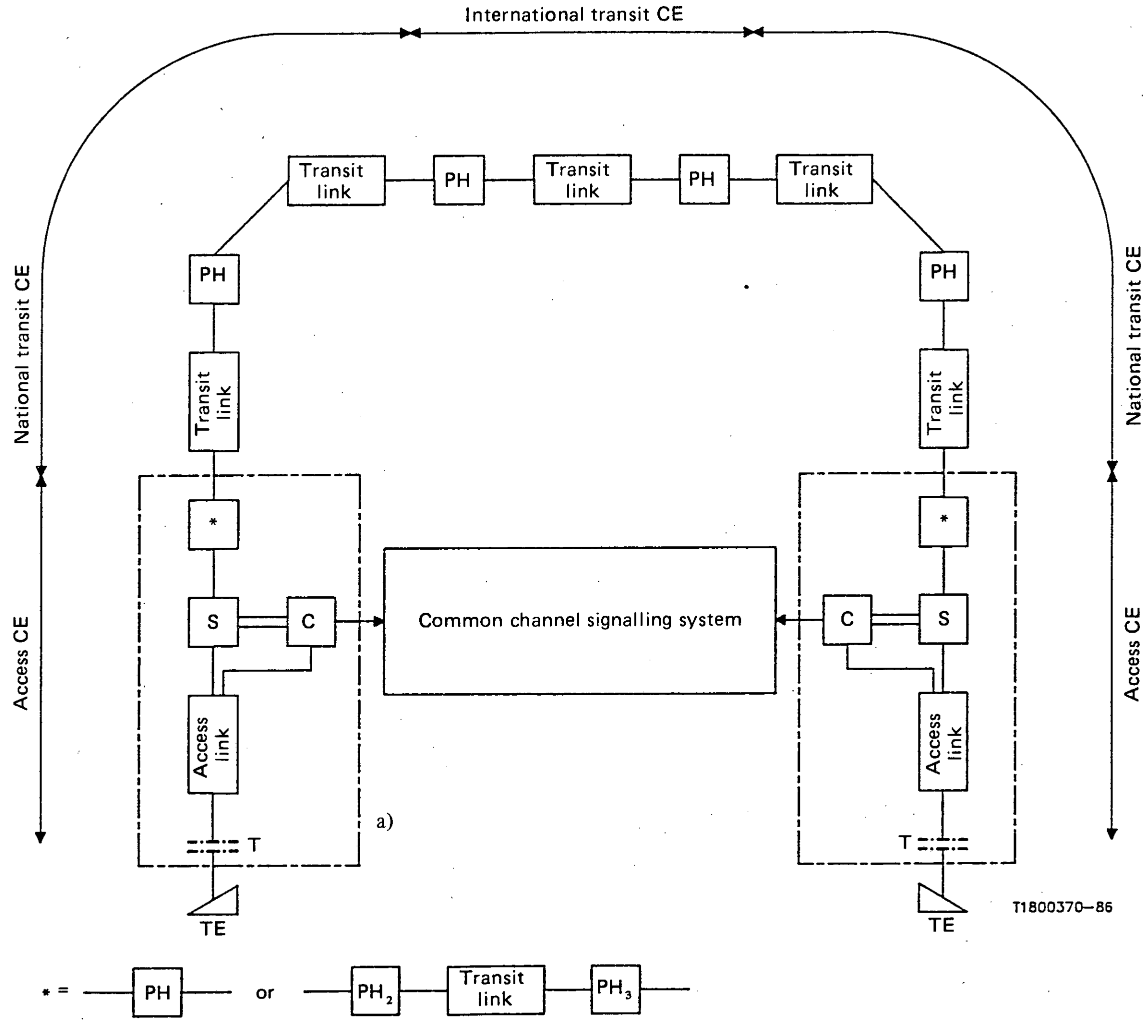
FIGURE 4/I.325

Reference configuration – 64 kbit/s circuit group

4.2 *Packet class*

Recommendation X.31 illustrates the scenarios involved in providing packet switched capability in the ISDN. These are in fact reference configurations for the access connection element. The possible reference configurations for the B-channel access packet mode connection type class are shown in Figures 5/I.325 and 6/I.325.

It should be noted that the Recommendations in the X.130-series also use the concepts of national and international portions of the connection for the purposes of the allocation of the division of network performance parameter values. In those cases the boundary between the national and the international portions is in the middle of the International Data Switching Exchange (IDSE) [or International Switching Centre (ISC)]. Further study is required to see if this approach should be taken in the ISDN.



PH_2 Level 2 packet handler

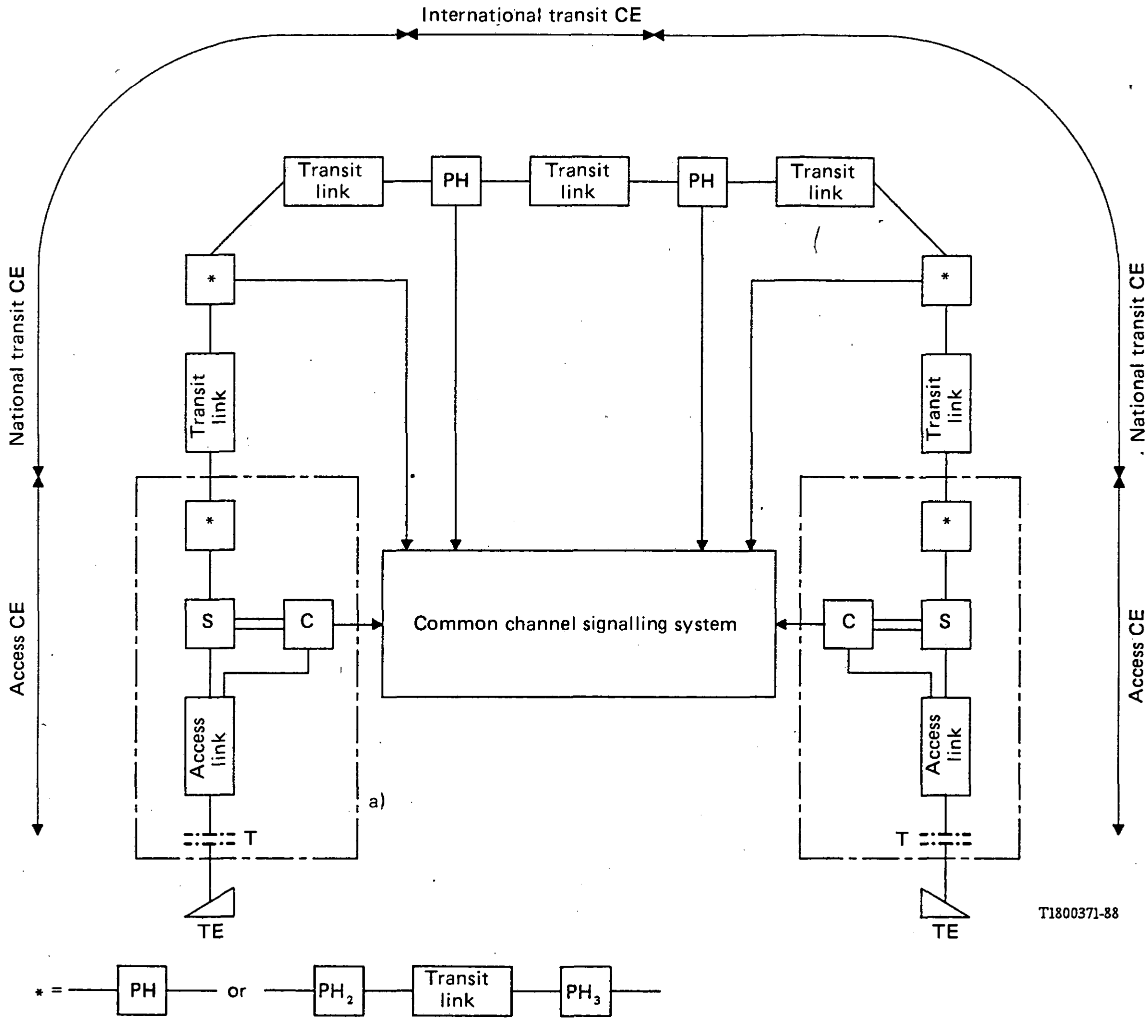
PH_3 Level 3 packet handler

S 64 kbit/s circuit switch function

a) See Figure 2/X.31.

FIGURE 5/I.325

Reference configuration – packet group



PH₂ Level 2 packet handler

PH₃ Level 3 packet handler

S 64 kbit/s circuit switch function

a) See Figure 2/X.31.

FIGURE 6/I.325

Reference configuration – packet group

4.3 *Broadband class*

Further study is required to determine what the salient features of this class of ISDN connection types are. According to Recommendation I.340 it would include permanent and semi-permanent connections at 384, 1536 or 1920 kbit/s.

REFERENCE CONFIGURATION FOR RELATIVE NETWORK RESOURCE REQUIREMENTS

(Melbourne, 1988)

1 General

The purpose of this Recommendation is to evaluate the relative network resource requirements associated with the provision of ISDN telecommunication services to subscribers as they are defined in the I.200-series.

The evaluation of relative network resource requirements and the definition of reference configuration is the first step in cost evaluation for ISDN services. Such cost evaluation is not covered in this Recommendation.

2 Relative resource requirements

2.1 *Relation with service provision*

For each service requested by a user the network has to provide network resources. These network resources involve switching, signalling and transmission capabilities. The selection of the appropriate network resource is part of the routing function.

The combination of permissible network resources is described by the logical concept of ISDN connection types. The list of agreed ISDN connection types can be found in Recommendation I.340.

The network resources described by an ISDN connection type are given in Figure 1/I.326.

The network resource has an overall scope and may imply several subnetworks, each having to provide an appropriate part of the overall network resource.

Network resource	– Switching capability – Transmission capability – Signalling capability

FIGURE 1/I.326

Network resource components

2.2 *Information transfer on network resource usage*

Information on ISDN network resources utilized and on resources utilized of any interworked networks needs to be gathered for charging or for accounting purposes and conveyed to possibly several points within the network(s). Much of this information is likely to be derived from data carried on the signalling network (e.g. information associated with set-up, clear-down, and/or change of status of connections). It may be passed in batch-mode between Administrations or may be conveyed in real-time.

3 Reference configuration for charging

3.1 *Development*

Recommendation I.340 and other relevant Recommendations (I.310, I.324, I.325) are considered as the starting point for the development of the reference configuration for relative cost evaluation.

ISDN resources would be represented by network functions, as for example:

- transmission functions (local, transit) using different techniques (digital, analogue, speech interpolation, etc.);
- switching functions (local, transit) for circuit-mode, packet-mode;
- interworking functions;
- high layer functions.

3.2 *Situations*

Reference configurations should include a description of the various situations encountered in international interconnections. This description should include the originating country, boundary, destination country, interworking unit location, international transit.

3.3 *Reference configuration for circuit-mode*

The reference configuration for circuit-mode ISDN connection types is made of three connection elements:

- access connection element;
- national transit connection element;
- international transit connection element.

The minimum relative resource requirements for international transit connection elements are described in Table 1/I.326.

TABLE 1/I.326

Service request	Possible resources for an international transit connection element	Relative resource requirement [d]
1) 64 kbit/s unrestricted	64 kbit/s	1
2) Speech	64 kbit/s, DSI/LRE gain 5:1 [a] A/μ, echo control [b]	As low as 0.2
3) 3.1 kHz audio	64 kbit/s, LRE gain 2:1 [c] A/μ, echo control [b]	As low as 0.5

[a] State-of-the-art voice processing technology is capable of achieving a circuit gain of up to 5:1 on speech calls by using a combination of digital speech interpolation (DSI) and low rate encoding (LRE) at 32 kbit/s. Even higher gains are conceivable in the future with advances in LRE technology.

[b] The need for echo control in end-to-end ISDN connections is under study.

[c] ISDN services when used to support voice-band data via modems cannot benefit from DSI gains.

[d] The values mentioned in the third column represent relative resource requirements (i.e. traffic allowed in terms of bit rate or bandwidth) and should not be interpreted as cost evaluation.

3.4 *Reference configuration for packet-mode*

For further study.

3.5 *Reference configuration for high layer functions (HLF)*

For further study.

3.6 *Reference configuration for additional low layer functions (ALLF)*

For further study.

3.7 *Reference configuration for public land mobile telecommunication services*

Reference configuration for public land mobile telecommunication systems can be found in Recommendation D.93.

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SECTION 3

NUMBERING, ADDRESSING AND ROUTING

Recommendation I.330

ISDN NUMBERING AND ADDRESSING PRINCIPLES

(Malaga-Torremolinos, 1984; amended at Melbourne 1988)

1 Introduction

1.1 This Recommendation provides the general concepts, principles, and requirements for addressing reference points located at subscriber premises, for addressing other functions, and for allowing communications with terminals.

1.2 Recommendation I.331 (E.164) describes the numbering plan for the ISDN era. Closely related information is contained in Recommendation I.332 on numbering principles for interworking between ISDNs and dedicated networks with different numbering plans. Recommendation I.333 on terminal selection and Recommendation I.334 on principles relating ISDN numbers/subaddresses to the OSI reference model network layer addresses represent additional sources of information having direct application to Recommendation I.330.

1.3 The following understanding of relevant nomenclature is established:

a) an ISDN number is one which relates to an ISDN network and ISDN numbering plan;

b) an ISDN address comprises the ISDN number and the mandatory and/or optional additional addressing information;

c) private communications facilities are communication capabilities confined to use by one or more particular subscribers, as opposed to facilities which are shared by subscribers of public networks. Examples of private communications facilities include local area networks (LANs), PABXs, and other private network arrangements.

1.4 Depending on the different cases and stages identifiable within an addressing process, an ISDN number may be (see Figure 10/I.330):

a) an international ISDN number;

b) a national ISDN number;

c) an ISDN subscriber number.

An ISDN address comprises:

i) the ISDN number;

ii) mandatory and/or optional additional addressing information.

1.5 As an objective, all ISDNs should evolve towards a single numbering plan, namely the ISDN numbering plan. Considering the wide penetration of the telephone network in the world and existing telephone network resources, the ISDN numbering plan has been developed by building from Recommendation E.163. Therefore, it is recommended that the telephone country code (TCC) be used to identify a particular country.[1)]

1.6 An existing numbering plan may interwork and thus co-exist with the ISDN numbering plan. A framework for interworking between an ISDN and existing numbering plans is given in Recommendation I.332. Recommendations E.166 and X.122 provide information describing selected interworking situations which have been considered by appropriate Study Groups. Preference should be given to single stage selection methods whenever possible.

1.6.1 It is recognized that some of the present data networks, for instance, could retain the X.121 numbering structure and interwork with ISDNs. A critical element of such interworking is numbering plan identification. Two approaches have been recommended:

1) the escape code method, now recognized within the format structures of Recommendations E.164 and X.121;

2) the NPI (Numbering Plan Identifier) method which applies distinct protocol provisions to distinguish numbering plan identity from address content.

Method 1) is intended for near-term applications while method 2) may be applied to both near-term and long-term interworking, with a view to general use of method 2) after year-end 1996.

1.6.2 It should be understood that call routing at each switching system is guided by reference to a destination numbering plan which is identified by either method 1) or method 2), not both. Method 1) interprets numbers in terms of the numbering plan incorporated into the basic operation of the switching system, unless incoming circuit class logic or an escape code explicitly overrides that interpretation, substituting a different numbering plan. Under method 2) an explicit numbering plan identifier is presented on each call.

1.6.3 When transmission of the calling party's number is appropriate, the numbering plan of the calling party is established in a comparable manner. For a given direction of transmission, either method 1) is used for both called and calling numbers or method 2) is applied in both cases.

1.6.4 After a switching system selects an outgoing route, the logical needs of the next switching system must be considered. Interworking between numbering plans may occur. The method used to inform the subsequent switch about applicable numbering plans may need to be adjusted, but numbering content should not be altered. Preference should be given to method 2) when it is practicable to introduce it since method 1) places constraints on maximum number length in some circumstances.

2 Principles for relating an ISDN number to ISDN user-network reference configurations

2.1 An ISDN number shall be able unambiguously to identify (a) particular:

a) physical interface at reference point T (see Figure 1/I.330);

b) virtual interface at reference point T; i.e., for an NT2 + NT1 configuration (see Figure 2/I.330);

c) multiple interfaces (physical or virtual) at reference point T (see Figure 3/I.330);

d) for point-to-point configurations, physical interface at reference point S (see Figure 4/I.330);

[1)] Country or geographical area.

e) for point-to-point configurations, virtual interface at reference point S (see Figure 5/I.330);

f) for point-to-point configurations, multiple interfaces (physical or virtual) at reference point S (see Figure 6/I.330);

g) for multi-point configurations (e.g. passive bus), all of the interfaces at reference point S (see Figure 7/I.330).

As a result, from the viewpoint of the network side of the interface, an ISDN number is associated with one (or a multiple of) D-channels used to signal to the user.

2.2 A particular interface, or multiple of interfaces, may be assigned more than one ISDN number. An example is shown in Figure 8/I.330.

2.3 All ISDNs shall be able to assign an ISDN number to an interface at reference point T or S. However, a particular ISDN number fulfills only one of the functions identified in § 2.1.

2.4 For mobile services an ISDN number shall be capable of unambiguously identifying an interface in the mobile subscriber's premises, as defined in § 2.1 (see Figure 9/I.330).

2.5 The ISDN number is not required to identify a particular connection where, on a particular interface, more than one connection may be present at a given instant.

2.6 The ISDN number is not required to identify directly a particular channel, where, within a particular interface, there may be more than one channel. Indirect identification of particular channels may occur: e.g. when the ISDN number identifies a particular interface and there is a one-to-one correspondence between that interface and particular channels.

3 Relationships between ISDN number, transit network/RPOA selection (when permitted), service indication, and quality of service indication

The establishment of an ISDN connection will require an ISDN address. In addition separate non-address related information may be necessary for completing a connection.

3.1 Routing of ISDN connections shall take into account the following information, when supplied by the user:

a) ISDN numbers, including destination network identification and digits for direct dialling-in (DDI) where applicable;

b) service identification, possibly including requested quality of service parameters such as transit delay, throughput, and security;

c) multiple transit RPOA/network selection, when permitted by the originating ISDN.

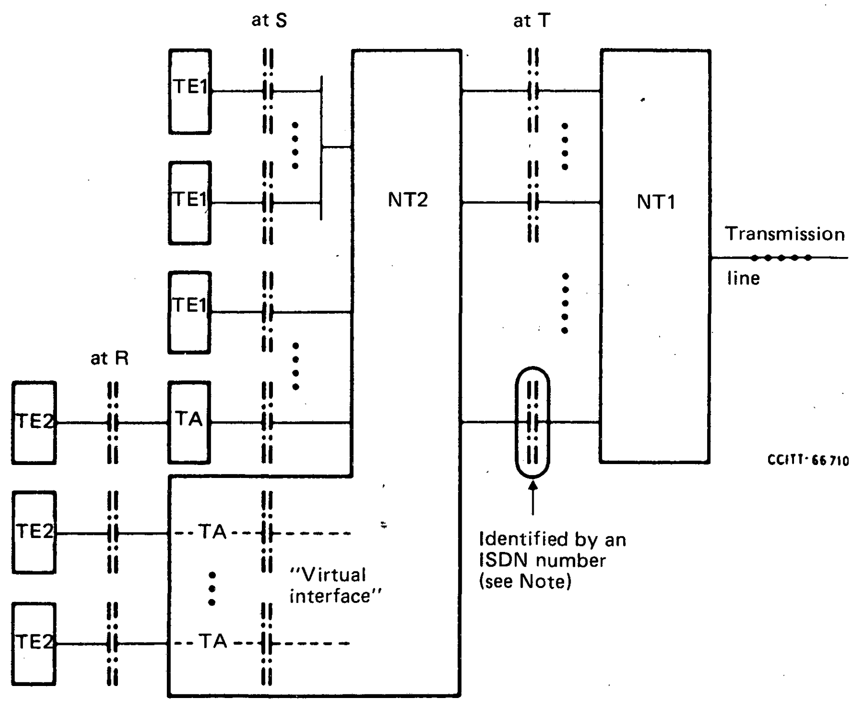
Note – The need for remote transit RPOA/network selection by the user of an ISDN which has no local transit RPOA/network selection is for further study.

In addition, transit RPOA/network selections by the originating ISDN, if provided, shall also be evaluated in the routing of a connection.

In national networks on a particular connection, the user may choose to specify some or all of this information, at either subscription time or connection-establishment time.

The ISDN number does not identify the particular nature of the service, type of connection, or quality of service to be used, nor does it identify a transit RPOA/network.

3.2 In the case where an ISDN number identifies a mobile TE or a TE served by several interfaces or networks, an ISDN may need to map from the ISDN number on to a specific interface designation.



Note – Example case corresponding to Figures 1/I.330 and 3/I.330: The interface at reference point T identified by an ISDN number as shown in Figure 1/I.330 could correspond to a high speed channel and service (e.g. for a video application) and the controlling D-channel, while the remaining interfaces at reference point T as shown in Figure 3/I.330 could correspond to e.g. primary rate interfaces used for B-channels and the corresponding D-channel. In this example, the switching and signalling of the high speed channel would be completely separate from the switching and signalling for the separate primary rate interface channels. The commonality shown in these figures is that these two sets of signals are multiplexed together on the transmission line, e.g. by layer 1 multiplexing in the NT1. Thus it is appropriate for separate ISDN numbers to be assigned to these two sets of interfaces at reference point T.

FIGURE 1/I.330

Example of an ISDN number identifying a particular interface at reference point T

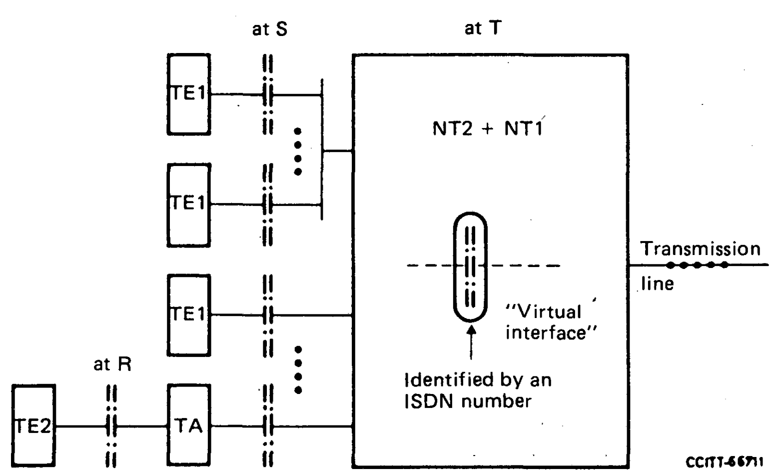


FIGURE 2/I.330

Example of an ISDN number identifying a particular "virtual interface" at reference point T

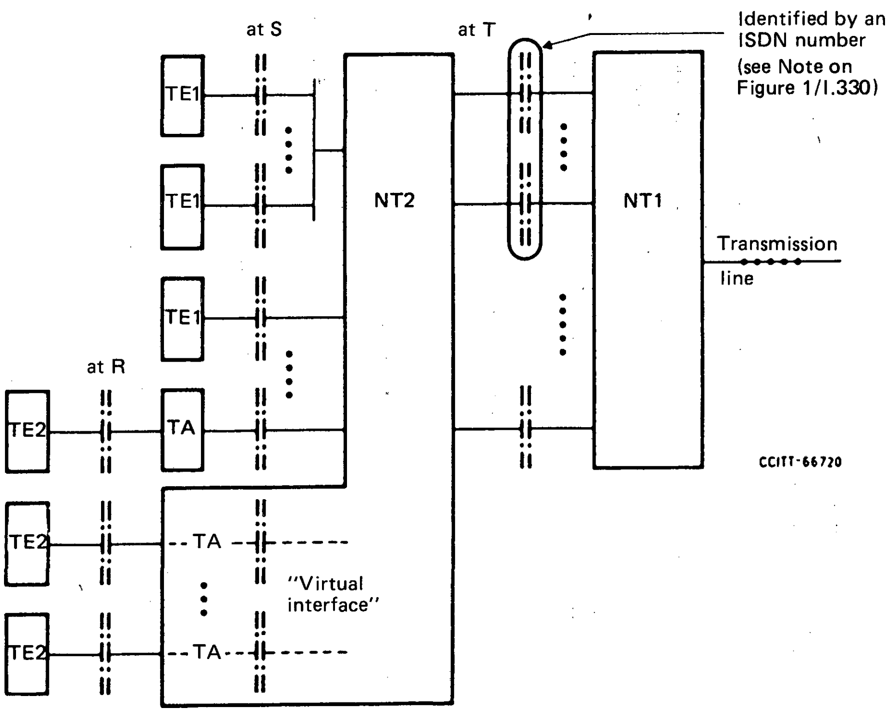


FIGURE 3/I.330

Example of an ISDN number identifying a particular multiple of interfaces at reference point

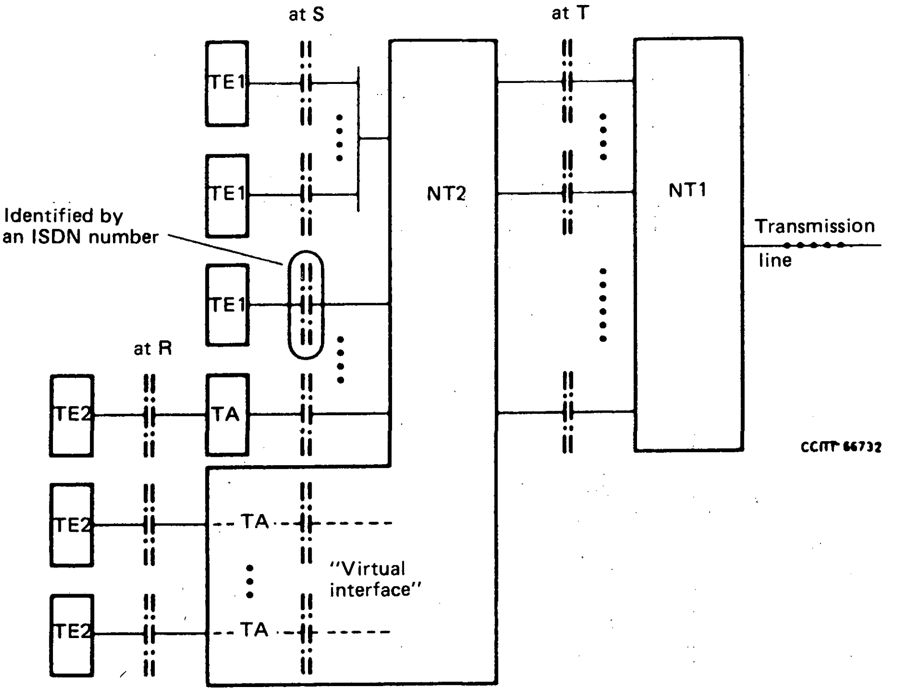


FIGURE 4/I.330

Example of DDI using an ISDN number identifying a particular physical interface at reference point S in a point-to-point configuration

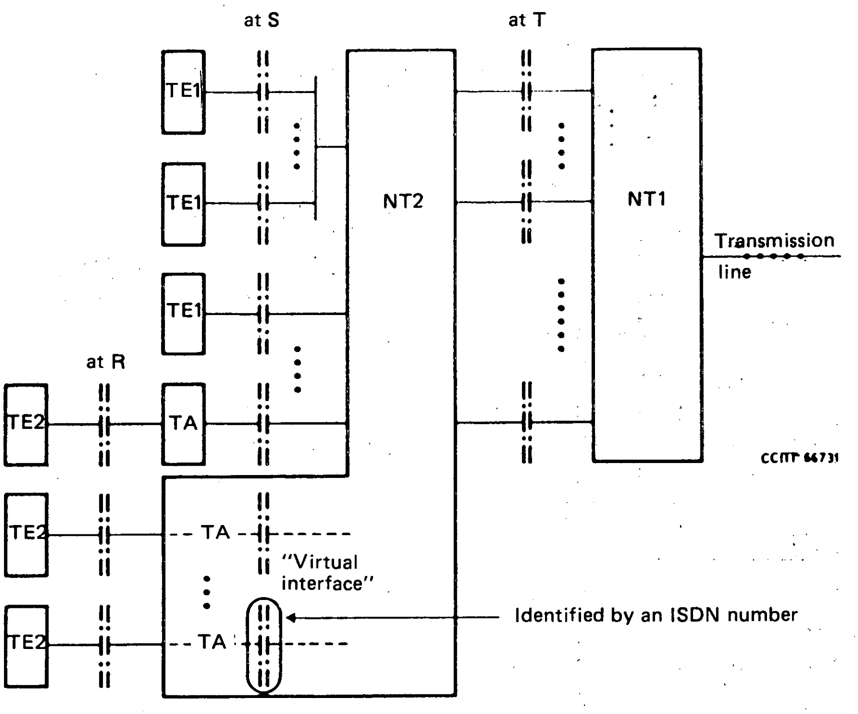


FIGURE 5/I.330

Example of DDI using an ISDN number identifying a particular "virtual interface" at reference point S

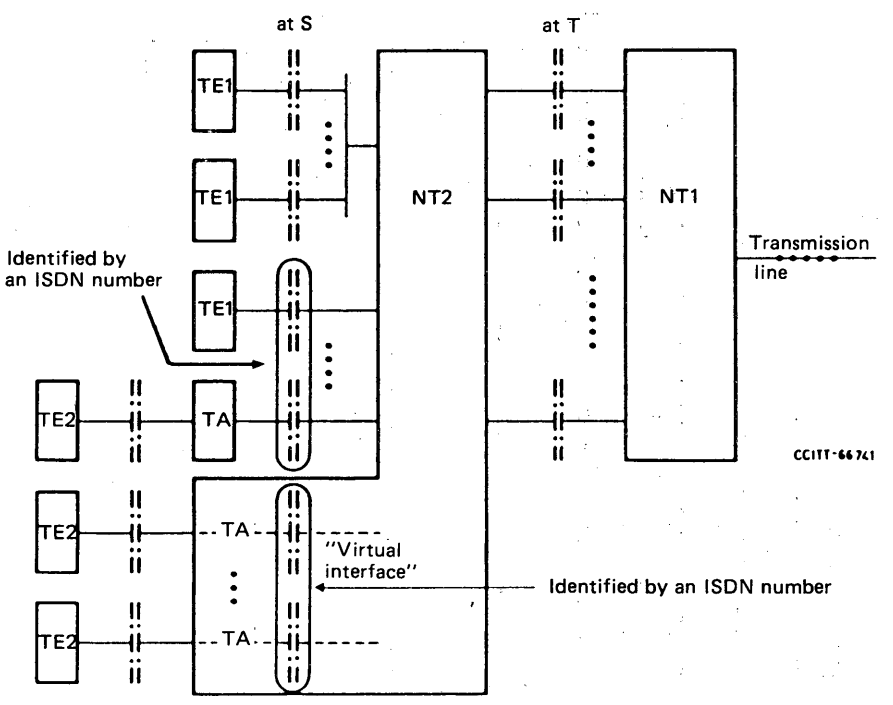


FIGURE 6/I.330

Example of DDI using ISDN numbers, each identifying a particular multiple of interfaces at reference point S in a point-to-point configuration

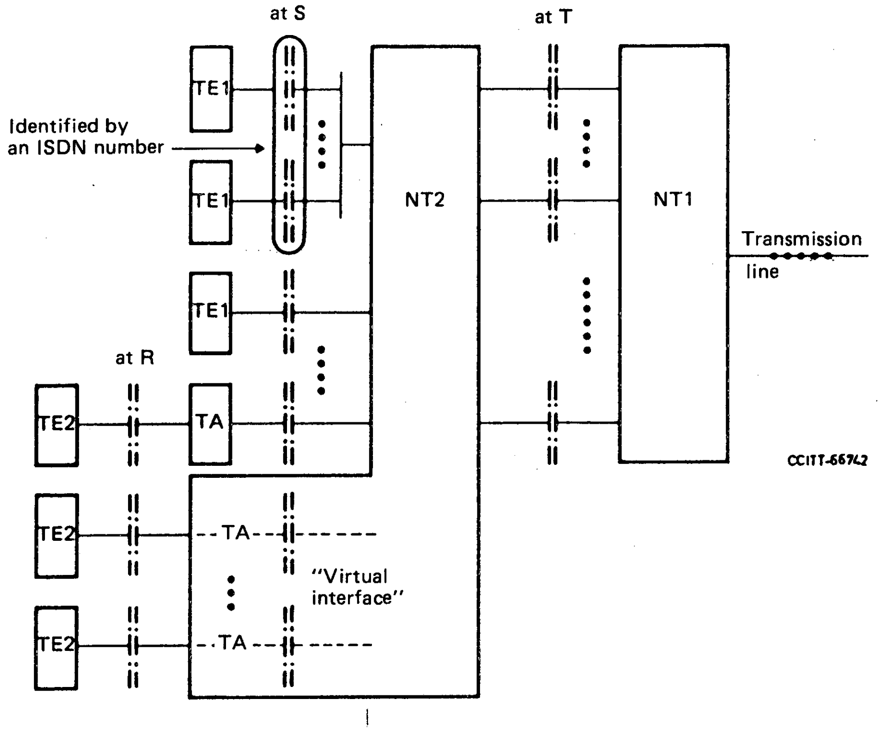


FIGURE 7/I.330

Example of DDI using an ISDN number identifying all of the interfaces at reference point S in a multipoint configuration

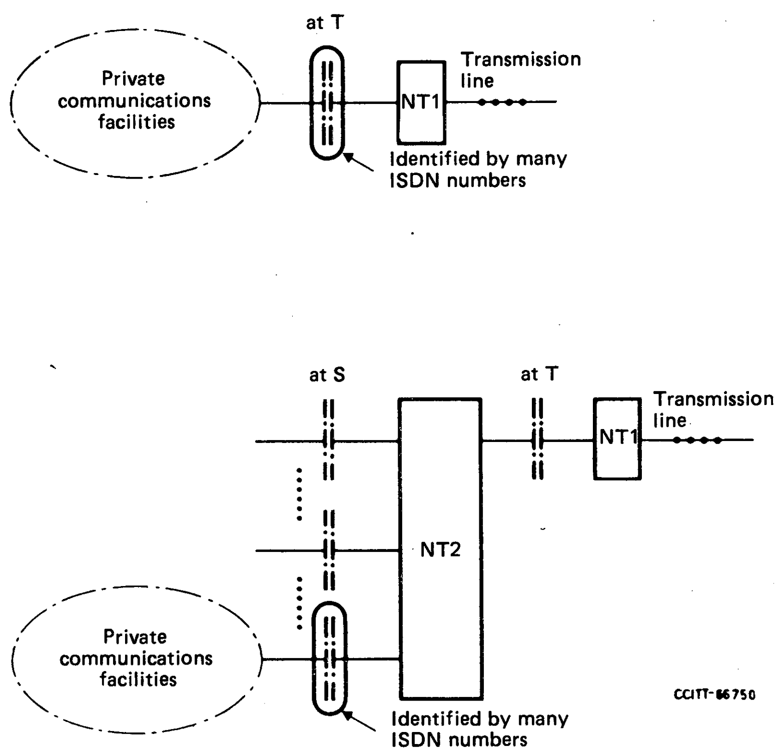


FIGURE 8/I.330

Examples of an interface identified by many ISDN numbers

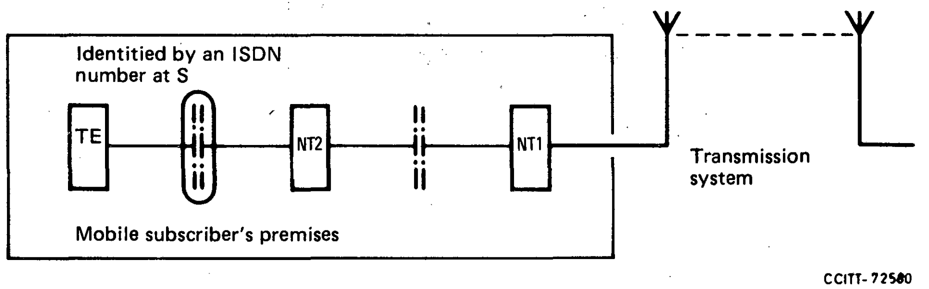


FIGURE 9/I.330

Example of an ISDN number identifying a mobile TE

4 ISDN number design considerations

4.1 Numbering plan design information is covered by Recommendation I.331 (E.164).

4.2 The ISDN number shall include an unambiguous identification of a particular country[2].

The ISDN number is allowed to include an unambiguous identification of a particular geographic area within a country[2].

4.3 As an objective, all ISDNs should evolve towards a single numbering plan. However, an existing numbering plan may interwork and thus coexist with the ISDN numbering plan.

4.4 When a number of public or private ISDNs exist in a country[2], it shall not be mandatory to integrate the numbering plans of the ISDNs. Methods for interworking are for further study, with the objective that connections between the TEs on these various networks can be completed by using only the ISDN address. See also Recommendatin I.332.

4.5 The ISDN number shall be capable of containing an identification of the ISDN to which the called user is attached. For a private network which spans more than one country[2], the international ISDN number will cause delivery of a call to the particular private network in the country specified by the country code.

4.6 The ISDN number shall be capable of providing for interworking of TEs on ISDNs with "TEs" on other networks. As an objective, with respect to the ISDN number, the procedure for interworking should be the same for all cases. The single-stage method of interworking is the preferred approach.

5 Structure of the ISDN address

5.1 The structure of the ISDN address is illustrated in Figure 10/I.330. A function marking the end of the ISDN number shall always be provided if a subaddress is present. The end of number function may also be provided even if no subaddress is present. When there is no subaddress present, the end of number and end of address functions are coincident, when used.

[2] Country or geographical area.

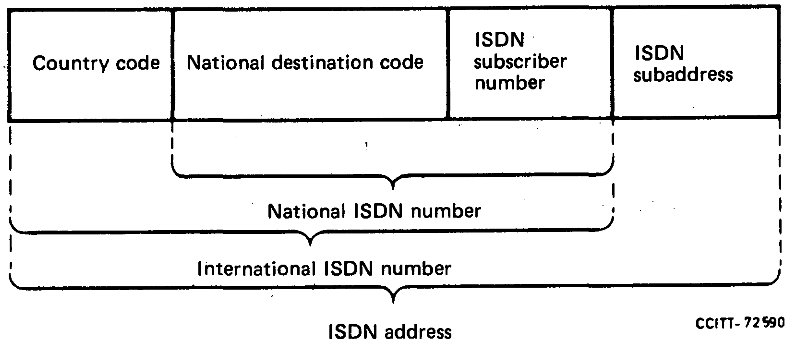


FIGURE 10/I.330

Structure of the ISDN address

5.2 The ISDN address may be of variable length.

5.3 *International ISDN number*

5.3.1 The structure of the international number and the maximum number length are as defined in Recommendation I.331 (E.164).

5.3.2 In a particular international ISDN number, the exact number of digits shall be governed by national and international requirements.

5.3.3 The ISDN numbering plan shall provide substantial spare capacity to accommodate future requirements.

5.3.4 The ISDN number shall be a sequence of decimal digits.

5.3.5 The ISDN number shall include the capability for direct dialling inward where this facility is offered.

5.4 *ISDN subaddress*

5.4.1 The subaddress is a sequence of digits, the maximum length of which shall be 20 octets (40 digits).

5.4.2 All ISDNs shall be capable of conveying the ISDN subaddress transparently and shall not be required to examine or operate on any of the subaddress information.

5.4.3 Special attention is drawn to the fact that subaddressing is not to be considered as part of the numbering plan, but constitutes an intrinsic part of ISDN addressing capabilities. The subaddress shall be conveyed in a transparent way as a separate entity from both ISDN number and user-to-user information. See also Recommendation I.334.

6 Representation of ISDN address

6.1 At the person-machine interface, the objective is to establish one method of distinguishing between abbreviated and complete representations of an ISDN number. This method is for further study. Internationally recommended methods will be chosen.

6.2 The method of distinguishing between an ISDN number and a number from another numbering plan shall be by separate identification of the applicable numbering plan. If such methods are required, internationally recommended procedures will be chosen.

Recommendation I.331

NUMBERING PLAN FOR THE ISDN AREA

(Malaga-Torremolinos, 1984; amended at Melbourne, 1988)

See Recommendation E.164, Volume II, Fascicle II.2.

Recommendation I.332

NUMBERING PRINCIPLES FOR INTERWORKING BETWEEN ISDNs AND DEDICATED NETWORKS WITH DIFFERENT NUMBERING PLANS

(Melbourne, 1988)

1 Introduction

Different public networks currently make use of different numbering plans. Single-stage interworking between ISDNs and dedicated networks as recommended in Recommendation I.330 requires adoption of solutions which make it possible to convey the addressing needs from one network to another.

This Recommendation represents a framework by which progress on numbering plan interworking within the various CCITT Study Groups may be coordinated. Detailed recommendations for numbering plan interworking are contained in Recommendations E.166 and X.122.

The ISDN international number exceeds the addressing capability of present dedicated public networks. Therefore, these networks may not be able to reach subscribers' terminals connected to an ISDN if these terminals make use of the 15 digits allowed in ISDN.

In order to support numbering plan interworking between ISDNs and present dedicated networks, procedures have to be identified which offer single-stage interworking solutions for the near term, while recognizing that other solutions supporting the 15 digits capability of the ISDN number will have to be supported in the future.

One of the major objectives of introducing the concept of Time *T* (given in Recommendation E.165), is to provide a target date by which the long-term numbering plan interworking solutions will be in place.

2 Principles for Time T

ISDNs are expected to interwork with dedicated networks. However, due to the different addressing capabilities between the ISDN and existing numbering plans some temporary constraints need to be imposed on the number length and digit analysis required to access the user network interfaces of the ISDNs, before Time *T*.

2.1 *Numbering constraints before Time T*

2.1.1 *ISDNs interworking with dedicated networks*

To allow numbering plan interworking with dedicated networks before Time *T*, an ISDN will not assign international E.164 (I.331) numbers longer than 12 digits to its user network interfaces capable of receiving calls from dedicated networks.

2.1.2 *ISDNs which do not interwork with dedicated networks*

These ISDNs are allowed to assign numbers to user network interfaces according to the full capability of the numbering plan for the ISDN era.

2.2 *Evolution after Time T*

After Time *T*, ISDNs and PSTNs can make use of the full capability of E.164 numbers to identify their user network interfaces and terminals respectively.

2.3 *Evolution up to Time T*

Between now and Time *T*, any new network or user equipment, in ISDNs, or networks intending to interwork with ISDNs, should be installed with the identified relevant post-*T* capability(ies).

3 Single-stage interworking between ISDNs and dedicated networks

3.1 Numbering plan interworking procedures for short-term and for long-term will be required between:

i) ISDN (E.164) to/from PSPDN (X.121)

ii) ISDN (E.164) to/from CSPDN (X.121)

Note – Requirements for Telex (F.69) are included in Recommendation U.202.

3.2 The recommended long-term numbering plan interworking solution is based on the NPI/TON field in the ISDN call set-up message.[1] The NPI elements is the numbering plan identifier (e.g. Recommendations E.164/E.163, X.121, F.69), whereas the TON indicates the type of number (e.g. local, national, international). This NPI/TON field will be carried as part of the call set-up message to the originating exchange, which will use this information to route the call. The NPI element will also be available within the network as part of the Initial Address Message in Recommendation Q.763.

An equivalent NPI/TON feature in Recommendations X.25/X.75 will also be available to support long-term numbering plan interworking between ISDNs and PSPDNs, employing X.31 procedures.

3.3 The short-term, single-stage interworking arrangements will use prefixes and escape codes to indicate the type of number and the numbering plan of the destination network, respectively. Definitions of prefixes and escape codes are provided in Annex A. As indicated in Annex A, prefixes are not part of the number and are not signalled over internetwork or international boundaries to that they are not subject to international standards. Escape codes however, may be carried forward through the originating network and across internetwork and international boundaries Therefore, the values of escape codes need to be standardized.

Note – The details on short-term interworking using escape codes are included in Recommendations E.166 and X.122.

3.4 Table 1/I.332 illustrates numbering considerations for single-stage interworking using the example of interworking between an ISDN and PDN.

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[1] As defined in Recommendation I.451 (Q.931).

3.5 *Principles for consistent interworking*

When considering Table 1/I.332, the following points should be taken into account:

1) It should be noted that X.25 procedures (containing E.164 numbers) may be used on ISDN subscriber-to-ISDN subscriber calls where no PDN is used. The choice of method for X.25/X.75 should allow this application.
2) During the interim period (pre-*T*), ISDN interfaces not interworking with any existing dedicated networks may be assigned E.164 numbers up to 15 digits in length. (Other ISDN subscribers would be assigned E.164 numbers according to Table 1/I.332).
3) The treatment of various addresses during call interworking, as outlined in Table 1/I.332, should apply to all kinds of addresses, e.g. calling party, redirecting, etc.

TABLE 1/I.332

Accommodation of numbers during ISDN/PDN interworking

Call type	Man machine selection	User-network interface	Gatenay between networks
ISDN to PDN	Terminal specific	*Interim* Recs. E.166 and X.122 or long-term solution *By time T* Numbering plan = Rec. X.121 Number = DNIC (DCC + NN) + NTN Type of number: international (DNIC present), national (DNIC omitted), or network specific	*Interim* Recs. E.166 and X.122 or long-term solution *By time T* Numbering plan = Rec. X.121 Number = DNIC (DCC + NN) + NTN Type of number: international (DNIC present), national (DNIC omitted), or network specific
PDN to ISDN	e.g. Request for PAD PAD/DTE implementation specific for support of user-network interface	e.g Recs. X.25/X.31, X.21/X.30 *Interim* Modified X-Series to support Rec. I.330 principles Numbering plan = Rec. E.164 (CC + NDC + SN) $\leq$ 12 digits *By time T* Modified Recs. X.25 and I.451 to support long-term interworking solution Numbering plan = Rec. E.164 (CC + NDC + SN) $\leq$ 15 digits	e.g Recs. X.75, X.71 *Interim* Modified X-Series to support Rec. I.330 principles Numbering plan = Rec. E.164 (CC + NDC + SN) $\leq$ 12 digits *By time T* Modified Recs. X.25, X.75 and Q.763 to support long-term interworking solution Numbering plan = Rec. E.164 (CC + NDC + SN) $\leq$ 15 digits

CC Country code
SN Subscriber number
DCC Data country code
NTN Network terminal number
NDC National destination code
DNIC Data network identification code
NN National number

Note 1 – Numbering plan interworking between ISDNs and between ISDN and PSTN is not required since a common numbering plan is used.

Note 2 – Other solutions at particular interfaces may *also* be supported by some networks. Such solutions should not conflict with the use of the indicated method. The method indicated should be supported by all networks.

4 Requirements by Time T

4.1 By Time *T* the numbering plan identifier and type of number (NPI/TON)[2)] capability should be exploited for calls within the ISDN and between ISDN and a dedicated network (e.g. PSPDN[3)] in the following cases:

i) NPI/TON must be used across internetwork and international boundaries where Signalling System No. 7 ISUP is used;

ii) the NPI/TON equivalent feature in the X.25 packet layer must be used when interworking from ISDN to a PSPDN employing X.31 procedures. (Reference Table 1/I.332)

4.2 Where ISDN is provided such that there is a mixture of PSTN and ISDN customers and traffic on a local exchange, the manner in which NPI/TON is used in the network is at the discretion of the Administration, taking due account of prevailing commercial, technical and regulatory considerations. Although Time *T* is not directly relevant to this decision, networks not fully exploiting the NPI/TON capability after *T* shall place no burden on those that do.

4.3 In those parts of a PSTN where inter-exchange signalling is other than Signalling System No. 7 ISUP, prefixes/escape digits may have to continue to be used.

ANNEX A

(to Recommendation I.332)

Prefixes and escape codes for numbering plan interworking

A.1. *Prefix*

The prefix is an indicator consisting of one or more digits, allowing the selection of different types of address formats (e.g. local, national, or international address formats), transit network and/or service selection. Prefixes are not part of the number and are not signalled over internetwork or international boundaries.

Note – When prefixes are used, they are always entered by the user or automatic calling equipment.

A.2 *Escape code*

An escape code is an indicator consisting of one or more digits. The indicator is defined in a given numbering plan, and is used to indicate that the following digits are a number from a different numbering plan. Escape codes are currently established within the X.121 and E.164 numbering plans.

An escape code may be carried forward through the originating network and can be carried across internetwork and international boundaries. Therefore, the digits for escape codes should be standardized.

Note – There may be cases when a standardized escape code may be numerically equal to a prefix already in use in the network. In this case a different digit (special prefix) other than the standardized escape code may be used, and the translation from the "special prefix" to the standardized escape code is performed by the network.

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2) As defined in Recommendation I.451 (Q.931).

3) Introduction of NPI may take place prior to Time *T*, provided that no burden is placed on networks not supporting the NPI when interworking unless bilaterally agreed.

TERMINAL SELECTION IN ISDN

(Melbourne, 1988)

1 Introduction

This Recommendation defines "terminal selection" as the procedures carried out between a terminating ISDN exchange and ISDN terminal equipment situated behind an ISDN interface leading to customer premises whereby terminal response equivalent to answer or rejection is solicited. The procedures apply to both point-to-point and point-to-multipoint terminal operations.

Note that in case of an existing terminal (TE2) connected via a terminal adaptor (TA) to an ISDN access, the combination of TA and TE2 is seen as to provide the same functionality as a TE1. As there should be no modifications to the existing terminal, the functions described are provided by the terminal adaptor.

Note – In the context of this Recommendation "terminal" is an abstract term and does not constrain the implementation of physical terminals which may consist of one or more logical terminals.

1.1 *Terminal selection responsibilities*

The network responsibility is to deliver a call to the interface identified by the called number using connection types consistent with the service requested by the calling party. It is the responsibility of the called party to arrange the terminals on the interface so that incoming calls properly originated are accepted only by the appropriate terminal(s). The network may provide additional functions to aid in the completion of calls from dedicated networks. The network may provide additional services to ensure that calls are completed only to terminals consistent with information provided by the caller. It is the responsibility of the terminal manufacturer and/or service provider to provide terminals that use the terminal selection data in a way that is consistent with the intended application of the terminal, (e.g. for telematic terminals according to Recommendation T.90).

The calling party agrees, when placing a call, to accept the terminating capabilities provided by the called party. The terminating exchange has a cooperative role with the terminal in establishing an information transfer which lends itself to the required terminal selection needs for a given interface.

1.2 *Identification requirements*

An ISDN number identifies any of the interfaces at reference point S (Recommendation I.330, § 2.1). Additional identifiers or terminal selection functions are therefore needed in those cases where the number is insufficient to make needed distinctions among terminals. This Recommendation addresses the general principles to be applied in identifying:

1) specific individual terminals or
2) groups of terminals among which no further distinction is required by the terminating user.

   Specific sequences in which identifying information is applied are not specified.

1.3 *General operations*

While specific selection sequences for the application of terminal identifiers are not required, the ISDN number is a fundamental discriminator. The whole network – including the terminating exchange – relies heavily on this resource. The bearer capability must also be given a high status since its transfer across the interface is mandatory with every call request. Other information potentially useful in the selection process is given in § 4. An originator of a call is generally not required to provide any of the other information in every call. Exceptions for telematic terminals are listed in Recommendation T.90.

If terminal selection is to be successful in establishing a connection between the calling and the called terminal in a prescribed manner, the calling terminal should conform to the reasonable expectations of the called subscriber's terminal arrangement. A calling subscriber who does not conform to the expectations of the called subscriber's terminal arrangement is inviting an irregularity. The terminating subscriber has a corresponding obligation to provide a means for needed discrimination among terminals. It should be noted that information expected at a called subscriber's terminal configuration may not, in all cases, be provided by the calling subscriber, (for example, interworking with a non-ISDN).

The point-to-multipoint operation tends to be emphasized in subsequent text because distinctions in this mode of operation require some terminal selection functions. Nevertheless, the treatment of both point-to-point and point-to-multipoint selection procedures are considered appropriate for this Recommendation. The terminal selection stage is said to be completed when an individual terminal reacts and is awarded the call. In the case of NT2, the call award need not come as a direct result of the point-to-point procedure but may come later from a terminal attached to the NT2.

The details regarding the processing of this information by the terminating exchange and the sequence used in offering this information to the user-network interface may be a matter of formal agreement between the subscriber and the Administration at the time of service provisioning. The call set-up and terminal selection procedures in ISDN require that the terminating exchange and the terminals play cooperative roles.

2 Objective

2.1 The primary objective of this Recommendation is to provide overall principles on terminal selection in ISDN. This Recommendation therefore provides a framework within which Administrations may choose appropriate terminal selection procedures, to suit their own operating environment and applications.

2.2 The guidelines contained in the appendices do not represent requirements on terminals for terminal selection functionality, but represent terminal selection techniques that are useful in appropriate circumstances. Possible choices are contained in appendices. However, other Recommendations, e.g. Recommendation T.90 have also to be taken into account.

3 Scope

3.1 It is recognized that call set-up is an end-to-end process requiring appropriate switching, signalling and terminal functionality at both ends. However, the frame of reference used in this Recommendation is mainly the terminating ISDN exchange and the terminal configuration(s) served by that exchange. The originating exchange and the terminal configuration(s) served by that exchange are covered only if a specific request for a terminal function at the calling side, supporting the terminal selection procedure at the called side, is identified.

3.2 It is also recognized that calls originating from existing dedicated networks with limited addressing and signalling capabilities will not be able to avail themselves of the full range of terminal identification functions. This Recommendation therefore addresses the terminal selection for the following types of calls:

- calls within the ISDN:
  - i) selection based on network assisted capabilities (e.g. see Appendices II and III);
  - ii) selection based on end-to-end user capability (e.g. see Appendices I and II);
- calls from public dedicated networks to ISDN.

Note – Calls from private networks to ISDN are not currently addressed in this Recommendation.

3.3 This Recommendation addresses terminal selection in ISDN for both basic and primary rate access.

3.4 Though selection of a specific terminal in a multipoint configuration in ISDN for maintenance and operation purposes may be a requirement, this Recommendation does not currently address this application.

3.5 This Recommendation is related to and/or is compatible with the following Recommendations:

- Recommendations of the I.200-Series on ISDN services;
- Recommendation I.330: ISDN numbering and addressing principles;
- Recommendation I.331 (E.164): Numbering plan for the ISDN era;
- Recommendations I.410, I.411, I.412: ISDN user-network interfaces;
- Recommendation I.441 (Q.921): ISDN user-network interfaces: layer 2 specifications;
- Recommendation I.451 (Q.931): ISDN user-network interfaces: layer 3 specifications;
- Recommendations of the I.500-Series defining interworking between various networks;
- Recommendation Q.932, Annex A: Generic procedures for the control of ISDN supplementary services – User service profiles and terminal identification;
- Recommendation T.90: Characteristics and protocols for terminals for telematic services in ISDN.

4 Terminal selection functions

4.1 Any information which categorizes attributes of an incoming call may be used for the terminal selection process (some information given hereafter is service oriented and some is terminal oriented):

1) an ISDN number;
2) bearer capability;
3) other low layer functionality;
4) higher layer functionality;
5) direct dialling-in (DDI) number, multiple subscriber number, or subaddress;
6) ISDN/non-ISDN call source indicator;
7) local exchange functionality.

In a point-to-multipoint configuration, call set-up information from the terminating ISDN exchange to the terminal configuration is transferred via broadcast procedures. All active terminals receive attribute values and determine whether or not to respond.

In the case of more than one terminal supporting the same service, the supplementary service Multiple Subscriber Number (MSN) (Note 1) or Direct Dialling-In (DDI) (Note 2) may be used to identify a specific terminal. To support these services the terminal must be able to recognize its own identity based typically on a number of digits, which consist of the whole, or a part of the Subscriber Number (SN) in the ISDN numbering plan. Alternatively, § 4.3 may apply.

This principle applies for both a homogeneous ISDN environment and for interworking cases with non-ISDN. In a homogeneous ISDN environment the subaddressing function (Note 3) may be used alternatively. However, it cannot be used in all cases of interworking.

Note 1 – Based on the use of distinct ISDN numbers, the multiple subscriber number supplementary service enables specific terminal(s), connected to the basic access in a point-to-multipoint configuration, to be indicated by the called party number.

Note 2 – Based on the use of distinct ISDN numbers, the direct dialling-in supplementary service enables a user to establish a connection to another user or an ISPBX, or other private system without attendant intervention.

Note 3 – Based on an extension of the addressing capability beyond the E.164 (I.331) numbering plan, subaddressing enables the calling user to select a specific terminal at the called user's termination and/or to invoke a specific process in the called terminal at the called user's termination.

4.2 The terminal selection function in § 4.1 is currently supported by Recommendation Q.931 (I.451) call set-up protocols, Q.932 and Q.921 as follows:

1) called party number information element;
2) bearer capability information element;
3) low layer compatibility information element;
4) High Layer Compatibility (HLC) information element;
5) called party number/subaddress information element;
6) progress indicator information element;
7) End point Identifier (EID) information element (see Q.932, Annex A);
8) Terminal End point Identifier (TEI) (see Q.921, § 3.3.4).

4.3 It is recognized that a local procedure, between the ISDN exchange and terminal, may be provided to allow the exchange to assign a particular terminal with network parameters (e.g. logical terminal profile). This identification mechanism will assist the exchange in providing additional terminal selection or service features (see Appendix III).

5 Terminal selection

5.1 *Calls within ISDN(s)*

5.1.1 *Terminal selection functions*

These are described in § 4.

5.1.2 *Processing of selection functions*

In the terminating exchange, the called subscriber number and the bearer capability are checked. If any form of subscriber profile exists for the interface, it may also be consulted.

a) For point-to-point applications

   Proceed to establish the connection according to subscriber requirements; for an NT2 transfer all appropriate information.

b) For point-to-multipoint applications (broadcast)

   i) As information is broadcast from the terminating exchange to the terminal configuration, each active terminal receives the presented information to identify the requested service, as described in § 4.1

   ii) Each active terminal which wishes to be awarded the call will inform the network. The network will award the call to the first terminal equipment which requests connection.

   When supporting multiple types of terminals, e.g. telematic and telephone terminals, on a point-to-multipoint configuration, improper call handling will occur if inappropriate terminals request connection of the call. Appendices I, II and III provide possible solutions to these problems. e.g. solutions specifically aimed at telematic terminals are included in Appendix I.

The development of terminal configurations in addition to those described in the appendices which will operate successfully in specific circumstances (e.g. select a specific terminal from among several for services, supplementary services, maintenance operations, etc.) are for further study. Provision of guidance to terminal manufacturers, ISDN subscribers, and network operators about how terminals might respond in such circumstances, requires further study.

5.1.3 *Terminal differentiation*

The terminating party is expected to arrange available terminals to facilitate access. Distinctions may be drawn, for example, by taking notice in a terminal of the presence or absence (not the content) of a subaddress (see also § 4.2). Calls interworking from PSTN (bearer capability 3.1 kHz audio), for example, could be accepted by terminals sensing no subaddress, while allowing more capable terminals to bid for calls with the same bearer capability and subaddress as well.

5.2 *Calls from PSTN to ISDN*

A call originated in the PSTN, supported by conventional signalling prior to arrival at the ISDN interworking point, will belong to one of two indistinguishable call types, i.e. ordinary speech or voiceband data. At the interworking point the bearer capability "3.1 kHz audio" will be assigned to assure compatibility with these call types. A progress indicator is also applied to mark a non-ISDN call source. Some PSTN customers, however, will be served from ISDN-capable exchanges and calls will be supported by common channel signalling for the entire connection. This affords some added opportunities to make distinctions. The extent to which this should be recommended is for further study.

Those cases where the bearer capability "3.1 kHz audio" does not apply (such as digital data service based on digital PSTNs) require further study, based on Recommendation I.231, and Recommendation I.515.

5.3 *Calls from PSPDN to ISDN*

A call originated in the PSPDN will carry either a circuit or a packet bearer capability when presented to an ISDN terminal (case A or B according to Recommendation X.31). Terminal selection procedures in these cases are for further study.

5.4 *Calls from CSPDN to ISDN*

A call originated in the CSPDN will carry a circuit bearer capability and indicate the kind of bitrate adaption used when presented to an ISDN terminal configuration. If the CSPDN is used to offer a teleservice, e.g. Teletex in some countries, the interworking point may not be able to provide this information to ISDN. Therefore, a distinction between a circuit mode data call and a Teletex call may not be possible and again the only basic principle which allows individual distinction between terminals is the supplementary service multiple subscriber number.

APPENDIX I

(to Recommendation I.333)

Examples of terminal selection for general purpose terminals

I.1 *Scope*

The aim of this Appendix is to describe terminal selection functions for general purpose terminals which allow operation when multiple terminals supporting a variety of services (including telematic services) are in a point-to-multipoint configuration (S/T bus), and the full complement of terminal selection functions (including HLC information element) have to be invoked for successful terminal selection.

Terminals which comply with the clauses below do not impose any constraints on terminal configurations with respect to existing recommendations dealing with telematic services.

Application of the terminal selection guidelines contained in this Appendix is described in § I.3.

I.2 *Terminal functions*

To meet the requirements mentioned in the scope of this Appendix, the following functions shall be provided by terminals connected to an ISDN. The functions are grouped into those which shall be provided as a minimum for offering an adequate quality of service and into those which may be implemented additionally.

Note – The processing of information at the called side can be executed in the order appropriate to a particular customer installation. The order chosen in this Recommendation is for description and does not impose any constraints on implementations.

I.2.1 *Terminals supporting bearer services*

I.2.1.1 *Minimum functions*

I.2.1.1.1 For outgoing calls, generation of information defining the service and address information, i.e. bearer capability and called address.

I.2.1.1.2 For incoming calls, analysis of whether a bearer service is requested (not a teleservice). If a higher layer protocol (repesenting a specific teleservice) is requested, the terminal shall ignore the call. This function may be provided by the simple determination of the *existence* of higher layer protocol information received with the incoming call message.

I.2.1.1.3 For incoming calls, analysis of the individual bearer service requested. This function is obtained by the analysis of the bearer capability information received with the incoming call message.

I.2.1.1.4 For incoming calls, analysis of multiple subscriber number information, if provided. A call shall only be answered if the requested multiple subscriber number matches the identity assigned to the terminal.

Terminals which do not support the multiple subscriber number supplementary service, shall at least detect the presence of this information. If present, such terminals shall not answer the call.

Terminals supporting the multiple subscriber number supplementary service must analyze this information and will only answer the call if the received information matches the pre-assigned identity or if there is a global call.

I.2.1.1.5 For incoming calls, analysis of subaddress information. A call shall only be answered if the requested subaddress matches the one assigned to the terminal.

Terminals which do not support the subaddressing mechanism, shall at least detect the presence of this information. If present, such terminals shall not answer the call.

Terminals supporting the subaddressing mechanism must analyze this information and will only answer the call if the received information matches the pre-assigned information. Terminals with subaddress capability shall not reject calls on the absence of subaddress information.

I.2.1.1.6 Terminals supporting more than one bearer service must apply rules of §§ I.2.1.1.1, I.2.1.1.2 and I.2.1.1.3 individually. The assignment of a multiple subscriber number or a subaddress may be common for all bearer services.

I.2.1.2 *Optional functions*

I.2.1.2.1 Terminals supporting the multiple subscriber number supplementary service may be pre-assigned more than one number and will therefore answer incoming calls which match one of the pre-assigned identities or which have a global identity (global call) (see Note).

I.2.1.2.2 Terminals supporting the subaddressing mechanism may be pre-assigned more than one subaddress and will therefore answer incoming calls which match one of the pre-assigned subaddress or which have no subaddress (global call).

Note – An incoming call is global if there is no information contained in the call set-up message to relate the call to sub-set of the terminal population based on terminal identity (information on terminal identity is conveyed in the called party number information element). The term "global identity" is used to reflect the global relationship with respect to terminal identity, and suitable coding methods are:

- to omit the called party number information element;
- to define a specific called party number as a global number (see also Recommendation Q.931).

I.2.2 *Terminals supporting teleservices*

I.2.2.1 *Minimum functions*

I.2.2.1.1 For outgoing calls, generation of information defining the service and address information, i.e. bearer capability, higher layer protocol information specifying the requested teleservice and called address.

I.2.2.1.2 For incoming calls, analysis of whether a teleservice is requested (and not a bearer service), i.e. if high layer protocol information (representing a specific teleservice) is *not* requested, the terminal shall ignore the call. This function may be provided by the simple determination of the *exitence* of high layer protocol information received with the incoming call message. As high layer compatibility (HLC) information may not be provided in the case of interworking with a non-ISDN, its absence should not be used as a reason for rejecting the call (see § I.2.3.1).

I.2.2.1.3 For incoming calls, analysis of the individual teleservice requested. This function is obtained by the analysis of the bearer capability information and the high layer protocol information received with the incoming call message.

I.2.2.1.4 For incoming calls, analysis of multiple subscriber number information. A call shall only be answered if the requested multiple subscriber number matches the identity assigned to the terminal.

Terminals which do not support the multiple subscriber number supplementary service, shall at least detect the presence of this information. If present, such terminals shall not answer the call.

Terminals supporting the multiple subscriber number supplementary service must analyze this information and will only answer the call if the received information matches the pre-assigned identity or if there is a global call.

I.2.2.1.5 For incoming calls, analysis of subaddress information. A call shall only be answered if the requested subaddress matches the one assigned to the terminal.

Terminals which do not support the subaddressing mechanism shall at least detect the presence of this information. If present, such terminals shall not answer the call.

Terminals supporting the subaddressing mechanism must analyze this information and will only answer the call if the received information matches the pre-assigned information. Terminals with subaddress capability shall not reject calls on the absence of subaddress information.

I.2.2.1.6 Terminals supporting more than one teleservice must apply rules of §§ I.2.2.1.1, I.2.2.1.2 and I.2.2.1.3 individually. The assignment of a multiple subscriber number or a subaddress may be common for all teleservices.

I.2.2.2 *Optional functions*

I.2.2.2.1 Terminals supporting the multiple subscriber number supplementary service may be pre-assigned more than one number and will therefore answer incoming calls which match one of the pre-assigned identities or which have a global identity (global call).

I.2.2.2.2 Terminals supporting the subaddressing mechanism may be pre-assigned more than one subaddress and will therefore answer incoming calls which match one of the pre-assigned subaddress or which have no subaddress (global call).

I.2.3 *Terminals interworking with dedicated networks*

I.2.3.1 *General*

For calls from the ISDN to a dedicated network the interworking function has to make provision that only calls which can be handled by the dedicated network are forwarded.

For calls originated in the dedicated network the interworking function may be unable to provide all elements exactly specifying the service requested according to the rules for a call within the ISDN. For example a call from the telephone network may be a request for telephony, for facsimile or for modem-based data transmission and is presented to the ISDN as a request for the 3.1 kHz audio bearer service.

In the case of interworking with a dedicated network, appropriate information is generated by the interworking function (progress indicator). The presence/absence of this information should be used as a criterion for different treatment of a call depending on whether the call originated within ISDN or within a dedicated network.

I.2.3.1.1 *Calls from PSTN to ISDN*

A PSTN call, supported by conventional signalling prior to arrival at an ISDN interworking point, will belong to one of two indistinguishable call types, i.e. ordinary speech of voiceband data, of which the latter includes facsimile and modem-based data. At the interworking point the bearer capability "3.1 kHz audio" is routinely assigned to assure compatibility with any of these call types. A "progress indicator" is also applied to mark a non-ISDN call source. Some PSTN customers, however, will be served from ISDN-capable exchanges and calls will be supported by common channel signalling for the entire connection. This affords some added opportunities to make distinctions between the call types. The extent to which this should be recommended is for further study.

I.2.3.1.2 *Calls from PSPDN to ISDN*

(See § 5.3 of this Recommendation.)

I.2.3.1.3 *Calls from PSPDN to ISDN*

(See § 5.4 of this Recommendation.)

I.2.3.1.4 *Calls from networks referred to as digital PSTNs, pre-ISDNs, pilot ISDNs or extended IDNs to ISDNs*

Calls providing a 64 kbit/s transfer rate transparently from one of the above-mentioned networks to an ISDN terminal configuration are not yet finally defined. The 64 kbit/s unrestricted bearer service will be used, but in any case there is an interworking taking place. A progress indicator is present, indicating a non-ISDN call source. Specific high or low layer functionality information cannot, however, be guaranteed. Therefore, the only basic principle which allows distinction between individual terminals is the supplementary service multiple subscriber number.

I.2.3.2 *Telephone terminals in ISDN*

Telephone terminals have certain particular characteristics which have to be taken into account. With these terminals, compatibility checking will be aided by the HLC. Details are for further study. In the case of absence of HLC information, telephone terminals may be considered in a similar manner as terminals supporting bearer services described in § I.2.1 above – even if telephony is a teleservice.

Telephone terminals must interwork with the existing analogue telephone network. For incoming calls they must therefore accept not only the bearer capability "speech", which occurs in calls within ISDN, but also the bearer capability "3,1 kHz audio", which is the bearer capability in case of interworking with the analogue telephone network and which is accompanied with call progress information indicating the interworking case.

I.2.3.3 *Facsimile terminals in ISDN*

A facsimile terminal on ISDN may have the capability to support both Group 2/3 mode and Group 4 mode (Group 3/Group 4 machine), Group 2/3 mode only (Group 3 machine) or Group 4 mode only (Group 4 machine).

In order to cater for the case where calls are incoming from networks not able to convey HLC information (e.g. PSTN, switched 64 kbit/s, non-ISDN networks) it must be possible for a facsimile terminal to accept calls without the provision of an HLC information element. This may involve subscription to the Multiple Subscriber Number (MSN) supplementary service, in order to substitute the missing HLC information element. Moreover, for successful call establishment the facsimile terminal has to support the bearer service offered by the interworking function and the mode requested by the calling facsimile terminal.

Similar problems may occur for facsimile calls within the ISDN, if a Group 3 machine in combination with a terminal adaptor (TA) function is connected to the ISDN.

It is obvious that a Group 4 machine and a Group 3 machine are unable to communicate, whatever the network configuration is, when interworking with a dedicated network or TA. However, a Group 3/Group 4 machine is able to communicate to a facsimile machine connected to a dedicated network (this is a Group 3 machine in the case of PSTN, and a Group 4 machine in the case of switched 64 kbit/s, non-ISDN Networks) or connected to the ISDN by means of a TA function. Appendix IV describes the circumstances and capabilities of facsimile terminals for the interworking situations identified above.

I.2.3.4 *Data terminals in ISDN*

Data terminals in ISDN may interwork with compatible data terminals in a dedicated data network or in the telephone network. For outgoing calls, the terminal has to operate as described in § I.2.1 above and it selects the proper bearer capability according to the service request. For incoming calls, a data terminal shall function as described for terminals supporting bearer services in § I.2.1 above. In case of interworking with the telephone network it has to accept calls indicating the bearer capability 3.1 kHz audio which is accompanied with the call progress information.

Automatic answering data terminals connected to the ISDN and interworking with the telephone network or with the CSPDN shall support the multiple subscriber number supplementary service, because this is the only safeguard to avoid that a data terminal will capture each incoming telephone call, facsimile call from the PSTN or possibly each teletex call from the CSPDN.

I.3 *Applications*

Terminals (or terminal adaptors) that follow these terminal selection guidelines can be used on the same point-to-multipoint configuration with terminals of different functionality (e.g. Telefax, Teletex), but following the same terminal selection guidelines, thereby allowing incoming calls to be selected by the appropriate terminal. The inclusion on a point-to-multipoint configuration of terminals not following these guidelines may result in the mishandling of some calls.

Since the application of the terminal selection guidelines is not mandatory for ISDN terminals, it is essential to ensure that the terminals used on each multipoint interface are compatible among themselves for terminal selection.

APPENDIX II

(to Recommendation I.333)

Examples of terminal selection in illustrative configurations

II.1 *Scope*

This appendix describes arrangements indicating some methods which could be used in terminal selection. The different terminal capabilities described in the arrangements are for illustration only. It is the responsibility of the terminal provider to provide terminals with capabilities appropriate to the intended use of the terminal. It is the responsibility of the called party to arrange the terminals on the interface so that incoming calls are handled according to the desires of the called party.

Each illustration indicates likely circumstances for use, and the potential impact of using the terminals on a point-to-multipoint configuration with terminals having different terminal selection functionality. Other terminal selection arrangements may be useful for certain circumstances.

Since the application of the terminal selection guidelines is not mandatory for ISDN terminals, it is essential that the terminals used on each multipoint interface are compatible among themselves for terminal selection.

II.2 *Limited functionality speech terminal*

II.2.1 *Configuration*

An example of a simple terminal configuration is illustrated in Figure II-1/I.333. The multiple terminal configuration example consists of up to eight voice terminals without terminal selection logic.

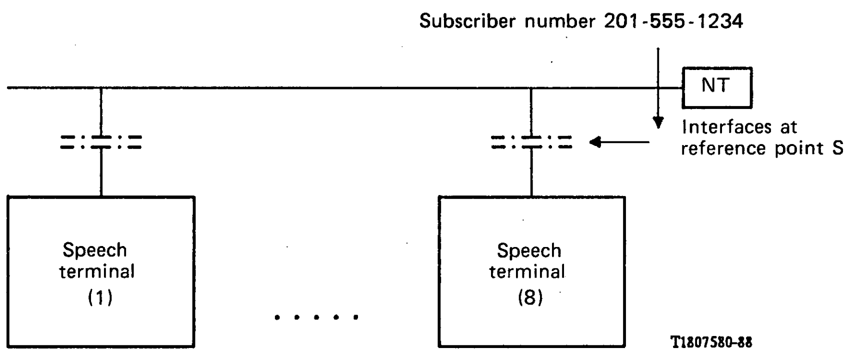


FIGURE II-1/I.333

Limited functionality speech terminals

II.2.2 *Terminals and network capabilities*

Calls are delivered to the interface on the basis of an ISDN subscriber number (ISDN-SN). The terminals respond to the call offered on the basis of presumed eligibility to complete the call.

II.2.3 *Offered call treatment*

A terminal will respond to a set-up message regardless of other terminal selection information (e.g. LLC) present in the set-up message. More than one terminal may answer the offered call, but the network awards the call to the first terminal from which it receives an answer (connect) indication.

II.2.4 *Application*

This type of terminals is appropriate for subscribers who wish only to receive speech calls and who are not concerned with which terminal answers the call. The use of this type of terminal on a point-to-multipoint configuration with terminals designed for anything other than speech calls will result in the mishandling of some calls.

II.3 *Terminal selected by end point identifier (EID) or subaddress*

II.3.1 *Configuration*

- Multiple terminals with the same subscriber number.
- Distinction among the terminals is obtained using the EID or the subaddress (see Figure II-2/I.333).

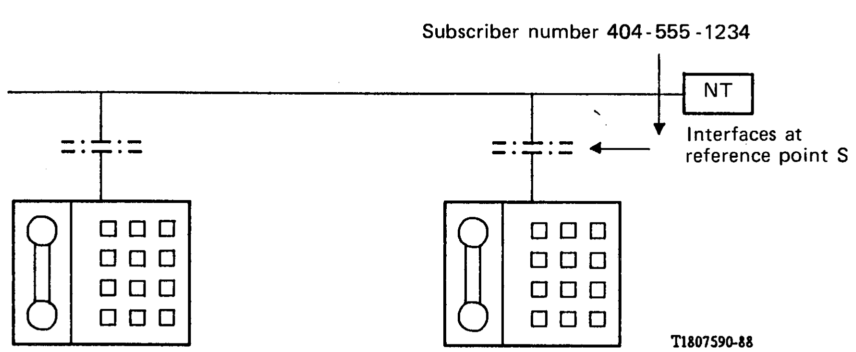


FIGURE II-2/I.333

Multiple terminals with the same ISDN subscriber number

II.3.2 *Terminals and network capabilities*

The network may deliver the call using terminal identification procedures based on the end point identifier (EID). The terminal may respond to the set-up message based on terminal identification procedures (e.g. use of the EID as defined in Recommendation Q.932 or subaddressing).

II.3.3 *Offered call treatment*

The network provides a set-up message with terminal selection information that uniquely identifies a terminal. The terminal identification procedures based on EID or subaddressing schemes will identify a particular terminal and this terminal will respond according to the call or service offered.

II.3.4 *Application*

The EID is provided by the network to identify a specific terminal. The network may make use of a User Service Profile together with terminal selection data to select the EID. In other applications, particularly those involving data terminals, each terminal may be assigned a subaddress and would respond only to calls containing that subaddress.

II.4 *Multiple different terminals on a passive bus*

II.4.1 *Configuration*

This example considers a speech terminal, a terminal adaptor for analogue interface, and a terminal adaptor for digital interface connected on a passive bus. The interface has been assigned three numbers that can be used (by non-ISDN customers) to indicate the terminal they wish to access. The arrangement is shown in Figure II-3/I.333.

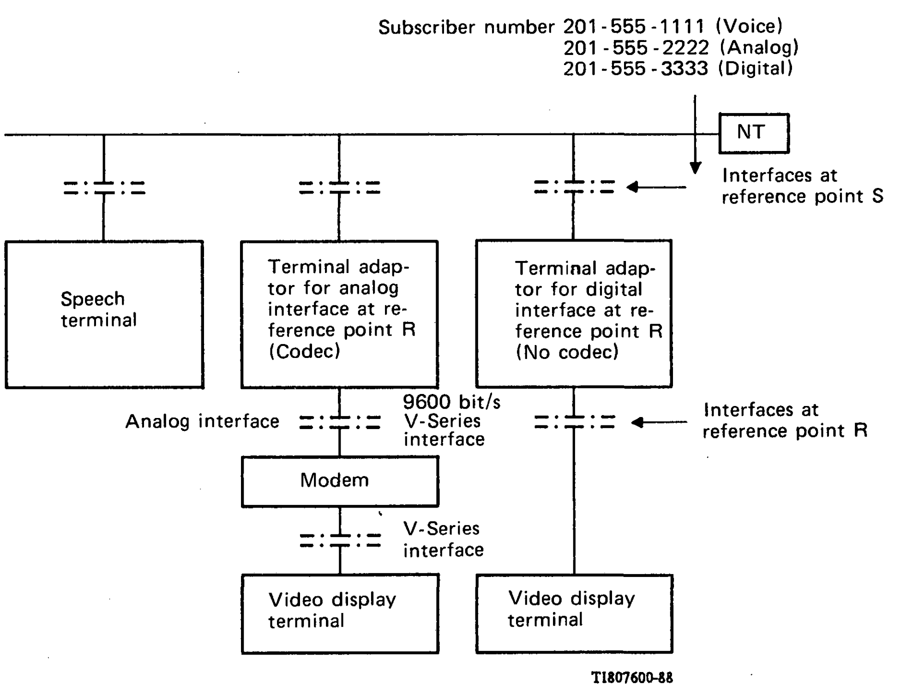


FIGURE II-3/I.333

Multiple different terminals on a passive bus

II.4.2 *Terminals and network capabilities*

In this example, the terminals are connected to an interface that has been assigned three numbers. Any of the three numbers may be used from another ISDN for any service supported by the subscribers' terminals. For callers from networks that cannot indicate directly the service required (PSTNs, CSPDNs, and PSPDNs), the first number "201-555-1111" is intended for speech services. The second number, "201-555-2222" is intended for modem data services. The third number, "201-555-3333" is intended for access to the terminal adaptor for digital interface.

Terminal selection based on the ISDN subscriber number, bearer capability, and progress indicators is used to identify one (or none) of the three terminals that is appropriate to respond to an offered call.

II.4.3 *Offered call treatment*

II.4.3.1 *Speech terminal* (see Figure II-4/I.333)

Offered call bearer capability – "Speech":
The terminal responds to the call.

Offered call bearer capability – "3.1 kHz audio":

1) Progress indicator – non-ISDN:

   i) Called number – 201-555-1111:
   The terminal responds to the call

   ii) Other called numbers:
   The terminal does not respond.

2) No progress indicator – ISDN origination and transit:
   The terminal assumes that the call is a data call and does not respond.

Offered call with other bearer capabilities: the terminal does not respond.

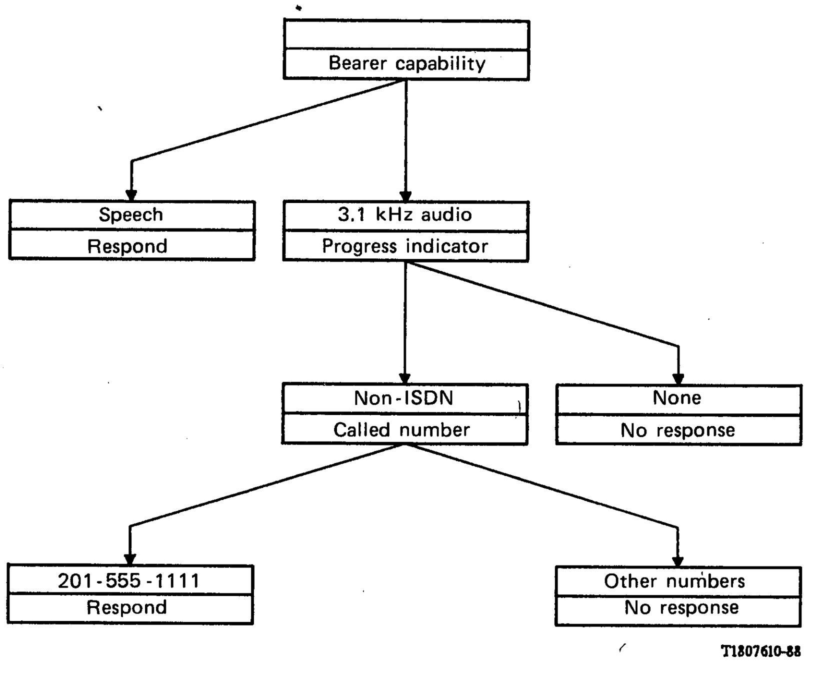


FIGURE II-4/I.333

Logic for speech terminal

II.4.3.2 *TA for analogue interface/video display terminal*

The terminal adaptor contains a codec that produces an analogue signal that is connected to a modem; the modem has a V-Series interface to the Video Display Terminal (VDT). The logic is shown in Figure II-5/I.333.

Offered call bearer capability – "3.1 kHz audio":

1) Progress indicator – non-ISDN:

   i) Called number – 201-555-2222:
      The terminal adaptor assumes that the call is a data call and responds. The call is connected to the video display terminal through a modem.

   ii) Other called number:
      The terminal adaptor does not respond.

2) No progress indicator – ISDN origination and transit:
   The terminal adaptor responds. It assumes that, since the call originated at an ISDN terminal, the call is a data call regardless of the called number.

Offered call with other bearer capabilities: the terminal adaptor does not respond.

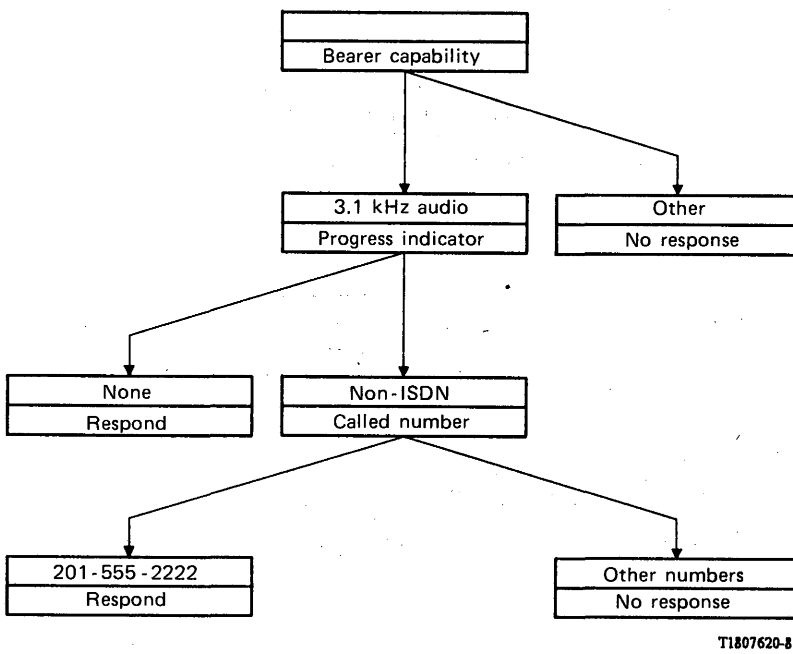


FIGURE II-5/I.333

Logic for the terminal adaptor for analog interface

II.4.3.3 *TA for digital interface/video display terminal*

The terminal adaptor adapts the V-Series interface to the interface at reference point S of ISDN.

The adaptation includes rate adapting the 9600 bit/s rate of the display terminal to the 64 kbit/s rate of a B-channel. The logic for the digital terminal adaptor is shown in Figure II-6/I.333.

For non-ISDN calls, it is assumed that the call is routed through an interworking function that establishes a bearer capability of 64 kbit/s for the call.

Offered call bearer capability – "64 kbit/s unrestricted":

1) Progress indicator – non-ISDN:

   i) Called number – 201-555-3333:
      The switch routes the connection through an interworking unit (e.g. a modem). The terminal adaptor for digital interface/display terminal answers the call.

   ii) Other called numbers:
      The terminal adaptor does not respond.

2) No progress indicator – ISDN origination and transit:
   The terminal adaptor responds. It assumes that, since the call originated at an ISDN terminal, the call is a data call regardless of the called number.

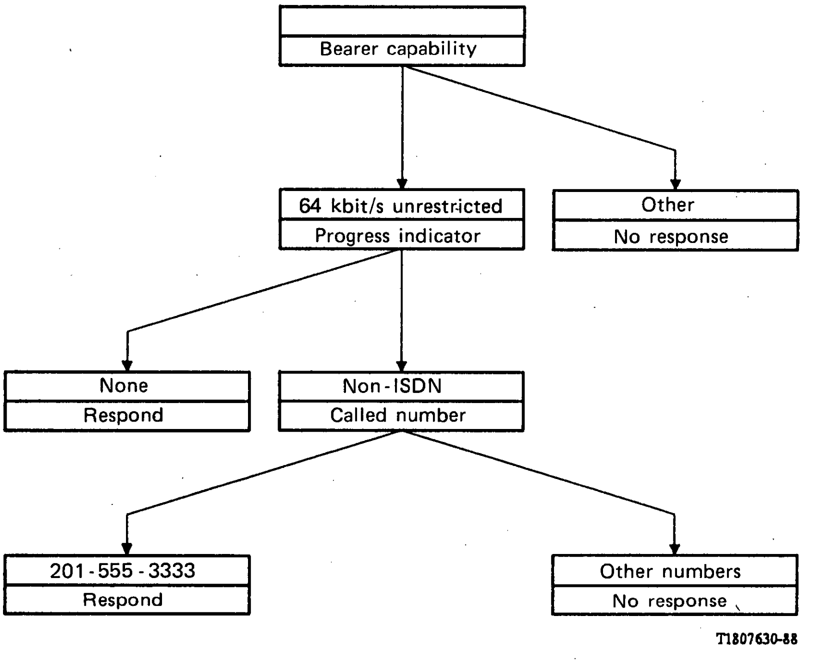


FIGURE II-6/I.333

Logic for the terminal adaptor for digital interface

II.4.4 *Application*

This example of multiple different terminals on a passive bus illustrates the terminal selection logic that allows the appropriate terminal, from among a speech terminal, a terminal adaptor for analogue interface, and a terminal adaptor for digital interface, to respond to an incoming call. Calls from a non-ISDN network are selected on the basis of the called ISDN number; calls from an ISDN subscriber are selected on the basis of the bearer capability. The addition to the interface of other terminals with different functionality but using the same bearer capability would result in incorrect terminal selection.

APPENDIX III

(to Recommendation I.333)

Examples of terminal selection using local terminal selection procedures

This appendix describes the concept of a logical terminal and its application in assisting the network to provide services to the access through local terminal identification mechanisms.

III.1 *Logical terminals*

There may exist up to 8 physical terminals on an S/T bus. Within each physical terminal there may exist one or more logical terminals (as shown in Figure III-1/I.333). A logical terminal is considered to be the exchange's view of the physical terminal(s) on an interface. The parameters which are maintained by the exchange, which describe the logical terminal characteristics, are collectively termed to be the Logical Terminal Profile (LTP). The LTP may contain such information as subscriber numbers, bearer capabilities supported, services subscribed to, or other information which the exchange may require to successfully offer service to the terminals on the interface. A physical terminal can appear (to the network) to be several logical terminals by using several unique TEIs (see Note), each of which may map into a single LTP. The relationship of logical terminals to LTPs may be one-to-one or many-to-one. The relationship between physical terminals, logical terminals. TEIs and LTPs is illustrated in Figure III-2/I.333).

Note – The terminal end point identifier (TEI) is part of the D-channel layer 2 address field [see Recommendation Q.921 (I.441)].

Eight logical terminals (the inner boxes, labeled LT1 to LT8) are shown in a total of four physical terminals (the outer boxes, labeled PT1 to PT4). Each logical terminal corresponds to one TEI. This arrangement reflects a customer subscribing to the multiple subscriber number (MSN) supplementary service.

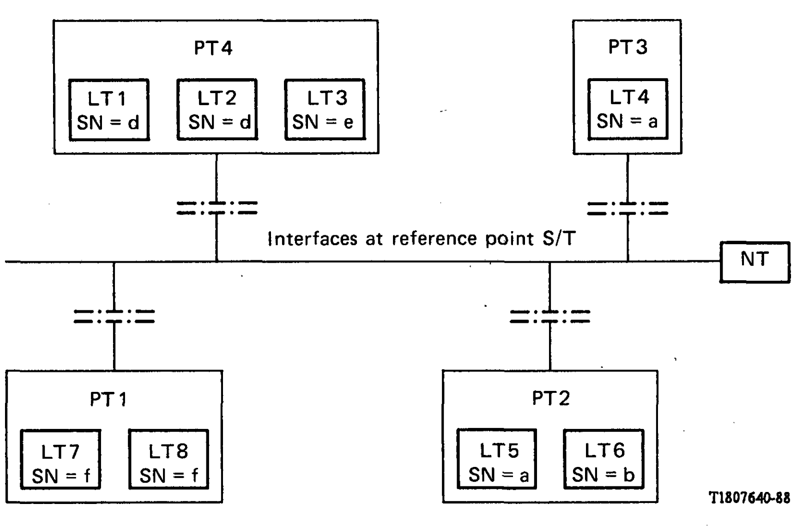
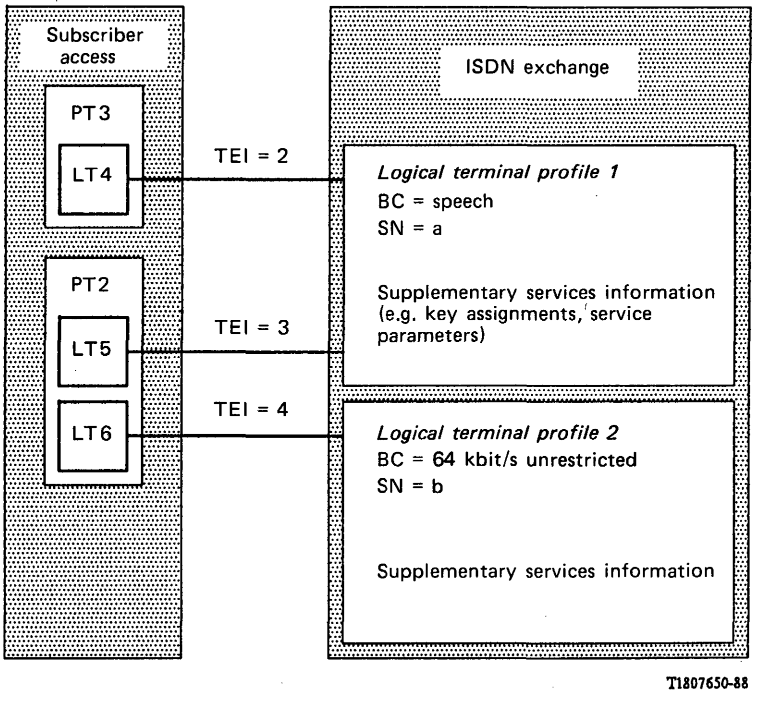


FIGURE III-1/I.333

Example of logical terminal arrangement



PT Physical terminal
LT Logical terminal
BC Bearer capability
SN Subscriber number
SN = a Subscriber number with value "a"
NT Network termination

FIGURE III-2/I.333

Relationship of LTs and LTPs

III.2 *Application*

It is considered that the subscriber may want the exchange to provide terminal selection functions for his terminals. A local terminal selection procedure will accommodate this. In addition, future services may be facilitated which could require special call treatment based on knowledge of the terminal(s) maintained in an LTP and identified using a local procedure.

In the context of terminating calls, when an exchange receives digits of a subscriber number (SN) for a call to a terminal on a subscriber line, it would search for the LTP(s) associated with the SN. It would then formulate network-layer call control messages to alert these terminals based on the descriptions associated with the LTP. The Q.932 procedure is used to allow association of a TEI with an LTP. The procedures used for all establishment comply with Recommendation Q.931 (I.451).

APPENDIX IV

(to Recommendation I.333)

Facsimile terminals in ISDN

IV.1 *Outgoing calls*

In accordance with § I.2.2.1.1 a G3/G4 (Group3/Group/4) machine or a G4 machine attempting a G4 call shall use the bearer capability according to the capabilities of the network, which may be either "circuit-mode 64 kbit/s unrestricted 8 kHz structured" (category I.231.1) or "virtual call" (category I.232.1), or both of them, and provide the HLC information element with high layer characteristics identification "facsimile group 4".

In accordance with § I.2.2.1.1 a Terminal Adaptor (TA) supporting a G3 machine shall use the 3.1 kHz audio bearer capability and shall provide the HLC information element with high layer characteristics identification "facsimile group 3".

The actions to be taken by the calling facsimile terminal following an unsuccessful call attempt where incompatibility has been indicated (e.g. cause "incompatible destination" for calls within the ISDN, or call rejection with a suitable cause indication in the case of interworking with a dedicated network) require further study. The optimum condition to achieve compatibility in a call re-attempt greatly depends on the cause indication provided to the calling facsimile terminal and its capability to divert to the requested characteristics for the call re-attempt. For a certain type of facsimile terminal these actions may include:

i) A G3 machine shall release the call and take no further action.

ii) A G4 machine shall release the call.

The G4 machine may initiate a call re-attempt, if a mismatch of the bearer capability has been indicated and it can match the requested characteristics, e.g. in the case where the "virtual call" (category I.232.1) bearer capability has been requested by the calling facsimile terminal and interworking with switched 64 kbit/s non-ISDN network takes place. Otherwise it cannot take further actions and is unable to communicate with the called facsimile terminal.

iii) A G3/G4 machine shall release the call.

If interworking ISDN to PSTN has been indicated, or cause "incompatible destination" for calls within the ISDN, when the call has been rejected, the G3/G4 machine may initiate a re-attempt in the G3 mode. It shall use the 3.1 kHz audio bearer capability and shall provide the HLC information element with high layer characteristics identification "facsimile group 3".

If interworking ISDN, to switched 64 kbit/s non-ISDN network, has been indicated when the call has been rejected, actions according to item ii) may be appropriate.

IV.2 *Incoming calls*

For incoming calls originated within ISDN, the facsimile terminal shall function as described for terminals supporting teleservices in § I.2.2.

For incoming calls from non-ISDN networks such as the telephone network (PSTN), the facsimile terminal will receive the appropriate information indicating an interworking situation (call progress information). It shall rely on the call progress information element to accept calls which are offered without information specifying high layer protocols, if it matches other elements describing the incoming call. Otherwise it shall release or ignore the call (user options). Facsimile terminals connected to the ISDN and interworking with non-ISDN networks must support the supplementary service Multiple Subscriber Number. This supplementary service allows to substitute the missing information describing the call and is the only means to avoid having a facsimile terminal accept calls which are not appropriate to it, e.g. incoming call from non-ISDN networks such as telephone calls or data calls.

The rules below are applicable to a certain type of facsimile terminal. They define the criteria which should be used by the terminal to determine whether, and in what mode it should answer the call:

i) A TA supporting a G3 machine should answer the call if the following criteria are fulfilled:

a) The called party number information element, if present, contains a number which matches the number assigned to the TA; and

b) the bearer capability information element indicates the information transfer capability "3.1 kHz audio"; and

c1) the progress indicator information element indicates the progress description "call is not end-to-end ISDN" (incoming call from PSTN);and

d1) the high layer compatibility information element is not present; and

e1) the called party subaddress information element is not present;

or (instead of c1, d1, e1)

c2) the progress indicator information element is not present (incoming call from ISDN); and

d2) the high layer compatibility information element indicates high layer characteristics identification "facsimile group 3"; and

e2) the called party subaddress information element, if present, contains a number which matches the subaddress assigned to the terminal.

ii) A G3/G4 machine should answer the call in the G3 mode (including modem and codec functions) if the following criteria are fulfilled (incoming call from PSTN);

a) The called party number information element, if present, contains a number which matches the number assigned to the terminal; and

b) the bearer capability information element indicates the information transfer capability "3.1 kHz audio"; and

c) the progress indicator information element indicates the progress description "call is not end-to-end ISDN"; and

d) the high layer compatibility information element is not present; and

e) the called party subaddress information element is not present.

iii) A G3/G4 machine (or a G4 machine) should answer the call in the G4 mode (neither modem nor codec functions) if the following criteria are fulfilled (incoming call from switched 64 kbit/s network (non-ISDN);

a) The called party number information element, if present, contains a number which matches the number assigned to the terminal; and

b) the bearer capability information element indicates the information transfer capability "unrestricted digital information" and transfer mode "circuit mode"; and

c) the progress indicator information element indicates the progress description "call is not end-to-end ISDN"; and

d) the high layer compatibility information element is not present; and

e) the called party subaddress information element is not present.

iv) A G3/G4 machine (or a G4 machine) should answer the call in the G4 mode (neither modem nor codec functions) if the following criteria are fulfilled (incoming call from ISDN);

a) The called party number information element, if present, contains a number which matches the number assigned to the terminal; and

b) the bearer capability information element indicates the information transfer capability "unrestricted digital information" and a transfer mode which is supported by the called facsimile terminal ("circuit mode" or "packet mode"); and

c) the progress indicator information element is not present; and

d) the high layer compatibility information element indicates high layer characteristics identification "facsimile group 4"; and

e) the called party subaddress information element, if present, contains a number which matches the subaddress assigned to the terminal.

PRINCIPLES RELATING ISDN NUMBERS/SUBADDRESSES TO THE OSI REFERENCE MODEL NETWORK LAYER ADDRESSES

(Melbourne, 1988)

1. *Introduction*

Recommendation X.200, covering the open systems reference model, applies the term "address" to identify service access points at each layer. With respect to the network layer, a service access point may be identified by an ISDN number/subaddress. This Recommendation is provided to clarify the concepts and terminology which relate ISDN numbers and subaddresses to one another and to OSI reference model network layer addresses.

1.1 *Basic relationships*

The essential purpose of the network layer is to achieve routing of information within the Open Systems Interconnection (OSI) environment. To that purpose it may be useful to establish a correspondence between an ISDN address (ISDN number, possibly with subaddress) and an X.200 network layer service access point. However, an ISDN address may in some instances identify an end-system not conforming to the OSI model. In such cases the format and syntax of the subaddress are available for user-specific purposes. Section 2 summarizes the coding agreements which allow this flexibility. (The publication of the summary in this Recommendation is for information only and does not indicate administrative responsibility for contents nor assure current status of the material presented.)

1.2 *NSAPs and ISDN addresses*

The ISDN address (ISDN number, possibly with subaddress) may include the OSI network layer address and thereby offer means to identify Network Service Access Points (NSAPs). Figure 1/I.334 shows the three cases, a), b) and c) below, relating an ISDN address to a particular OSI NSAP address.

For completeness, references to protocol elements are included in the three cases which follow. For circuit mode access, the calling/called subaddress information elements associated with the Q.931 SET-UP message are used to transmit subaddress information, while the X.25 address extension field serves this purpose for packet mode access. For interoffice circuit mode calls, the Q.931 subaddress information elements may be transmitted within the access transport parameter of the Signalling System No. 7 (S.S. No. 7) initial address message. On packet mode internetwork calls, the X.75 address extension field is available to carry subaddress information.

The components of the OSI NSAP address are the AFI (Authority and Format Identifier), the IDI (Initial Domain Identifier) and possibly the DSP (Domain Specific Part) (see also § 3).

a) The OSI NSAP address is comprised only of an AFI IDI, in which the IDI is semantically identical to the ISDN number. There is no DSP. A terminal can do one of the following:

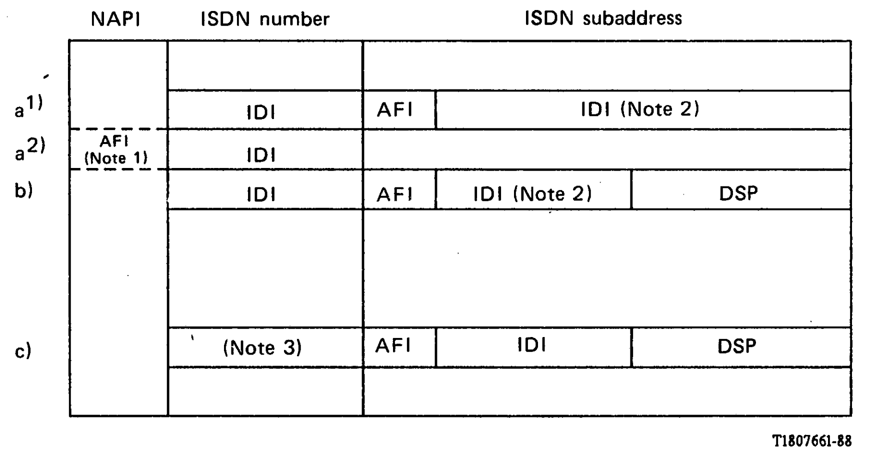
   a1) The entire NSAP is carried in the subaddress field; or

   a2) If the conditions in § 1.3.1 are satisfied, the NSAP address can be inferred from the E.164 number.

   Note – For circuit mode calls, the semantic content of the AFI may be contained in the numbering and addressing plan identification in the Q.931 or S.S. No. 7 calling/called address protocol elements. For packet mode calls, similar information may be found in the X.25/X.75 protocol. Until such time as a protocol mechanism for identifying the numbering plan and the type of number is implemented in X.25/X.75, analogous to that which exists in Q.931/S.S. No. 7, such information may be derivable from the X.25/X.75 address fields which may include a numbering plan escape code. It may also be possible for the semantic content of the AFI to be implied by network arrangements.

b) The OSI NSAP address is comprised of an AFI + IDI + DSP, in which the IDI is semantically identical to the ISDN number. In this case, the entire NSAP address is carried in the subaddress/address extension field.

c) The OSI NSAP address is comprised of an AFI + IDI + DSP, in which the IDI is not related to the ISDN number. The entire NSAP address is conveyed in the subaddress/address extension field.



Note 1 – The semantic content of AFI is contained in the numbering/addressing plan identification (NAPI) in the Q.931/X.25 address information element or implied by network arrangement.

Note 2 – The IDI of the OSI NSAP address is semantically identical to the ISDN number.

Note 3 – The ISDN number is not related to the NSAP address.

FIGURE 1/I.334

Relationship of NSAP address to ISDN number

1.3 *Encoding of NSAP addresses*

1.3.1 *Use of the AF (Address Field)*

Under certain conditions, the NSAP address, as defined in ISO 8348 AD2, may be conveyed entirely in the AF. These conditions are:

a) the NSAP address consists solely of the IDP (i.e. the DSP is null);

b) the AFI can be deduced from the contents of the AF (e.g. with knowledge of the subnetwork to which the DTE is attached); and

c) the IDI is the same as the SNPA (Subnetwork Point of Attachment) address.

When all the above conditions are satisfied, the AF may be used to convey the semantics of the entire NSAP address (the AFI is implied and the contents of the AF are equivalent to the IDI). In these cases, the AEF (Address Extension Field) may also be used (see § 1.3.2).

1.3.2 *Use of the AEF (Address Extension Field)*

When the conditions in § 1.3.1 are not satisfied, the AEF shall be used. The NSAP address, complete with AFI, is placed in the AEF (type of subaddress is X.213/ISO 8348 AD2). In this case, the contents of the AF are not defined by this Recommendation.

1.4 *Decoding of NSAP addresses*

1.4.1 *Absent AEF case*

If the AEF is not present, then local knowledge is required by the receiving NL (Network Layer) entity to determine whether an OSI NSAP address is to be deduced from the content of the AF. If this local knowledge indicates that an NSAP address is present, its abstract syntax is as follows:

a) the AFI is deduced from knowledge of the subnetwork from which the packet was received;

b) the IDI is the same as the contents of the AF; and

c) the DSP is absent.

1.4.2 *AEF case*

If the AEF is present and the type of subaddress is X.213/ISO 8348 AD2, then the NSAP address is contained entirely within the AEF. The abstract syntax is as follows:

a) the AFI is contained within the first two digits of the AEF;

b) the IDI is the remainder of the Initial Domain Part (IDP) after any leading and trailing padding digits are discarded; and

c) the DSP, if present, constitutes the remainder of the AEF content after any trailing padding digits are discarded.

2 **Means to specify the type of subaddress**

Considering the three cases in which the NSAP address may be related to the ISDN address/subaddress, a mechanism which permits determination of the type of subaddress present may be useful in making distinctions. The method of distinction is dependent upon the protocol being used.

In the case of Q.931/I.451, 3 bits within octet 3 of each subaddress information element (i.e., calling and called party subaddress)[1)] establish the "type of subaddress". Two existing assignments, subject to change by responsible authorities are "user-specified" and "X.213/ISO 8348 AD2". All other values are reserved.

The actual subaddress information is coded beginning in octet 4 with the possibility of continuing up to octet 23, i.e., the subaddress information element has the capacity to carry a maximum of 20 octets of subaddress information.

- Under the X.213/ISO 8348 AD2 encoding of type of subaddress, the initial two digits of the subaddress represent the AFI which permits further distinction in subaddress encoding schemes as specified in Figure 2/I.334.
- Under the user-specified encoding of type of subaddress, the subaddress field is encoded according to user specifications subject to a maximum length of 20 octets.

In the case of packet mode calls using X.25/ISO 8208, bits within the first octet of the calling/called address extension facility parameter field indicate the "type of address extension" in a similar manner.

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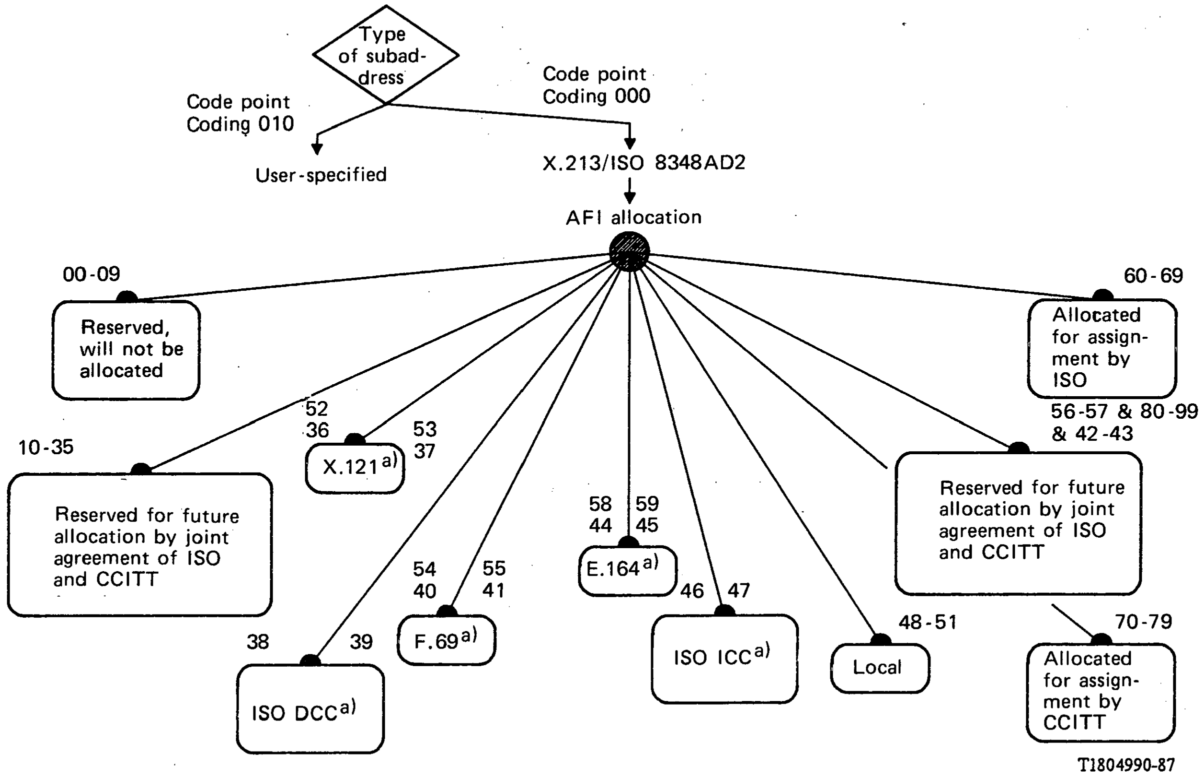
1) Octets 1 and 2 of the subaddress information elements serve as information element and length identifiers, respectively.



a) The IDI format shown within the box is associated with the AFI values above the box. The AFI values on the left are indicative of decimal DSP syntax, whereas those on the right are associated with a binary DSP syntax. Where four AFI values are shown, the two numerically lowest AFI values indicate that, if present, leading zero digits in the IDI are not significant, and do not constitute part of the value of the IDI. The numerically greatest AFI values indicate that leading zero digits are significant.

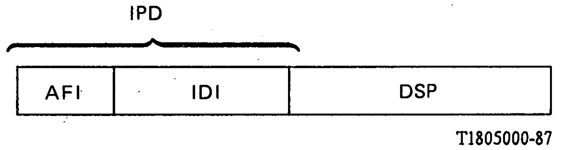
FIGURE 2/I.334

NSAP address allocation

3 The OSI NSAP address format

For reference purposes, a description of terms used in connection with NSAP addresses is provided below:

The format of the NSAP address is:



IDP – Initial Domain Part. This is the part which contains all the internationally standardized parts of the NSAP address, i.e. those addresses and numbers which are controlled either by ISO or CCITT.

AFI – Authority and Format Identifier. This 2-digit code indicates the authority responsible for the number following the AFI, such as X.121 or E.164 and the format of the DSP. This is always two digits and is allocated as per X.213/ISO 8348 AD2.

IDI – Initial Domain Identifier. This may contain, for example, an E.164 or X.121 number. The networks which use these numbering schemes are termed subnetwork by ISO. The overall length of the field is determined by the maximum length of the number format being used.

DSP – Domain Specific Part. In the context of an E.164 IDI, this part contains an address which is relevant only to the domain which has been accessed beyond the domain specified within the IDI, such as a PBX extension, a LAN terminal and so on. This is a variable length field, and is constrained by the length of the IDP, as the overall maximum length of the OSI NSAP address is 20 octets.

Recommendation I.335

ISDN ROUTING PRINCIPLES

(Melbourne, 1988)

1 Introduction

A wide range of services is likely to be offered on ISDNs, which will be supported by a specific set of network capabilities. From a routing point of view, the relationship between these services and network capabilities must therefore be considered.

The aim of this Recommendation is to lay down basic routing principles defining the relationship between ISDN telecommunication services, as described in the I.200-Series of Recommendations, and ISDN network capabilities as described in the I.300-Series of Recommendations. This Recommendation addresses the relevance of these principles to the proposed routing plan for ISDN, and indicates what factors are involved in processing a call. ISDN routing implications of interworking (intra-ISDN and with other networks) are for further study.

2 General routing principles

As described in Recommendation I.210, telecommunication services are the communication capabilities offered to customers. The service concept can therefore be considered to be time independent. A particular instance (or use by the user) of a service is commonly referred to as a call.

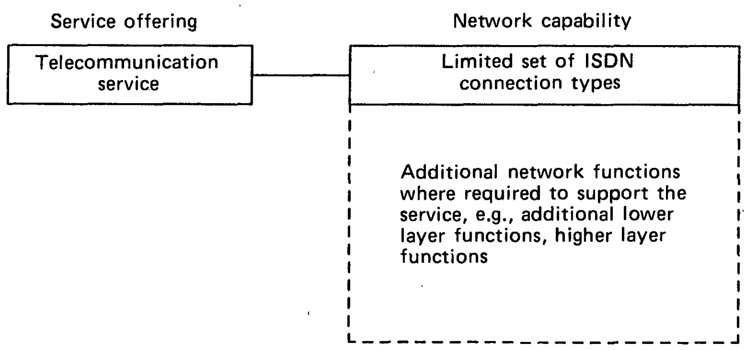
Likewise, the network capabilities which support services, the ISDN connection types, are described in Recommendation I.340. These connection types are also time independent in their concept.

The ISDN network architecture Recommendation I.324 explains how an ISDN connection type is made up of connection elements:

- the "access connection element";
- the "national transit connection element"; and
- the "international transit connection element".

The connection elements, also time independent, are used for the description of the different reference configurations associated with the different connection types (see Recommendation I.325).

It should be noted that the user specifies only the service required. The network allocates the resources to set up a connection of the specific type as necessary to support the requested service. For certain services, additional network functions, e.g. additional lower layer function and/or higher layer functions, may be required as depicted in Figure 1/I.335. For examples of such cases refer to Recommendation I.310.



T1807670-88

FIGURE 1/I.335

The role of network capabilities in supporting service offerings

Figure 2/I.335 shows the general relationship between telecommunication services and ISDN connection types. It also shows in general the association with the actual realization of a service provision (call) by the establishment of a connection through the selection of a route.

The relationship between a call and a connection is a *route*. This means that a route is the application of a particular connection to a specific call. The connection (being an instance of a connection type) will specify the network capabilities being used on a particular call. A route therefore has geographical significance.

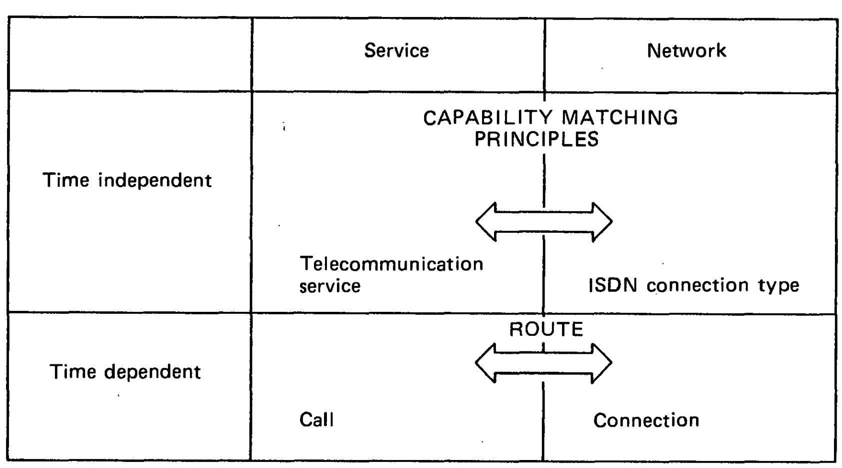


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FIGURE 2/I.335

ISDN capability matching principles and its relationship to a route

In order to establish a communication an ISDN must select:

– an appropriate connection type, i.e. functional grouping, to support the service;

– an appropriate association between the selected functional grouping in terms of a physical realization, i.e. the network allocates the set of connection elements necessary to realize the appropriate connection type.

The concept of connection type describes network capabilities using the attribute technique. One of these attributes is known as "information transfer susceptance". Some other attributes (e.g. "connection control protocol") describe the signalling capabilities.

i) *Information transfer susceptance*

For each service requested by the user, the network has to provide a connection type having a suitable value of the information transfer susceptance attribute, involving switching and transmission capability. The selection of an appropriate connection type is part of the routing functions.

The relationship between the information transfer susceptance attribute of a connection type and the transmission/switching capabilities is detailed in Recommendation E.172.

ii) *Signalling capabilities*

Since the telephone network will progressively evolve towards ISDN, not all part of the network will initially have the same signalling capabilities. Between two given exchanges in the network, the following signalling systems for example, may be available:

- channel associated signalling: R1, R2.
- Signalling System No. 6
- Signalling System No. 7: TUP
- Signalling System No. 7: ISUP

These different signalling systems have different signalling capabilities. The routing functions have to take into account the signalling capabilities of the network to ensure that the required service will be correctly provided. It is also necessary to consider the case where the required service can be provided, but with some restrictions.

Example – For a telephone call between two ISDN subscribers, TUP may be sufficient to set up a call but does not allow end-to-end information transfer and some supplementary services.

The routing principles consider these different cases.

The ISDN routing process, which is further detailed in § 4 is divided into three aspects:

1) matching between telecommunication services and ISDN connection types;
2) determination of parameters relevant to routing to be conveyed and possibly processed across the signalling network;
3) selection of rules for routing through the different connection elements with respect to the reference configurations in Recommendation I.325.

The "routing plan" itself, which is the set of rules for path selection in the ISDN, is given in Recommendation E.172.

This routing plan follows the routing principles outlined in Recommendation I.335 as well as other factors. Among others, the use of connections over geostationary satellites does not call for any alterations in the basic principles of ISDN routing.

Figure 3/I.335 shows the relationship between Recommendations relating to routing.

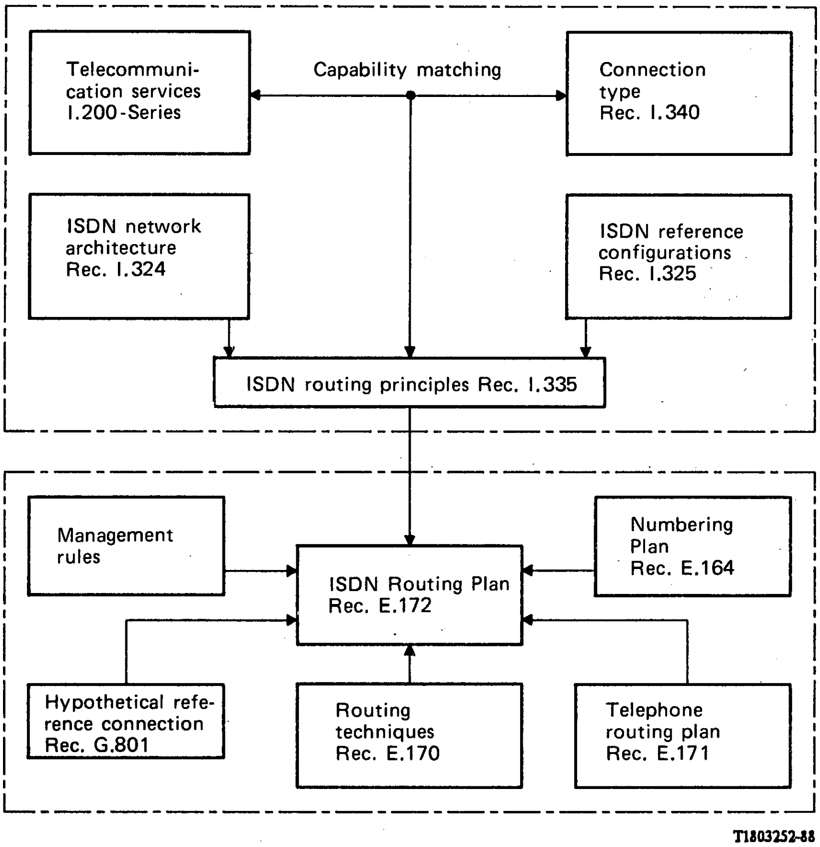
3 Matching between telecommunication services and connection types

3.1 *General*

The user requests a service not a connection type. It is the responsibility of the network, as part of its routing functions, to allocate a suitable connection type to support the requested service. Providing a mapping between the ISDN services and connection types would assist the network in its routing decisions.

Network operators will have freedom of choice in the selection of a suitable connection type for a given service request.

For international connections, the connection type selected should, for reasons of economy, generally be the minimum necessary to support the service. If for reasons of congestion such a connection type is not available the next higher capability connection type could be selected.



Note – The headings above are elements to be considered when undertaking call routing at the different "Connection Elements" boundaries.

FIGURE 3/I.335

Relationship between Recommendations relating to routing

3.2 *List of bearer services*

Tables 1a/I.335 and 1b.I.335 list the attribute values and recommended provision of circuit-mode and packet-mode bearer service, respectively, as described in Recommendations I.231 and I.232.

3.3 *List of teleservices*

Table 2/I.335 lists the attribute values of teleservices described in Recommendation I.241.

3.4 *List of connection types*

Table 3/I.335 lists the recommended connection types in an ISDN as described in Recommendation I.340.

3.5 *Mapping of bearer services for ISDN connection types*

Tables 4a/I.335, 4b/I.335 and 4c/I.335 show the mapping between bearer services and connection types.

Note that, in certain cases, more than one connection type may be suitable for a given bearer service. The first value would usually represent an exact match to the already defined bearer service attribute values, and subsequent values would represent acceptable alternative(s).

Therefore, in determining the connection types usable for a given bearer service the network may provide:

a) a connection type which is an exact mapping between the already defined bearer service and connection type attribute values;

b) a connection type wherein the mapping between the bearer service and the connection type attribute values differs for certain attributes, but shall provide equivalent or superior performance to that of a).

Also, permanent services might be supported on semi-permanent connections. This is for further study.

3.6 *Mapping of teleservices to ISDN connection types*

Teleservices are expected to be supported by the same set of connection types, but further studies are needed on additional routing aspects that may be required (see Table 5/I.335).

4 Routing process in an ISDN

This section describes the routing process within the ISDN using the general model of the ISDN provided in the Recommendation I.324.

The routing process is the sequence of steps required to establish a connection in response to a service request.

A diagram of how routing parameters are used in the ISDN routing process, using the currently defined Q.760 parameter fields is provided in Figure 4/I.335.

4.1 *Description*

4.1.1 *User-network interface*

The user places a request for a particular service. The terminal equipment converts this request into a Q.931 set-up message. This Q.931 set-up message is presented to the user-network interface to request one of the following:

– a bearer service

– a bearer service and supplementary service(s)

– a teleservice

– a teleservice and supplementary service(s)

The Q.931 request is coded to indicate the appropriate attributes of the requested service. The information elements indicated within the Q.931 message will vary depending on the type of bearer service or teleservice and supplementary service(s) requested.

4.1.2 *Originating local CRF*

The originating local connection related function (CRF), e.g. local exchange, processes the Q.931 service request and determines if network routing is required. If network routing is required using S.S. No. 7 ISDN user part (ISUP), the local CRF translates this request into an appopriate initial address message (IAM) and determines the network resources needed to support this service. The IAM contains certain attributes of a connection type that specifies network capabilities sufficient to support this service. During the translation of the request the local CRF selects appropriate basic connection components.

4.1.3 *Transit CRF*

The transit CRF processes the incoming IAM and generates an appropriate outgoing IAM for the next stage of the call. The outgoing IAM contains certain attributes that defines network capabilities required to support this service. The transit CRF also allocates appropriate basic connection components, e.g. echo cancellers, μ-A law converters, satellite links.

TABLE 1a/I.335

Circuit-mode bearer services recommended in an ISDN [a)]

No.	Transfer mode	Transfer rate (kbit/s)	Transfert capability	Establishment of communication	Structure	Communication configuration	Symetry [b)]
1.1	circuit	64	unrestricted digital [c)]	demand	8 kHz	pt-pt	bidirectional symmetric
1.2	circuit	64	unrestricted digital [c)]	reserved	8 kHz	pt-pt	bidirectional symmetric
1.3	circuit	64	unrestricted digital [c)]	permanent	8 kHz	pt-pt	bidirectional symmetric
2.1	circuit	64	speech	demand	8 kHz	pt-pt	bidirectional symmetric
2.2	circuit	64	speech	reserved	8 kHz	pt-pt	bidirectional symmetric
2.3	circuit	64	speech	permanent	8 kHz	pt-pt	bidirectional symmetric
3.1	circuit	64	3.1 kHz audio	demand	8 kHz	pt-pt	bidirectional symmetric
3.2	circuit	64	3.1 kHz audio	reserved	8 kHz	pt-pt	bidirectional symmetric
3.3	circuit	64	3.1 kHz audio	permanent	8 kHz	pt-pt	bidirectional symmetric
4.1	circuit	64	alt speech/unrestricted	demand	8 kHz	pt-pt	bidirectional symmetric
4.2	circuit	64	alt speech/unrestricted	reserved	8 kHz	pt-pt	bidirectional symmetric
4.3	circuit	64	alt speech/unrestricted	permanent	8 kHz	pt-pt	bidirectional symmetric
5.1	circuit	2 × 64	unrestricted	demand	8 kHz [d)]	pt-pt	bidirectional symmetric
5.2	circuit	2 × 64	unrestricted	reserved	8 kHz [d)]	pt-pt	bidirectional symmetric
5.3	circuit	2 × 64	unrestricted	permanent	8 kHz [d)]	pt-pt	bidirectional symmetric
6.1	circuit	384	unrestricted	demand	8 kHz	pt-pt	bidirectional symmetric
6.2	circuit	384	unrestricted	reserved	8 kHz	pt-pt	bidirectional symmetric
6.3	circuit	384	unrestricted	permanent	8 kHz	pt-pt	bidirectional symmetric
7.1	circuit	1536	unrestricted	demand	8 kHz	pt-pt	bidirectional symmetric
7.2	circuit	1536	unrestricted	reserved	8 kHz	pt-pt	bidirectional symmetric
7.3	circuit	1536	unrestricted	permanent	8 kHz	pt-pt	bidirectional symmetric
8.1	circuit	1920	unrestricted	demand	8 kHz	pt-pt	bidirectional symmetric
8.2	circuit	1920	unrestricted	reserved	8 kHz	pt-pt	bidirectional symmetric
8.3	circuit	1920	unrestricted	permanent	8 kHz	pt-pt	bidirectional symmetric

[a)] As given in Recommendation I.231.

[b)] Unidirectional services are for further study.

[c)] During an interim period some networks may only offer restricted digital information transfer capability (i.e. an all-zero octet is not allowed).

[d)] With RDTD “Restricted differential time delay”.

TABLE 1b/I.335

Packet mode bearer services [a]

	Bearer service No.	Transfer mode	Transfer rate	Transfer capability	Establishment of the communication	Structure
Virtual call	P1 P2	packet packet	FS FS	unrestricted unrestricted	demand permanent	SDU SDU
User to user signalling	P3 P4	packet packet	FS FS	unrestricted unrestricted	demand permanent	SDU SDU

[a] As given in Recommendation I.232.

FS For further study.

SDU Service data unit.

TABLE 2/I.335

List of teleservices (as described in Recommendation I.241)

No.	Teleservice	Transfer mode	Transfer rate (kbit/s)	Transfer capability	Establishment of communication	Structure	Communication configuration	Symmetry
1.1	telephony	circuit	64	speech	demand	8 kHz	pt-pt	bidirectional symmetric
1.2	telephony	circuit	64	speech	reserved	8 kHz	pt-pt	bidirectional symmetric
1.3	telephony	circuit	64	speech	permanent	8 kHz	pt-pt	bidirectional symmetric
1.4	telephony	circuit	64	speech	demand	8 kHz	multipt	bidirectional symmetric
1.5	telephony	circuit	64	speech	reserved	8 kHz	multipt	bidirectional symmetric
1.6	telephony	circuit	64	speech	permanent	8 kHz	multipt	bidirectional symmetric
2.1	teletex	circuit	64	unrestricted	demand	8 kHz	pt-pt	bidirectional symmetric
3.1	telefax (Group 4)	circuit	64	unrestricted	demand	8 kHz	pt-pt	bidirectional symmetric
4.1	mixed mode	circuit	64	unrestricted	demand	8 kHz	pt-pt	bidirectional symmetric
5.1	videotex [a]	circuit	64	unrestricted	demand	8 kHz	pt-pt	bidirectional symmetric
5.2	videotex [b]	circuit	64	unrestricted	demand	8 kHz	pt-pt	bidirectional symmetric
5.3	videotex [b]	circuit	64	unrestricted	permanent	8 kHz	pt-pt	bidirectional symmetric
5.4	videotex [b]	circuit	64	unrestricted	demand	8 kHz	multipt	bidirectional symmetric
5.5	videotex [b]	circuit	64	unrestricted	permanent	8 kHz	multipt	bidirectional symmetric
5.6	videotex [b]	packet	FS	unrestricted	demand	SDU	pt-pt	bidirectional symmetric
5.7	videotex [b]	packet	FS	unrestricted	permanent	SDU	pt-pt	bidirectional symmetric
5.8	videotex [b]	packet	FS	unrestricted	demand	SDU	multipt	bidirectional symmetric
5.9	videotex [b]	packet	FS	unrestricted	permanent	SDU	multipt	bidirectional symmetric
6.1	telex	circuit	64	unrestricted	demand	8 kHz	pt-pt	bidirectional symmetric
6.2	telex	circuit	64	unrestricted	reserved	8 kHz	pt-pt	bidirectional symmetric
6.3	telex	circuit	64	unrestricted	permanent	8 kHz	pt-pt	bidirectional symmetric
6.4	telex	circuit	64	unrestricted	demand	8 kHz	multipt	bidirectional symmetric
6.5	telex	circuit	64	unrestricted	reserved	8 kHz	multipt	bidirectional symmetric
6.6	telex	circuit	64	unrestricted	permanent	8 kHz	multipt	bidirectional symmetric
6.7	telex	packet	FS	unrestricted	demand	SDU	pt-pt	bidirectional symmetric
6.8	telex	packet	FS	unrestricted	demand	SDU	multipt	bidirectional symmetric

[a] Transmission between user terminal and Videotex centre.

[b] Transmission between Videotex centres and external computers.

FS For further study.

SDU Service data unit.

TABLE 3/I.335

ISDN connection types (based on Table 2/I.340)

Connection type No.	Transfer mode	Transfer rate (kbit/s)	Transfer capability	Structure	Establishment of connection	Communication configuration [a]	Symmetry
A.1	circuit	64	unrestricted digital	8 kHz	switched	pt-pt	bidirectional symmetric
A.2	circuit	64	unrestricted digital	8 kHz	semi-permanent	pt-pt	bidirectional symmetric
A.3	circuit	64	unrestricted digital	8 kHz	permanent	pt-pt	bidirectional symmetric
A.4	circuit	64	speech	8 kHz	switched	pt-pt	bidirectional symmetric
A.5	circuit	64	speech	8 kHz	semi-permanent	pt-pt	bidirectional symmetric
A.6	circuit	64	speech	8 kHz	permanent	pt-pt	bidirectional symmetric
A.7	circuit	64	3.1 kHz audio	8 kHz	switched	pt-pt	bidirectional symmetric
A.8	circuit	64	3.1 kHz audio	8 kHz	semi-permanent	pt-pt	bidirectional symmetric
A.9	circuit	64	3.1 kHz audio	8 kHz	permanent	pt-pt	bidirectional symmetric
A.10	circuit	2×64	unrestricted digital	8 kHz [b]	switched	pt-pt	bidirectional symmetric
A.11	circuit	2×64	unrestricted digital	8 kHz [b]	semi-permanent	pt-pt	bidirectional symmetric
A.12	circuit	2×64	unrestricted digital	8 kHz [b]	permanent	pt-pt	bidirectional symmetric
B.1	packet	64 (FS)	unrestricted digital	SDU	switched	pt-pt	bidirectional symmetric
B.2	packet	64 (FS)	unrestricted digital	SDU	semi-permanent	pt-pt	bidirectional symmetric
C.1	circuit	384	unrestricted digital [c]	8 kHz	switched	pt-pt	bidirectional symmetric
C.2	circuit	384	unrestricted digital [c]	8 kHz	semi-permanent	pt-pt	(unidirectionnal: FS)
C.3	circuit	384	unrestricted digital [c]	8 kHz	permanent	pt-pt	(unidirectionnal: FS)
C.4	circuit	1536	unrestricted digital	8 kHz	switched	pt-pt	bidirectional symmetric
C.5	circuit	1536	unrestricted digital	8 kHz	semi-permanent	pt-pt	(unidirectional: FS)
C.6	circuit	1536	unrestricted digital	8 kHz	permanent	pt-pt	(unidirectional: FS)
C.7	circuit	1920	unrestricted digital	8 kHz	switched	pt-pt	bidirectional symmetric
C.8	circuit	1920	unrestricted digital	8 kHz	semi-permanent	pt-pt	(unidirectional: FS)
C.9	circuit	1920	unrestricted digital	8 kHz	permanent	pt-pt	(unidirectional: FS)

[a] For multipoint services the necessary multipoint capabilities have to be provided.

[b] With RDTD “Restricted differential time delay”.

[c] During an interim period some networks may only offer restricted digital information transfer capability (i.e. an all-zero octet is not allowed).

FS For further study.

SDU Service data unit.

TABLE 4a/I.335

Mapping of bearer services at 64 kbit/s to connection types

Bearer services \ Connection types		64 kbit/s Unrestricted digital			Speech			3.1 kHz audio			Unrestricted digital 2 × 64 kbit/s			Notes
		A.1	A.2	A.3	A.4	A.5	A.6	A.7	A.8	A.9	A.10	A.11	A.12	
Unrestricted digital 64 kbit/s	1.1	X												
	1.2		X											
	1.3		X	X										
Speech	2.1	a)			X			X						b)
	2.2		a)			X			X					b)
	2.3		a)	a)		X	X		X	X				b)
3.1 kHz audio	3.1	a)						X						b)
	3.2		a)						X					b)
	3.3		a)	a)					X	X				b)
Alternate speech/64 kbit/s unrestricted	4.1	a)												c)
	4.2		a)											c)
	4.3		a)	a)										c)
Unrestricted digital 2 × 64 kbit/s	5.1										X			
	5.2											X		
	5.3											X	X	

a) May present A-μ law conversion problems, echo control problems, etc.

b) Analogue transmission may also be used.

c) For the possibility of change of service during a call, see § 5.2 of Recommendation I.340.

X Indicates that the connection type can definitely support the service.

Note 1 – During an interim period, some networks may only support restricted transfer capability (i.e. no all-zero octet allowed).

Note 2 – For multipoint services the necessary multipoint capabilities have to be provided.

TABLE 4b/I.335

Mapping of bearer services 64 kbit/s (up to primary rate) to connection types

Bearer services \ Connection types		384 kbit/s unrestricted			1536 kbit/s unrestricted			1920 kbit/s unrestricted		
		C.1	C.2	C.3	C.4	C.5	C.6	C.7	C.8	C.9
384 kbit/s unrestricted	6.1	X			a)			a)		
	6.2		X			a)			a)	
	6.3		X	X		a)	a)		a)	a)
1536 kbit/s unrestricted	7.1				X			a)		
	7.2					X			a)	
	7.3					X	X		a)	a)
1920 kbit/s unrestricted	8.1							X		
	8.2								X	
	8.3								X	X

[a] An appropriate rate adaption scheme must be defined and utilized.

X Indicates that the connection type can definitely support the service.

TABLE 4c/I.335

Mapping of packet-mode bearer services to connection types

Bearer services \ Connection types	B.1	B.2
P.1	X	
P.2		X
P.3 [a]		
P.4 [a]		

[a] The connection types for these bearer services are for further study.

TABLE 5/I.335

Mapping of teleservices to ISDN connection types

Teleservices \ Connection types		64 kbit/s unrestricted			64 kbit/s speech			64 kbit/s 3.1 kHz audio			Packet		User signalling		Notes
		A.1	A.2	A.3	A.4	A.5	A.6	A.7	A.8	A.9	B.1	B.2	B.3	B.4	
Telephony	1.1	a)			X			X							b)
	1.2		a)			X			X						b)
	1.3		a)	a)		X	X		X	X					c) b)
	1.4	a)			X			X							c) b)
	1.5		a)			X			X						c) b)
	1.6		a)	a)		X	X		X	X					c) b)
Teletex	2.1	X													
Facsimile	3.1	X													
Mixed mode	4.1	X													
Videotex	5.1	X													
	5.2	X													
	5.3		X	X											
	5.4	X													c)
	5.5		X	X											c)
	5.6										X				
	5.7											X			c)
	5.8										X				c)
	5.9											X			c)
Télex	6.1	X													
	6.2		X												
	6.3		X	X											c)
	6.4	X													c)
	6.5		X												c)
	6.6		X	X											
	6.7										X				
	6.8										X				c)

a) May present A-μ law conversion problems; echo control problems, etc.

b) Analogue transmission may also be used.

c) For multipoint services the necessary multipoint capabilities have to be provided.

X Indicates that the connection type can definitely support the service.

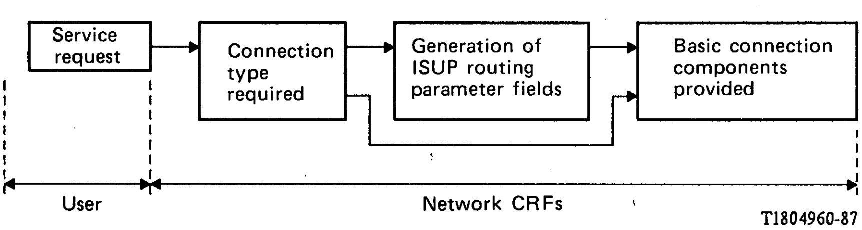


FIGURE 4/I.335

4.1.4 *Terminating local CRF*

The terminating local CRF, e.g. local exchange, processes the incoming IAM. The local CRF uses the information from within the incoming IAM to generate an appropriate Q.931 set-up message. The set-up message is then offered to the destination terminal across the user network interface, subject to certain local conditions and decisions.

4.2 *Elements and parameters*

The routing plan is a set of rules defining the process of selecting appropriate basic connection components conforming to the connection elements capable of supporting a given telecommunication service. These rules are developed in Recommendation E.172. To be able to implement these rules the CRFs must be capable of processing an elaborate set of parameters.

4.2.1 *Description*

This section describes the elements and parameters that may be required for the call routing process. Different network CRFs need not require a complete set of these parameters; however each CRF will require a minimum set to ensure efficient and effective routing.

a) *Calling customer's subscription parameters*

The local CRF may validate service requests against the customer's subscription parameters before the outgoing route is selected.

b) *Incoming route*

Some incoming routes may require special treatment (e.g. not allow access to all outgoing routes).

c) *Called number*

The called number, when provided, is used for routing. Access may be barred to a particular network or a particular customer, under either administrative or network management control, by analysis of the called number.

Note – For destination network, see Table 7/I.335.

d) *Basic telecommunication service request*

The nature of the bearer or teleservice requested, requires parameter analysis to determine relevant attribute values of the minimum necessary connection type capable of supporting that service (e.g. information transfer susceptance, signalling system capabilities, etc.).

The parameters analyzed, for call routing, are predominantly related to the lower layers (e.g. BC). The network may, however, additionally analyze higher layer parameters (e.g. HLC).

e) *Transmission medium requirement (TMR)*

The TMR is the encoding of the information transfer susceptance attribute value of the minimum necessary connection type capable of supporting the call.

Note – Relevant attributes of the minimum necessary connection type are derived at the originating local CRF from the BC (Bearer Capability) and supplementary service request as an intermediate step in determining the values of routing parameters. The information transfer susceptance is derived from the information transfer capability and information transfer rate fields contained in the Q.931 BC information element.

The encoding of the TMR may, depending on the network operator's policy, represent a higher value of the information transfer susceptance attribute that the minimum necessary to support the call. However, between international and internetwork gateways, the TMR should represent the minimum necessary (to support the requested service) and should not be modified. The TMR can then be used between such gateways to perform efficient routing. This does not preclude that some gateways may need to examine additional information [e.g. USI (User Service Information)].

Table 6/I.335 identifies the relationship between some circuit-mode bearer services and teleservices identified in I.230 with the (minimum) TMR value.

The values of TMR for other services is for further study.

TABLE 6/I.335

Relationships between the requested service and the minimum TMR value

<table>
<tr><td colspan="3" rowspan="2">Requested service</td><td colspan="3">TMR value</td></tr>
<tr><td>Speech</td><td>3.1 kHz audio</td><td>64 kbit/s unrestricted</td></tr>
<tr><td rowspan="3">Bearer services</td><td colspan="2">64 kbit/s unrestricted</td><td></td><td></td><td>X</td></tr>
<tr><td colspan="2">3.1 kHz audio</td><td></td><td>X</td><td></td></tr>
<tr><td colspan="2">Speech</td><td>X</td><td></td><td></td></tr>
<tr><td rowspan="3">Teleservices</td><td colspan="2">Telephony 3.1 kHz</td><td>X</td><td></td><td></td></tr>
<tr><td>Facsimile
Teletex
Mixed mode</td><td>64 kbit/s</td><td></td><td></td><td>X</td></tr>
<tr><td colspan="2">Videotex 64 kbit/s</td><td></td><td></td><td>X</td></tr>
</table>

f) *User Service Information (USI)*

The USI is the encoding of the Q.931 BC into Q.762 ISUP. The USI parameter may be used to regenerate attributes of the TMR required by the routing function(s) at intermediate CRFs [see item e) above].

g) *Supplementary service request*

Both ISDN and PSTN services may invoke various supplementary services which may require analysis before the outgoing route is selected. The services can be split into those supported by both the ISDN and PSTN and those supported only by the ISDN. Within each of these two groups, some supplementary services may be realized as a function of the originating local exchange (e.g. short code dialling) while others will require end-to-end capabilities across the network (e.g. calling line identification and closed user group). The provision of these latter supplementary services can influence call routing in terms of the signalling system capability requirement.

Therefore the supplementary service requested can influence the value of the signalling system capability attribute of the connection type capable of supporting that combination of basic and supplementary service.

h) *ISUP preference indicator*

This is an indicator contained within the forward call indicators parameter field of ISUP, sent in the forward direction indicating whether or not the ISDN user part (ISUP) is required or preferred or not required in all parts of the network connection. This information is derived at the originating local CRF from the network signalling capability attribute of the minimum necessary connection type, which is itself derived from the BC and supplementary service request contained in the Q.931 set-up message.

i) *Environment of the connection*

This information element contains three secondary attributes of the requested bearer service that may influence the routing process, namely:

1) the establishment of communication (demand, reserved, permanent);

2) the configuration of communication (point-to-point, multipoint, broadcast);

3) symmetry (symmetric, asymmetric).

These secondary attributes are contained in the Q.931 BC information element and are directly transposed by the originating local CRF into the ISUP user service information parameter field [see item f) above]. The impact of the environment of the connection on TMR for future service is for further study.

Note – Each of these three secondary attributes may invoke special arrangements that may be necessary in order to establish, for example, point-to-multipoint, or asymmetric calls.

j) *Network management conditions*

There may be cases where network management control of routing functions is required. (Route selection may be under control of routing information dynamically updated by network routing processors, i.e. processors monitoring network traffic flows.) For this reason CRFs may be required to implement capabilities for supporting this facility.

k) *Transit network selection*

National networks may implement capabilities allowing requests for specific transit network(s) to be used in the call. Impact of this on call routing may require further study.

l) *Connection history*

In order to ensure that the number of links, the number of satellite hops and any other network limiting functions are not exceeded in a connection, a connection history should be available for processing prior to route selection. A set of relevant parameters is provided in ISUP by the nature of connection indicators parameter field. This field is generated at the originating local exchange and modified at subsequent transit exchanges each time a relevant parameter (e.g. number of satellite links) is affected as a result of the transmission path chosen. Code points for other parameters, e.g. number of sections with digital circuit multiplication equipment (DCME) and A-μ law converters, may not be required for routing purposes since these should be taken into account in the hypothetical digital reference connection (HDRC) at the exchange routing data planning stage. However a signalling capability may be necessary to provide a means of verifying that parameter values are within the allowed limits.

Note – It is considered that the responsibility of international operators for correctly setting up exchange routing data is of paramount importance to ensure that signalling systems and exchange processors are not burdened with the need for per-call conveyance and examination of unnecessary information.

m) *Time of day*

Because of varying traffic distributions during a 24 hour period, it may be advantageous to change the call routing arrangements as a function of the time of day.

4.2.2 *Application in the routing process*

This section deals with the application of the information elements and parameters in the routing process identified in § 4.2.1. The elements and parameters are given in Table 7/I.335 together with their significance with regard to different network CRFs (nodes).

4.2.2.1 *Originating local CRF*

The originating local CRF processes the Q.931 service request and determines if network routing is required. When routing is required, the local CRF maps the requested service into attributes of a connection type that specifies network capabilities sufficient to support this service. This mapping, discussed in § 3, defines the network resources needed to support the service and results in the generation of an appropriate IAM. Additionally, the local CRF allocates the appropriate basic connection components which, as a minimum, conform to the required connection type.

4.2.2.2 *Transit CRF*

The transit CRF will process an incoming IAM and will generate an appropriate outgoing IAM.

The incoming and outgoing IAM mesage contains the following parameter fields which may be used for routing purposes:

- nature of connection indicators,
- forward call indicators,
- calling party's category,
- transmission medium requirement (TMR),
- called party number,
- user service information (USI),
- transit network selection (national use only).

The IAM message may contain other parameters whose presence may influence the choice of signalling system capability for the call. These parameters are:

- call reference,
- calling party number,
- optional forward call indicators,
- redirecting number,
- CUG interlock code,
- connection request,
- user-to-user information,
- access transport.

The parameters listed above contain all the signalling information needed to perform routing in the international network.

In the international network, the TMR is set to the value that represents the minimum network capability to provide the requested service and that value is not modified.

5 ISDN routing principles applicable to network interworking

This section describes routing considerations in network interworking situations (i.e. ISDN to/from other networks), defined in the I.500-Series of Recommendations.

5.1 *ISDN-PSTN interworking*

Routing implications of the following ISDN-PSTN interworking scenarios are described:

i) *ISDN to PSTN*

In this scenario, the call is initiated from an ISDN access and terminated on a PSTN access.

ii) *PSTN to ISDN*

In this scenario, the call is initiated from a PSTN access and terminated on an ISDN access.

These scenarios do not apply to network interworking situations wherein a transit network other than an ISDN or PSTN is involved.

The ISDN bearer capabilities that are compatible with the capabilities of the PSTN are identified in Recommendation I.530. In the general case, an ISDN-originated call incompatible with PSTN capabilities is cleared with an appropriate message.

5.1.1 *ISDN to PSTN direction*

In the ISDN to PSTN direction, a call originating from an ISDN access encounters ISDN to PSTN interworking in the following cases:

i) the call destination is on a PSTN access;

ii) interworking with a non-ISUP signalling system is encountered.

TABLE 7/I.335

Elements and parameters in routing process (Note 1)

Generic list of information which may be required for call routing	Information to be taken into account for routing purposes at:			
	Originating local exchange	National transit exchange	International exchange (ISC)	Terminating local exchange
a) Calling customer's subscription parameters	X			
b) Incoming route		X	X	
c) Called number (including NPI/TON information, if present)	X	X	X	X
Destination network	X	X	X	
d) Basic service request – bearer capability (BC)	X			
e) Transmission medium requirement (TMR)	Generated	X	X (Note 2)	Terminated
f) User service information (USI)	Generated	X	X (Note 2)	
g) Supplementary service request	X (Note 3)			
h) ISUP preference indicator	Generated	X	X	Terminated
i) Environment of the connection	X			
j) Network management conditions	X	X	X	
k) Transit network selection	X	X		
l) Connection history	Generated	X	X	Terminated
m) Time of day	X	X	X	

Note 1 – This table identifies the elements and parameters normally used to route calls. The use of other elements and parameters is not precluded for special circumstances at any routing stage.

Note 2 – The USI parameter field containing the BC information element may be processed if necessary to regenerate the required TMR value capable of supporting the requested service. For calls where BD = speech or 3.1 kHz audio, between A and μ-law networks the BC would be modified (by the μ-law international gateway) accordingly.

Note 3 – The supplementary service request may influence the value of the ISUP preference indicator.

On ISDN to PSTN calls, the call is routed as in an ISDN up to the interworking point. The routing decision is performed at the interworking point. This decision is generally based on information available in the ISUP initial address message. If the interworking point is a transit CRF (national or international) where interworking with a non-ISUP signalling system is encountered, signalling interworking (ISUP to/from non-ISUP) is also performed. If the call can proceed to the PSTN, call establishment continues using normal routing procedures within the PSTN from the interworking point onwards.

On ISDN to PSTN calls, progress indications are returned via S.S. No. 7 ISUP and the procedures of Q.931 to the ISDN origination as soon as interworking with the PSTN is encountered.

5.1.2 *PSTN to ISDN direction*

In the PSTN to ISDN direction, a call encounters PSTN to ISDN interworking in the following cases:

i) the call destination is on an ISDN access;

ii) interworking with an ISUP signalling system is encountered.

In the general case, a call originating from a PSTN access is assumed by the network to be either a voice call or modem-derived voice-band data call; these two call types are indistinguishable. On PSTN to ISDN calls, the call is routed using normal PSTN routing procedures up to the interworking point. At the interworking point the call is routed in the ISDN and offered to the destination as a "3.1 kHz audio" call accompanied by an appropriate Q.931 progress indication.

For some cases, the selection of 3.1 kHz audio may be inappropriate. For example, for PSTN-ISDN data interworking using the 64 kbit/s bearer service, refer to Recommendation I.231. Various selection mechanisms are contained in Recommendation I.515. The routing impacts are for further study.

If the interworking point is a transit CRF (national or international) where interworking with an ISUP signalling system is encountered, signalling interworking (non-ISUP to/from ISUP) is performed at this interworking point.

5.2 *ISDN-PSPDN interworking*

Routing implications of ISDN-PSPDN interworking are for further study.

5.3 *ISDN-CSPDN interworking*

Routing implications of ISDN-CSPDN interworking are for further study.

5.4 *ISDN-ISDN interworking over concatenated networks*

Network concatenation occurs when an existing network (e.g. PSTN, CSPDN, PSPDN) provides a connection between the originating and terminating ISDNs. The routing implications of network concatenation scenarios are for further study.

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SECTION 4

CONNECTION TYPES

Recommendation I.340

ISDN CONNECTION TYPES

(Malaga-Torremolinos, 1984; amended at Melbourne, 1988)

1 General

The ISDN may be described by a limited set of user-network interfaces (refer to Recommendation I.411) and a limited set of ISDN connection types to support the telecommunication services described in the I.200-Series of Recommendations. This Recommendation identifies and defines these connection types which are a description of the lower layer functions (refer to Recommendation I.310) of the ISDN network needed to support the basic services.

This Recommendation should be considered in conjunction with other Recommendations in the I-Series, with particular reference to Recommendations I.120, I.200-Series, I.310, I.320, I.324, I.411 and I.412. For definitions of terms used in this Recommendation, refer to Recommendation I.112.

2 Basic concept of ISDN connection types

2.1 *Introduction*

An ISDN provides a set of network capabilities which enable telecommunication services to be offered to a user (refer to I.200-Series Recommendations).

ISDN connection types are a description, using the attribute method of Recommendation I.140, of the basic low layer functions (BLLFs) of the ISDN. The set of possible values of attributes is given in § 3. It is possible to select combinations of attribute values which are either impractical or of little use; therefore, a set of agreed connection types is given in § 3.

An ISDN connection is a connection established between ISDN reference points (see Recommendations I.310, I.410 and I.411). All ISDN connections are made to support a request for an ISDN service and are time dependent and of finite duration. All ISDN connections will fall under the category of one or other of the connection types. It follows therefore that an ISDN connection type is a time dependent description and an ISDN connection is an instance of a type.

2.2 *Purpose of international connection types*

The definition of a set of ISDN connection types provides the necessary input to identify the network capabilities of ISDNs. Other key requirements of an ISDN are contained in other I-Series Recommendations, in particular in Recommendations I.310, I.410 and I.411.

In addition to describing network capabilities of an ISDN, the identification of ISDN connection types facilitates the specification of network-to-network interfaces. It will also assist in the allocation of network performance parameters.

It should be noted that the user specifies only the service required while the network allocates resources to set up a connection of the specific type as necessary to support the requested service. It is further noted that for certain services additional functions (e.g. additional lower layer functions and or higher layer functions) may be required as depicted in Figure 1/I.340. For examples of such cases, refer to Recommendation I.310.

2.3 *Functions associated with ISDN connection types*

Any ISDN connection type involves an association of functions to support telecommunication services. These functions are fully described in Recommendation I.310.

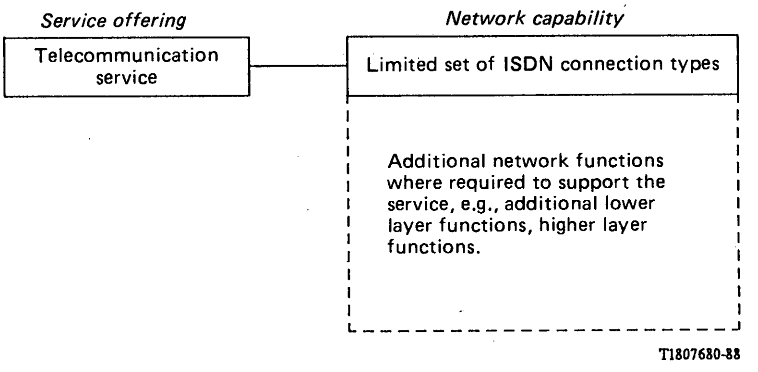


FIGURE 1/I.340

The role of network capabilities in supporting service offerings

2.4 *Applications of ISDN connection types*

Four situations have been identified thus far to which ISDN connection types apply:

– between two ISDN user-network interfaces, i.e. between S/T reference points (refer to Figure 2a/I.340);

  (*Note* – There may be a need in certain cases to differentiate between the S and T reference points. This is for further study.)

– between an ISDN user-network interface and an interface to a specialized network resource (refer to Figure 2b/I.340));

– between an ISDN user-network interface and a network-to-network interface (refer to Figure 2c/I.340);

– between two ISDN-to-other network interfaces (refer to Figure 2d/I.340).

2.5 *ISDN connection involving several networks*

An ISDN connection may comprise a number of tandem network connections. Figure 3/I.340 shows an example in which each end network is an ISDN. The intermediate networks may or may not be ISDNs but they offer the appropriate network capabilities for the service supported by the (overall) ISDN connection. Other configurations are for further study.

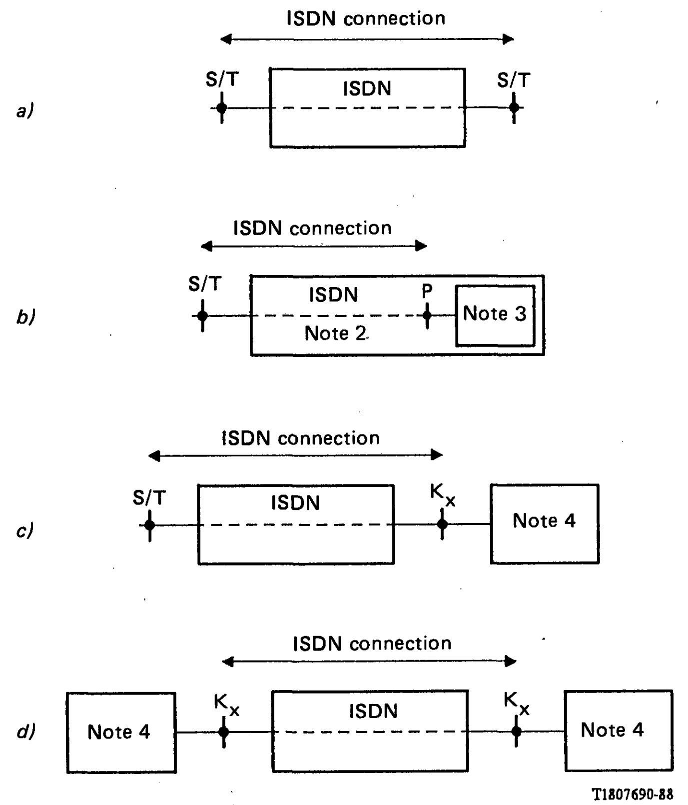
In (overall) ISDN connections involving several networks, each network provides a part of the connection and may be categorized by different attribute values. In such cases, the characterization of the performance for the overall ISDN connection is for further study.

3 ISDN connection types and their attributes

3.1 *Attributes and their values*

ISDN connection types are characterized by a set of attributes. Each attribute has a set of admissible values. The definitions of these attributes are given in Recommendation I.140. Table 1/I.340 of this Recommendation lists the set of attributes and their possible values for connection types and connection elements. The concept of connection elements is explained in detail in § 4.

Figure 4/I.340 shows an example of three different ISDN connections distinguished by differing values for the attribute "topology" in their ISDN connection types. Values for the other attributes of the connection type may be the same, e.g. speech.



Note 1 – The location of reference points used in this figure is defined in Recommendations I.324 and I.411.

Note 2 – This reference point becomes reference point M if the network specialized resource is outside the ISDN.

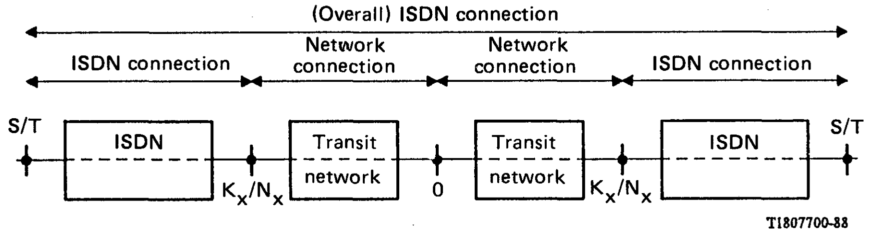
Note 3 – This box represents a specialized network resource. The use of a network specialized resource originates from a service request or is for internal administrative purposes. Some examples are:

1) a network node incorporating additional lower layer functions (ALLFs) and or higher layer functions (HLFs), (refer to Recommendation I.310);
2) a network provided database (which may also be used to fulfil network functions);
3) an operation or management centre.

Note 4 – This box represents either an existing telephone network or a dedicated network.

FIGURE 2/I.340

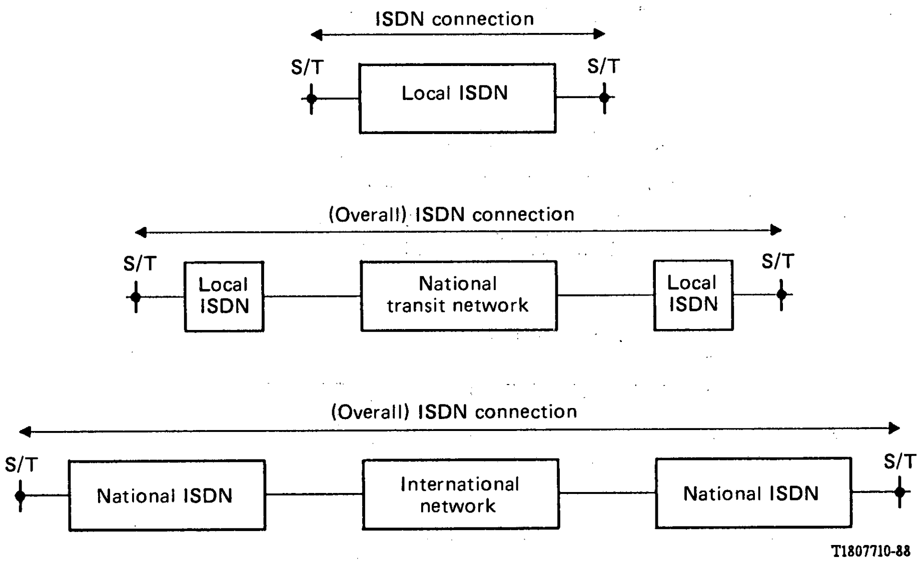
Applications of ISDN connection types



Note – Reference points are defined in Recommendation I.324 and I.411. Reference point 0 may or may not be an ISDN defined reference point.

FIGURE 3/I.340

Example of an ISDN connection involving several networks



Note 1 – (Overall) ISDN connections involving several networks are covered in § 2.5.

Note 2 – The interface points between the national ISDNs and the international network need not necessarily be at the highest hierarchical level of the national ISDNs.

FIGURE 4/I.340

An example of three different ISDN connections distinguished by differing values for the attribute "topology" in their ISDN connection types

The attributes which are associated with the ISDN connection types have a similarity to those used to define telecommunication services in Recommendations I.211 and I.212. However, the two sets of attributes differ in several important aspects. For example:

a) ISDN connection types represent the technical capabilities of the network and are a means to ensure defined performance and interworking between networks. Telecommunication services supported by the ISDN are the packages offered to users and the definition of their attributes is the means to standardize the service offerings worldwide.

b) Quality of service and commercial attributes are relevant to telecommunication services, whereas network performance, network operation and maintenance attributes are relevant to connection types.

3.2 *Rules of association for the attribute values of connection elements and connection types*

This section describes the relationship between the attribute values of connection elements and connection types (see Table 1/I.340). For each attribute the possible values recommended are listed. The definitions of the attributes and attribute values are contained in Recommendation I.140. In addition to the (possible) attribute values applicable to the connection elements, an association law is given (where appropriate) for each attribute to show how the value of the attribute for the overall connection type is obtained from the values of the attribute applicable to the connection elements.

TABLE 1/I.340

Values already identified for attributes for ISDN connection elements and connection types

Attributes	Values for attributes		
	Access connection element	National or international transit connection element	Overall connection type
1 Information transfer mode	Circuit, packet	Circuit, packet	Circuit, packet
2 Information transfer rate			
Layer 1	64, 2 × 64, 384, 1536, 1920	(16, 32), 64, 2 × 64, 384, 1536, 1920	(16, 32), 64, 2 × 64, 384, 1536, 1920
Layer 2	Throughput options for FS	Throughput options for FS	Throughput options for FS
Layer 3	Throughput options for FS	Throughput options for FS	Throughput options for FS
3 Information transfer susceptance	Speech processing equipment e.g. LRE, speech interpolation, μ/A conversion, echo suppression equipment, null	Speech processing equipment e.g. LRE, speech interpolation, μ/A conversion, echo suppression equipment, multisatellite hops, null	Unrestricted digital, 3.1 kHz audio, speech
4 Establishment of connection	Switched, semi-permanent, permanent	Switched, semi-permanent, permanent	Switched, semi-permanent, permanent
5 Symmetry	Unidirectional, bidirectional, symmetric, bidirectional asymmetric	Unidirectional, bidirectional, symmetric, bidirectional asymmetric	Unidirectional, bidirectional, symmetric, bidirectional asymmetric
6 Connection configuration			
Topology	Point-to-point (simple, tandem or 2 × 64 parallel)	Point-to-point (simple, tandem or 2 × 64 parallel) multipoint	Local, national, international (simple or 2 × 64 parallel)
Uniformity	Uniform, non uniform	Uniform, non uniform	Not applicable
Dynamics	Not applicable	Not applicable	Concurrent, sequential, add/remove, symmetry and/or topology change
7 Structure			
Layer 1	8 kHz integrity, 8 kHz integrity with RDTD, unstructured	8 kHz integrity, 8 kHz integrity with RDTD, unstructured	8 kHz integrity, 8 kHz integrity with RDTD, unstructured
Layer 2	SDU integrity, unstructured	SDU integrity, unstructured	SDU integrity, unstructured
Layer 3	SDU integrity, unstructured	SDU integrity, unstructured	SDU integrity, unstructured
8 Channel (rate)			
Information channel	D(16), D(64), B(64), H_0(384), H_{11}(1536), H_{12}(1920)	64, 1536, 1920, analogique	Not applicable
Signalling channel	D(16), D(64), D(16) + B(64), D(64) + B(64)	Common channel signalling system, packet	

Attributes	Values for attributes		
	Access connection element	National or international transit connection element	Overall connection type
9 Connection control protocol [a)]			Not applicable
			Layer 1, Rec. I.430, Rec. I.431, Rec. Q.702, Rec. X.75 physical level [c)], Rec. X.25 physical level [c)]
Layer 2	Rec. I.441, Rec. X.25 link level [c)] [d)], or null	Rec. Q.703, Rec. X.75 link level [c)], Rec. X.25 link level [c)]	
Layer 3	Rec. I.451, Rec. X.25 packet level [c)] [d)]	Rec. Q.704 + SCCP, Rec. X.75 packet level, Rec. Q.704 + ISUP, Rec. X.25 packet level [c)], null	
10 Information transfer coding protocol [a)]			Not applicable
Layer 1	Rec. I.430, Rec. I.431, Rec. G.711	Rec. G.711, Rec. Q.702, Rec. X.75 physical level [c)], Rec. X.25 physical level [c)]	
Layer 2	Rec. I.441, Rec. X.25 link level [c)], or null	Rec. Q.703, Rec. X.75 link level [c)], Rec. X.25 link level [c)] or null	
Layer 3	Rec. I.451, Rec. X.25 packet level [c)] [d)] or null	Rec. Q.704 + SCCP, Rec. X.75 packet level [c)], Rec. Q.704 + ISUP, Rec. X.25 packet level [c)] or null	
11 Network performance [b)]			
a) Error performance	Rec. G.821	Rec. G.821	Rec. G.821
b) Slip performance	Rec. G.822	Rec. G.822	Rec. G.822
12 Network interworking	FS	FS	FS
13 Operations and management	FS	FS	FS

FS further study

[a)] Where there are two or more S/T interfaces, different values of access attributes (attributes 8, 9 and 10) may occur at each interface. Values need to be specified for each channel of the interface structure. The role of the access attributes in determining connection types is for further study. Interfaces to network specialized resources and to other networks are for furter study.

[b)] Examples of the additional performance attributes which may be defined are:

- call and packet processing delays;
- probability of call faillure due to congestion;
- probability of call failure due to network malfunction or packet mishandling;
- information transfer delay;
- error performance [including attributes 11 a) and 11 b)].

[c)] Use of Rec. X.25 and X.75 in ISDN can be found in Rec. X.31.

[d)] Packet connection establishment/release may be a two stage process: stage 1 the selection of a B-channel, stage 2 the setting up of a packet connection. For further details, see Rec. X.31.

3.2.1 *Information transfer mode*

Attribute values for connection elements

Circuit or packet.

Attribute values for overall connection type

Circuit or packet.

Association law

Due to the nature of current packet systems, the use of packet mode in any connection element would make the overall connection type a packet type.

3.2.2 *Information transfer rate (kbit/s)*

Attribute values for connection elements

16 or 32 or 64 or 2 × 64 or 384 or 1536 or 1920

(Values 16 and 32 are not allowed in the access connection element).

Attribute values for overall connection type

(16 or 32) or 64 or 2 × 64 or 384 or 1536 or 1920.

Association law

The value for the overall connection type will be equal to the lowest value of any of its connection elements.

3.2.3 *Information transfer susceptance*

Attribute values for connection elements

Speech processing functions (e.g. low rate encoding (LRE) equipment, speech interpolation, μ/A law conversion) and/or echo suppression functions and/or multiple satellite hops or null.

The exact means of specification of the attribute is for further study. One method would be an appropriate reference to a Recommendation detailing operational requirements in the ISDN.

Attribute values for overall connection types

Unrestricted digital information or 3.1 kHz audio or speech.

Association law

For an overall connection type to have the value *unrestricted digital*, no connection element may contain speech processing functions or echo suppression functions. Connection elements containing speech processing devices having the flexibility to change operation between speech and 64 kbit/s unrestricted would on the other hand be allowed to be a part of a number of different connection types.

For an overall connection type to have the value *3.1 kHz audio*, it may contain echo suppression functions (or it has to disable them prior to data transfer); it must however contain μ/law conversion equipment when appropriate.

For an overall connection type to have the value *speech*, it must contain μ/law conversion equipment and echo suppression functions when appropriate.

These matters are dealt with in more detail in Recommendation I.335.

3.2.4 *Establishment of connection*

Attribute values for connection elements

Switched or semi-permanent or permanent.

Attribute values for overall connection type

Switched or semi-permanent or permanent.

Association law

If all connection elements are permanent, then the overall connection type is permanent.

If any of the connection elements are switched, then the overall connection type is switched. If one or more of the connection elements are semi-permanent and none of the connection elements are switched, then the overall connection type is semi-permanent.

3.2.5 *Symmetry*

Attribute values for connection elements

Unidirectional or bidirectional symmetric or bidirectional asymmetric.

Attribute values for the overall connection type

Unidirectional or bidirectional symmetric or bidirectional asymmetric.

Association law

The overall symmetry can only be generated from the connection elements by analysis of the connection element values in the context of the architecture of the connection.

3.2.6 *Connection of configuration*

3.2.6.1 *Topology*

Attribute values for connection elements

Point-to-point (simple, tandem or 2 × 64 parallel), or multipoint.

(The access connection element may not be multipoint.)

Attribute values for the overall connection type

Local or national or international. (Each simple or 2 × 64 parallel.)

Association law

No association is possible.

3.2.6.2 *Uniformity*

Attribute values for connection elements

Uniform or non-uniform.

Attribute values for the overall connection type

Not applicable.

Association law

Not applicable.

3.2.6.3 *Dynamics*

Attribute values for connection elements

Not applicable.

Attribute values for the overall connection type

Concurrent or sequential or add/remove, or symmetry and/or topology change.

Association law

Not applicable.

3.2.7 *Structure*

Attribute values for connection elements

Layer 1: 8 kHz integrity or 8 kHz integrity with RDTD (Restricted Differential Time Delay)[1), 2)] or unstructured

Layer 2: Service data integrity or unstructured

Layer 3: Service data integrity or unstructured

Attribute values for the overall connection type

As per values for connection elements.

Association law

For further study.

3.2.8 *Channels*

3.2.8.1 *Information channel (rate)*

Attribute values for connection elements

Access connection element: D(16) or D(64) or B(64) or H_0(384) or H_{11}(1536) or H_{12}(1920)

Transit connection element: 64 kbit/s or equivalent in a higher order multiplex or packet system or analogue transmission.

Attribute values for the overall connection type

Not applicable

3.2.8.2 *Signalling channel (rate)*

Attribute values for connection elements

Access connection element: D(16) or D(64) or B(64) + D(16) or B(64) + D(64)

Transit connection element: common channel signalling system or packet

Attribute values for the overall connection type

Not applicable

---

1) The term **RTTD** in the connection type context is defined as follows:

This value applies when:

i) at each point in a connection or connection element, the time slots are explicitly or implicitly demarcated for each information channel or an aggregate of information channels, and

ii) the information parts submitted to the time slots at the the transmitting end are delivered to the receiving end with a differential time delay or not more than 50 ms.

2) 50 ms is a provisional value that needs to be confirmed. This value has to take into account the maximum differential time delay of an appropriate HRX or part thereof as defined in the G-Series Recommendations.

3.2.9 *Connection control protocol*

Attribute values for connection elements

Access connection element:

Layer 1: I.430 or I.431

Layer 2: I.441 or I.441 + X.25 link level

Layer 3: I.451 or I.451 + X.25 packet level

Transit connection element:

Layer 1: Q.702 or X.75 physical level

Layer 2: Q.703 or X.75 link level or Q.703 + X.25 link level

Layer 3: Q.704 + SCCP or Q.704 + ISUP or X.75 packet level or Q.704 + SCCP + X.25 packet level or Q.704 + ISUP + X.25 packet level

Attribute values for the overall connection type

Not applicable.

3.2.10 *Information transfer coding/protocol*

Attribute values for connection elements

Access connection element:

Layer 1: I.430 or I.431 or I.430 + G.711 or I.431 + G.711

Layer 2: I.441 or X.25 link level or null

Layer 3: I.451 or X.25 link packet level or null

Transit connection element:

Layer 1: G.711 or G.702 or X.75 physical level

Layer 2: Q.703 or X.25 link level or X.75 link level or null

Layer 3: X.25 packet level or X.75 packet level or Q.704 + ISUP or null

Attribute values for the overall connection type

Not applicable.

3.2.11 *Network performance*

3.2.11.1 *Error performance*

Attribute values for connection elements

G.821

Attribute values for the overall connection type

G.821

Association law

G.821

3.2.11.2 *Slip performance*

Attribute values for connection elements

G.822

Attribute values for overall connection type

G.822

Association law

G.822

3.2.12 *Further attributes and attribute values*

Section 3.2 has outlined the relationships between those attributes values presently existing; the possibility for new values being added remains.

3.3 *Limited set of ISDN connection types*

From the given list of attributes and their possible values, a large number of connection types can be identified. However, some of these attributes are of a general or dominant nature and an initial set of ISDN connection types can be based on these dominant attributes.

Table 2/I.340 enumerates a limited set of connection types based on the following dominant attributes: information transfer mode, information transfer rate, information transfer susceptance, establishment of connection and symmetry. These connection types are intended to be sufficient to support the basic telecommunication services identified in the I.200-Series of Recommendations. Additional connection types are for further study.

4 **Connection elements**

The ISDN network architecture Recommendation I.324 explains how an ISDN connection type is made up of connection elements (CEs). This concept is illustrated in Figure 5/I.340 and this is valid for all connection types between S/T reference points. A particular ISDN connection may be local (i.e. only access connection elements are involved), national transit (i.e. involving access and national transit CEs), or international (i.e. involving all three kinds of CEs).

Current Recommendations allow collocation and non-collocation of each of the types of CRFs indicated in Figure 5/I.340. This is a national matter.

4.1 *Access connection element*

The access connection element is the portion of the connection from the S/T reference point to the local connection related function (CRF). In the case of permanent connection types an equivalent point to the local CRF needs to be defined.

4.2 *National transit connection element*

The national transit connection element is the portion of the connection between the local CRF and the international CRF. In the case of a national connection this would default to a "transit connection element", i.e. between two local CRFs, but could involve network elements from more than one network operator.

4.3 *International connection element*

The international connection element is the portion of the connection between the originating and destination international CRFs.

4.4 *Use of connection elements*

By using connection elements and attributes which have a layered nature, the construction of a connection type is more easily described. The use of different values for the same attribute in different connection elements allows for a greater degree of description and flexibility.

The connection element analysis may assist in the description of a complex and asymmetric ISDN connection. This is illustrated in Figure 6/I.340, in which the configuration attributes of topology, uniformity and dynamics for a connection type are described using the concept of connection elements.

Different connection elements which constitute an ISDN connection may have different sets of attributes. In this case the attributes across the connection are not homogeneous, and the available attributes of the connection are limited by the most restrictive set of attributes of all the connection elements of the connection.

TABLE 2/I.340

Set of ISDN connection types

ISDN connection type identity		Attributes												
		Dominant attributes which define ISDN connection types						Additional attributes						
		1	2	3	4	5	6	7	8	9	10	11	12	13
CT No.	ISDN CT category	Inform. transfer mode	Inform. transfer rate (kbit/s)	Inform. transfer susceptance	Establish-ment of connection	Symmetry	Connection configuration	Structure	Channel (rate) [a]	Connec-tion control protocol	Inform transfer coding/ protocol	Network perform-ance [c]	I/W	O & M
A 1	64 kbit/s unres-tricted digital	Circuit	64	Unrestricted digital	Switched	Bidirectional symetric	Pt-pt multipoint	8 kHz	B(64)	[e]				
A 2		Circuit	64	Unrestricted digital	Semi-perm-anent	Bidirectional symetric	Pt-pt multipoint	8 kHz	B(64)					
A 3		Circuit	64	Unrestricted digital	permanent	Bidirectional symetric	Pt-pt multipoint	8 kHz	B(64)					
A 4	Speech	Circuit	64	Speech	Switched	Bidirectional symetric	Pt-pt multipoint	8 kHz	B(64)					
A 5		Circuit	64	Speech	Semi-perm-anent	Bidirectional symetric	Pt-pt multipoint	8 kHz	B(64)					
A 6		Circuit	64	Speech	Permanent	Bidirectional symetric	Pt-pt multipoint	8 kHz	B(64)					
A 7	3.1 kHz audio	Circuit	64	3.1 kHz audio	Switched	Bidirectional symetric	Pt-pt multipoint	8 kHz	B(64)					
A 8		Circuit	64	3.1 kHz audio	Semi-perm-anent	Bidirectional symetric	Pt-pt multipoint	8 kHz	B(64)					
A 9		Circuit	64	3.1 kHz audio	Permanent	Bidirectional symetric	Pt-pt multipoint	8 kHz	B(64)					

TABLE 2/I.340 *(cont.)*

ISDN connection type identity		Attributes												
		Dominant attributes which define ISDN connection types						Additional attributes						
		1	2	3	4	5	6	7	8	9	10	11	12	13
CT No.	ISDN CT category	Inform. transfer mode	Inform. transfer rate (kbit/s)	Inform. transfer susceptance	Establishment of connection	Symmetry	Connection configuration	Structure	Channel (rate) [a]	Connection control protocol	Inform transfer coding/ protocol	Network performance [c]	I/W	O & M
A 10		Circuit	2×64	Unrestricted	Switched	Bidirectional symetric	Pt-pt multipoint +2×64 k	8 kHz RDTD	2 × B					
A 11	Circuit 2×64	Circuit	2×64	Unrestricted	Semi-permanent	Bidirectional symetric	Pt-pt multipoint +2×64 k	8 kHz RDTD	2 × B					
A 12		Circuit	2×64	Unrestricted	Permanent	Bidirectional symetric	Pt-pt multipoint +2×64 k	8 kHz RDTD	2 × B					
B 1	Packet	Packet	64 (FS)	Unrestricted	Switched	Bidirectional symetric	Pt-pt multipoint	SDU	B(64)					
B 2		Packet	64 (FS)	Unrestricted	Semi-permanent	Bidirectional symetric	Pt-pt multipoint	SDU	B(64)					
C 1		Circuit	384	Unrestricted	Switched	Bidirectional symetric	Pt-pt multipoint	8 kHz	H_0(384)					
C 2	Broadband [d]	Circuit	384	Unrestricted	Semi-permanent	Bidirectional symetric	Pt-pt multipoint	8 kHz	H_0(384)					
C 3		Circuit	384	Unrestricted	Permanent	Unidirectional [b]	Pt-pt multipoint	8 kHz	H_0(384)					

TABLE 2/I.340 *(end)*

ISDN connection type identity		Attributes												
		Dominant attributes which define ISDN connection types						Additional attributes						
		1	2	3	4	5	6	7	8	9	10	11	12	13
CT No.	ISDN CT category	Inform. transfer mode	Inform. transfer rate (kbit/s)	Inform. transfer susceptance	Establish-ment of connection	Symmetry	Connection configuration	Structure	Channel (rate) [a]	Connec-tion control protocol	Inform transfer coding/ protocol	Network perform-ance [c]	I/W	O & M
C 4		Circuit	1536	Unrestricted	Switched	Unidirectional [b]	Pt-pt multipoint	8 kHz	H_{11}(1536)					
C 5		Circuit	1536	Unrestricted	Semi-perm-anent	Unidirectional [b]	Pt-pt multipoint	8 kHz	H_{11}(1536)					
C 6	Broad-band [d]	Circuit	1536	Unrestricted	Permanent	Unidirectional [b]	Pt-pt multipoint	8 kHz	H_{11}(1536)					
C 7		Circuit	1920	Unrestricted	Switched	Unidirectional [b]	Pt-pt multipoint	8 kHz	H_{12}(1920)					
C 8		Circuit	1920	Unrestricted	Semi-perm-anent	Unidirectional [b]	Pt-pt multipoint	8 kHz	H_{12}(1920)					
C 9		Circuit	1920	Unrestricted	Permanent	Unidirectional [b]	Pt-pt multipoint	8 kHz	H_{12}(1920)					

CT Connection type

FS Further study

I/W Interworking

O & M Operations and management

RDTD Restricted differential time delay

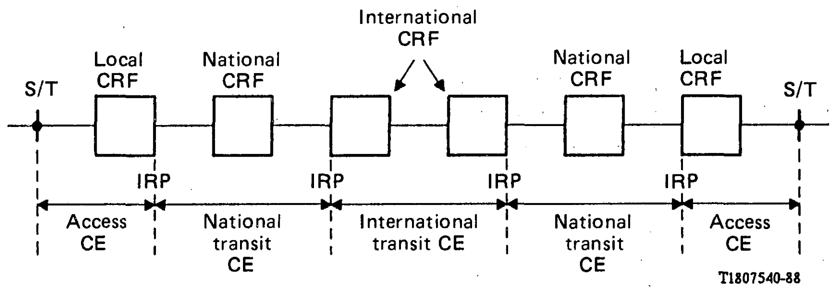
[a] D(16, 64) for signalling.

[b] Unidirectional: further study.

[c] Parameters have to be based on network performance parameter values as described in Recommendations G.821, G.822 and others.

[d] Some networks will not support these connection types until some future date; additionally, Recommendations are not yet available for the switching of H_0 and H_1 channels.

[e] Overall connection control protocol is the resultant of the interactions of the access and inter-exchange connection control protocols.



IRP Internal reference point
CRF Connection related function

FIGURE 5/I.340

General reference configuration for ISDN

4.5 *Basic connection components*

A connection element is composed of basic connection components. These are identified by the appropriate functional groupings and delimiting reference points.

Two categories of basic connection components are considered:

- where CRFs are not included, e.g. transmission links (Figure 7/I.340 shows such a basic connection component for the digital subscriber line section);
- where CRFs are included, e.g. exchange connections as they are defined in Recommendation Q.513. (Figure 8/I.340 shows such a basic connection component for a circuit switched, 64 kbit/s, point-to-point connection in a local or combined exchange.)

When referencing to the relevant switching and transmission Recommendations, the basic connection components provides a bridge between the connection type and the physical network. The definition of appropriate rules for the selection of references is for further study.

5 Relationship between services and ISDN connection types

5.1 *General relationship*

Given a user request for a telecommunication service at the initiation of a call, the network must choose a connection of a connection type that supports the attributes of the service requested. This selection of a connection is effected at the time of call set-up as a routing function based on a table of options derived during the planning and implementation of the network. The options a network implements will be based on the capabilities needed to support the services the network intends to offer.

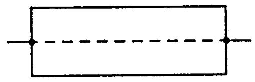
5.2 *Network capability to support a change in service during a call*

Recommendation I.231 identifies a bearer service alternate speech/64 kbit/s unrestricted which has a value of the information transfer capability attribute which can alternate.

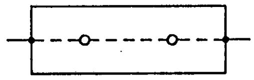
When the user requests this service, this alterable attribute value should be identified in the signalling mesages during call set-up. During the call, the user will also use signalling messages to request a change in absolute value of this attribute when it is actually desired; and the network will confirm the request for change.

a) *Topology*

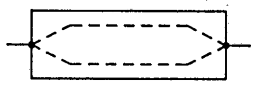
i) Simple



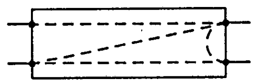
ii) Tandem,



iii) Parallel



iv) Multipoint [a]



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v) Others (for further study)

vi) Combination of the above

b) *Uniformity*

i) Uniform (all connection elements identical)

ii) Non-uniform (some connection elements different)

c) *Dynamics*

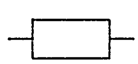
i) Concurrent (all connection elements established and released simultaneously)

ii) Sequential (only one connection element established at a given time)

iii) Add/remove (connection elements may be added and/or removed during a call)

iv) Symmetry and/or topology change (the symmetry attribute value may be changed during a call).

Connection element



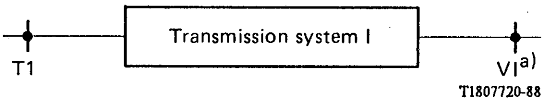
ISDN connection type

T1807750-88

[a] Each segment of the multipoint connection consists in general of several connection elements in tandem. The use of non-hierarchical networks, e.g. a satellite based network, may allow a reduction of the connection elements for each segment.

FIGURE 6/I.340

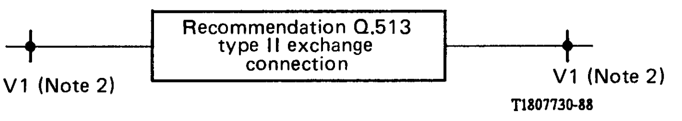
Description of the connection configuration attributes of an ISDN connection using the connection element analysis



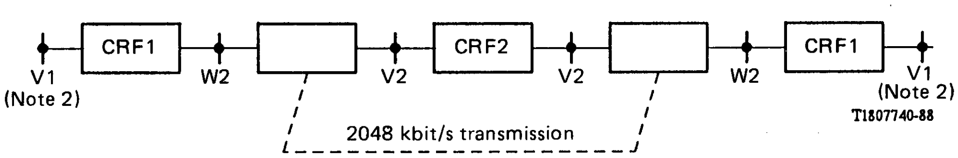
a) Or at other interfaces at the local exchange to be identified.

FIGURE 7/I.340

A basic connection component for the transmission section of a basic subscriber access



a) Basic connection components for a circuit switched, 64 kbit/s, point-to-point connection in a local or combined exchange for a local call, between basic accesses



CRF1 + CRF2 + CRF1 is equivalent to type II exchange connection.

b) Basic connection components for a circuit switched, 64 kbit/s, point-to-point connection in a local or combined exchange for a local call between basic accesses, where remote concentrators are used

Note 1 — Depending on national implementations a basic connection component can be split into more than one BC. This can apply for example to a local network where a remote switching unit is used [see part b) of the figure which is a splitting of part a) of the figure when remote concentrators are used].

Note 2 — Or at other interfaces at the local exchange to be identified.

FIGURE 8/I.340

Unless the change in service capability is requested by the user (and agreed to by the network) at the time of call establishment, a change in service request during a call may or may not be granted by the network. The user always has, of course, the option of terminating the call and establishing a new call with different service characteristics.

For service and operational reasons a rapid and reliable changeover is required and this should be considered in implementing the capability for change in service during a call.

When the connection elements/components have an inherent alterable feature which can be dynamically changed from the adjoining exchanges using out-of-band control signalling, then a rapid and reliable changeover can be achieved. The changes may involve disabling, bypassing or introduction of particular network functions (e.g. circuit multiplication equipment, A/μ law converters, echo control, digital pads). The inter-exchange signalling principles to support the alternate speech/64 kbit/s unrestricted ISDN bearer service are contained in Recommendation Q.764. The network capability to support a change in service during a call is for further study.

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SECTION 5

PERFORMANCE OBJECTIVES

Recommendation I.350

GENERAL ASPECTS OF QUALITY OF SERVICE AND NETWORK PERFORMANCE IN DIGITAL NETWORKS, INCLUDING ISDN

(Melbourne, 1988)

1 General

1.1 *Purpose of Recommendation*

This Recommendation has been developed to:

- provide descriptions of Quality of Service and Network Performance;
- illustrate how the Quality of Service and the Network Performance concepts are applied in digital networks, including ISDNs;
- describe the features of, and the relationship between, these concepts;
- indicate and classify performance concerns for which parameters may be needed;
- identify generic performance parameters.

The generic term "performance" refers to Quality of Service and to Network Performance as they are defined in § 1.2.

1.2 *Descriptions of Quality of Service (QOS) and Network Performance (NP)*

1.2.1 *Description of Quality of Service*

QOS is defined in Recommendation G.106 *(Red Book)* as follows: "Collective effect of service performances which determine the degree of satisfaction of a user of the service".

The note of Recommendation *(Red Book)* underlines that the QOS is characterized by the combined aspects of:

- service support and service operability performance, and
- servability and service integrity performance.

The definition of Quality of Service in Recommendation G.106 *(Red Book)* is a wide one encompassing many areas of work, including subjective customer satisfaction. However, within this Recommendation the aspects of Quality of Service that are covered are restricted to the identification of parameters that can be directly observed and measured at the point at which the service is accessed by the user. Other types of QOS parameters which are subjective in nature, i.e. depend upon user actions or subjective opinions, will not be specified in the I-Series Recommendations on QOS.

1.2.2 *Description of Network Performance*

Network Performance is a statement of the performance of the connection element or concatenation of connection elements employed to provide a service. It is defined and measured in terms of parameters which are meaningful to the network provider and are used for the purposes of system design, configuration, operation and maintenance. NP is defined independently of terminal performance and user actions.

network performance (NP) is defined as the ability of a network or network portion to provide the functions related to communications between users.

Note – The performance of a network and its component parts contributes to servability performance and service integrity performance as defined in Recommendation G.106 *(Red Book)*, and is characterized by a set of measurable and calculable parameters.

2 Purpose of QOS and NP

2.1 *General*

Bearer services and teleservices as described in the I.200-Series Recommendations are the objects which network and service providers offer to their customers. A major attribute of these services is the set of QOS parameters which a particular service offers. These parameters are user oriented and take into account the elements involved in a particular service as given in Figure 2/I.211.

Bearer services and teleservices are supported by a range of connection types, each of which comprises several connection elements. The performance of the connection types is characterized by a set of NP parameters. These parameters are network oriented.

Figure 1/I.350 illustrates how the concepts of QOS and NP are applied in the ISDN environment.

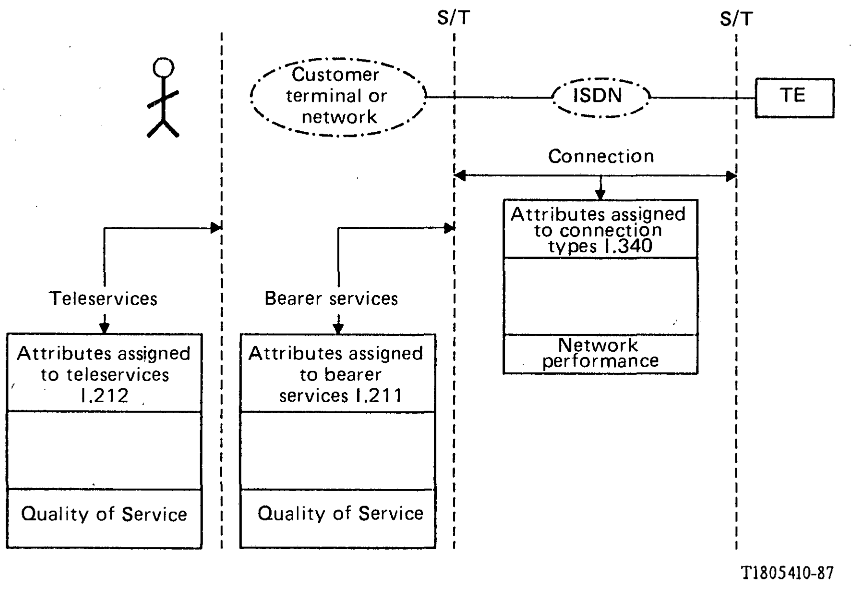

FIGURE 1/I.350

General scope of Quality of Service and network performance

2.2 *Purpose of QOS*

A typical user is not concerned with how a particular service is provided, or with any of the aspects of the network's internal design. However, he is interested in comparing one service with another in terms of certain universal, user-oriented performance concerns which apply to any end-to-end service. Therefore from a user's point of view, Quality of Service is best expressed by parameters which:

- focus on user-perceivable effects, rather than their causes within the network;
- do not depend, in their definition, on assumptions about the network internal design;
- take into account all aspects of the service from the user's point of view which can be objectively measured at the service access point;
- may be assured to a user at the service access point by the service provider(s);
- are described in network independent terms and create a common language understandable by both the user and the service provider.

2.3 *Purpose of NP*

A network provider is concerned with the efficiency and effectiveness of the network, in providing services to customers. Therefore from a network provider's point of view, NP is best expressed by parameters which provide information for:

- system development;
- network planning, both nationally and internationally;
- operation and maintenance.

3 **Principles for the development of QOS and NP parameters and values**

3.1 *General principles*

3.1.1 *Distinction between QOS and NP*

The user oriented QOS parameters provide a valuable framework for network design, but they are not necessarily usable in specifying performance requirements for particular connections. Similarly, the NP parameters ultimately determine the (user observed) QOS, but they do not necessarily describe that quality in a way that is meaningful to users. Both types of parameters are needed, and their values must be quantitatively related if a network is to be effective in serving its users. The definition of QOS and NP parameters should make mapping of values clear in cases where there is not a simple one-to-one relationship between them.

Table 1/I.350 shows some of the characteristics which distinguish QOS and NP.

3.1.2 *Measurability of QOS and NP parameter values*

Due to separating QOS and NP, a number of general points should be noted when considering the development of parameters:

- the definition of QOS parameters should be clearly based on events and states observable at service access points and independent of the network processes and events which support the service;
- the definition of NP parameters should be clearly based on events and states observable at connection element boundaries, e.g. protocol specific interface signals;
- the use of events and states in the definition of parameters should provide for measurements at the boundaries identified above. Such measurements should be verifiable in accordance with generally accepted statistical techniques.

TABLE 1/I.350

Distinction between quality of service and network performance

Quality of service	Network performance
User oriented	Provider oriented
Service attribute	Connection element attribute
Focus on user-observable effects	Focus on planning, development (design), operations and maintenance
Between (at) service access points	End-to-end or network connection elements capabilities

3.1.3 *Multiple network provider environments*

It should be recognized in the development of parameter values that services may be provided by multiple providers. In such an environment different levels of QOS may be supported. Therefore, in practice, users may experience a variety of ranges of QOS. It is thus important to establish minimum performance levels for each service and for connection elements providing international connections.

3.2 *QOS principles*

For the definition of parameters for QOS in the ISDN, the concept of bearer services and teleservices needs to be borne in mind. In particular, there is a difference between the kinds of parameters which would describe the QOS of a bearer service and that of a teleservice, since the point of observation of, or access to, the service is different in each case. Figure 1/I.350 illustrates this point.

In the case of teleservices the interface between the user and the service provider may be a man-machine interface. In the case of bearer services this interface corresponds to the S/T reference points. As a result, some of the parameters for describing the QOS of a teleservice will be different from those which describe the QOS of a bearer service.

In describing the QOS of teleservicess, the performance of the terminal equipment (TE) has to be taken into account. For a teleservice, there should be a mapping between the QOS of the teleservice and the performance of the customer equipment including the terminal and the overall (end-to-end) NP of the connection elements supporting this service.

For bearer service there should be mapping between the QOS of the bearer service and the overall (end-to-end) NP of connection elements supporting this service.

3.3 *NP principles*

When developing NP parameters the following points should be borne in mind:

– NP parameters must be measurable at the boundary of the network connection element(s) to which they are applied. The definitions should not be based on assumptions about either the internal characteristics of a network (or portions thereof), or the internal causes of impairments observed at the boundaries;

- the division of a network portion into sub-components should only be done if they must be specified separately in order to ensure satisfactory end-to-end performance or, where appropriate, to derive fair and reasonable allocations among providers. No network provider should bear a disproportionate cost in establishing and operating a service.

3.4 *Primary and derived performance parameters*

3.4.1 *Description*

primary performance parameter

A parameter or a measure of a parameter determined on the basis of direct observations of events at services access points or connection element boundaries.

derived performance parameter

A parameter or a measure of a parameter determined on the basis of observed values of one or more relevant primary performance parameters and decision thresholds for each relevant primary performance parameter.

3.4.2 *Relationship between primary and derived performance parameters*

A number of event types can be directly observed at service access points or connection element boundaries. Examples of such events are:

- the layer 3 protocol state transition associated with the transfer of a SETUP message or a DISCONNECT message across a connection element boundary;
- the correct receipt of an information bit (or a specified number of information bits) at an interface.

Parameters related to the time interval between specific events and the frequency of events can be measured. These directly measurable parameters or primary performance parameters describe the QOS (at service access points) or the NP (at connection element boundaries) during periods when the service or connection is available.

Derived performance parameters describe performance based on events which are defined as occurring when the value of a function of a primary performance parameter(s) crosses a particular threshold. These derived threshold events identify the transitions between the available and the unavailable states. Parameters related to the time interval between these derived threshold events and their frequency can be identified. These derived performance parameters describe the QOS and the NP for all time intervals; i.e. during periods when the service or connection is available or unavailable.

Note – Primary performance parameters are measured for all time intervals, since the transitions between available and unavailable states depend upon the value of these parameters. However, the values of primary performance parameters would not be specified for a service or connection in the unavailable state.

4 Generic performance parameters

Nine generic primary performance parameters are listed below. These have been developed as a result of the matrix approach described in Annex A. These parameters may be used in developing specific QOS and NP parameters:

- access speed;
- access accuracy;
- access dependability;
- information transfer speed;
- information transfer accuracy;

- information transfer dependability;
- disengagement speed;
- disengagement accuracy;
- disengagement dependability.

Section 3.4 defines derived performance parameters in addition to primary parameters. Derived performance parameters are determined utilizing a function of the primary performance parameter values. Recommendation G.821 defines one such function, which identifies transitions between available and unavailable states based on a threshold for severely errored seconds. The generic derived performance parameter associated with such a function is availability.

Examples of specific primary and derived performance parameters for bearer service QOS and those for circuit-switched and packet-switched NP are provided in Annex B.

ANNEX A

(to Recommendation I.350)

Method of identifying parameters

A.1 *The matrix approach*

The matrix provides a systematic method of identifying and organizing candidate network performance parameters with the objective of defining a concise set of parameters and, where appropriate, their QOS counterparts. This tool should be used as the basis for collection and evaluation of network performance parameters for digital networks, including ISDNs.

A.2 *3 × 3 matrix approach for network performance*

The 3 × 3 matrix approach for network performance is illustrated in Figure A-1/I.350. The main features are as follows:

1) Each row represents one of the three basic and distinct communication functions.

   Note – The access function represents the connectionless as well as connection oriented services which are possible with ISDNs.

2) Each column represents one of the three mutually exclusive outcomes possible when a function is attempted.

3) The 3 × 3 matrix parameters are defined on the basis of events at connection element boundaries and are termed "primary performance parameters". "Derived performance parameters" are defined on the basis of a functional relationship of primary performance parameters, outage thresholds and an observation interval.

4) NP primary performance parameters should be defined so as to be measurable at the boundaries of the connection element(s) to which they apply. NP parameter definitions should not depend upon assumptions about impairment causes that are not detectable at the boundaries.

5) Availability is a derived performance parameter. Decisions on the appropriate primary performance parameters, outage threshold and algorithms for its definition require further detailed study.

Note – The following terminology problems are pointed out. Appropriate terms should be selected after further study:

a) the term "access" is used. However, the term "selection (of the connection type, the destination and facility)" has been proposed as an alternative.

b) The term "dependability" is used. However, the definition of dependability as used here is somewhat different from that in Recommendation G.106 *(Red Book)*. Alternative terms, "inserveability" and "refusal" are proposed.

c) The term "availability" is provisionally used. An alternative term "acceptability" has been proposed.

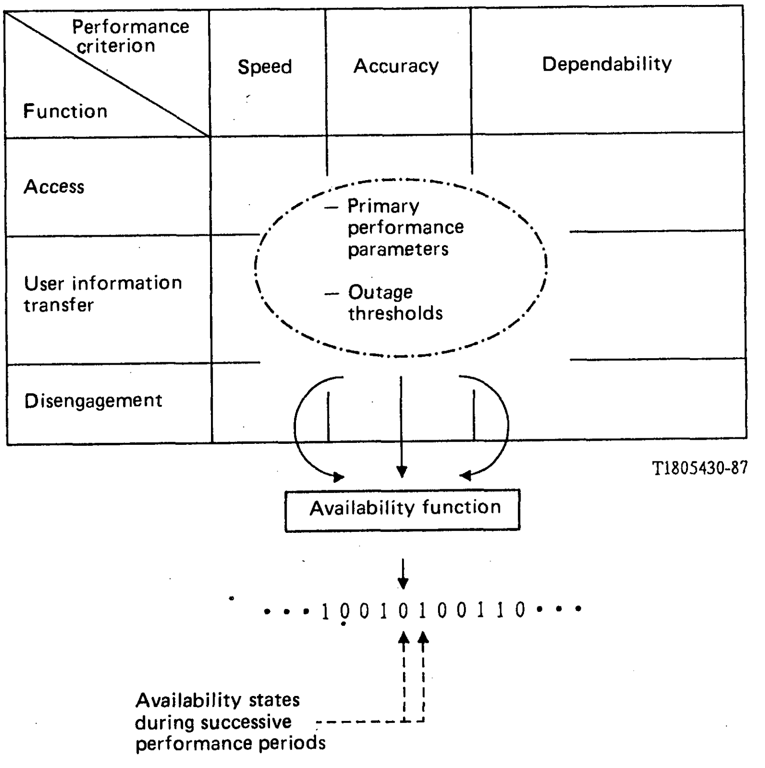

FIGURE A-1/I.350

3×3 matrix approach and determination of availability states

A.3 *3 × 3 matrix approach for QOS*

The same 3 × 3 matrix approach as that described for network performance may be used for the related Quality of Service parameters.

QOS parameters should be defined so as to be measurable at service access points. QOS parameter definitions should not depend upon assumptions of impairment causes that are not detectable at the service access points.

Loss of service parameters are considered to be derived QOS parameters. An alternative matrix has been proposed and is still under consideration.

A.4 *Description of the basic communication functions*

A.4.1 *Access*

The access function begins upon issuance of an access request signal or its implied equivalent at the interface between a user and the communication network. It ends when either:

1) a ready for data or equivalent signal is issued to the calling users, or

2) at least one bit of user information is input to the network (after connection establishment in connection-oriented services).

It includes all activities traditionally associated with physical circuit establishment (e.g. dialling, switching, and ringing) as well as any activities performed at higher protocol layers.

A.4.2 *User information transfer*

The user information transfer begins on completion of the access function, and ends when the "disengagement request" terminating a communication session is issued. It includes all formatting, transmission, storage, error control and media conversion operations performed on the user information during this period, including necessary retransmission within the network.

A.4.3 *Disengagement*

There is a disengagement function associated with each participant in a communication session: each disengagement function begins on issuance of a disengagement request signal. The disengagement function ends, for each user, when the network resources dedicated to that user's participation in the communication session have been released. Disengagement includes both physical circuit disconnection (when required) and higher-level protocol termination activities.

A.5 *Description of the performance*

A.5.1 *Speed*

Speed is the performance criterion that describes the time interval that is used to perform the function or the rate at which the function is performed. (The function may or may not be performed with the desired accuracy.)

A.5.2 *Accuracy*

Accuracy is the performance criterion that describes the degree of correctness with which the function is performed. (The function may or may not be performed with the desired speed.)

A.5.3 *Dependability*

Dependability is the performance criterion that describes the degree of certainty (or surety) with which the function is performed regardless of speed or accuracy, but within a given observation interval.

ANNEX B

(to Recommendation I.350)

Relationship between generic and possible specific QOS and NP parameters

This Annex illustrates the qualitative relationship between the generic parameters defined in this Recommendation and a candidate set of specific QOS and NP parameters. Tables B-1/I.350, B-2/I.350 and B-3/I.350 illustrate the relationship between the generic parameters and specific bearer service QOS, circuit-switched NP, and packet-switched NP parameters, respectively.

TABLE B-1/I.350

Qualitative relationship between generic performance parameters and candidate bearer service QOS parameters

Bearer service QOS parameters / Generic parameters		Primary performance parameters												Derived performance parameters		
		Access delay	Incorrect access probability	Access denial probability	User information transfer delay	User information transfer rate	User information error probability	Extra user information delivery probability	User information misdelivery probability	User information loss probability	Disengagement delay	Incorrect disengagement probability	Disengagement denial probability	Service availability	User information transfer denial probability	Service outage duration
Primary	Access speed	X														
	Access accuracy		X													
	Access dependability			X												
	Information transfer speed				X	X										
	Information transfer accuracy						X	X	X							
	Information transfer dependability									X						
	Disengagement speed										X					
	Disengagement accuracy											X				
	Disengagement dependability												X			
Derived	Availability													X	X	X

TABLE B-2/I.350

Qualitative relationship between generic performance parameters and candidate circuit-switched NP parameters

Generic parameters	Circuit-switched NP parameters	Primary performance parameters												Derived performance parameters	
		Connection set-up delay	Alerting delay	Connection set-up error probability	Coonnection set-up denial probability	Propagation delay	Degraded minutes	Severely errored seconds	Errored seconds	Disconnected delay	Release delay	Premature disconnect probability	Connection clearing denial probability	Network capability outage duration	Network availability
Primary	Access speed	X	X												
	Access accuracy			X											
	Access dependability				X										
	Information transfer speed					X									
	Information transfer accuracy						X	X	X						
	Information transfer dependability														
	Disengagement speed									X	X				
	Disengagement accuracy											X			
	Disengagement dependability												X		
Derived	Availability													X	X

TABLE B-3/I.350

Qualitative relationship between generic performance parameters and candidate packet-switched NP parameters

Generic parameters \ Packet-switched NP parameters		Primary performance parameters: Virtual circuit set-up delay	Virtual circuit set-up error proba-bility	Virtual circuit set-up denial proba-bility	Date packet transfer delay	Through-put capacity	Residual error rate	Reset proba-bility	Reset stimulus proba-bility	Virtual circuit clearing delay	Virtual circuit clearing denial proba-bility	Virtual circuit premature discon-nect proba-bility	Virtual circuit premature discon-nect stimulus proba-bility	Derived performance parameters: Network capability outage duration	Network availa-bility
Primary	Access speed	X													
	Access accuracy		X												
	Access dependability			X											
	Information transfer speed				X	X									
	Information transfer accuracy						X	X	X						
	Information transfer dependability						X	X	X						
	Disengagement speed									X					
	Disengagement accuracy														
	Disengagement dependability										X	X	X		
Derived	Availability													X	X

Recommendation I.351

RECOMMENDATIONS IN OTHER SERIES CONCERNING NETWORK PERFORMANCE OBJECTIVES THAT APPLY AT REFERENCE POINT T OF AN ISDN

(Melbourne, 1988)

The following Recommendations of the G-Series are applicable to reference point T of an ISDN:

G.821 Error performance of an international digital connection forming part of an integrated services digital network.

G.822 Controlled slip rate objectives on an international digital connection.

Recommendation I.352

NETWORK PERFORMANCE OBJECTIVES FOR CONNECTION PROCESSING DELAYS IN AN ISDN

(Melbourne, 1988)

1 General

1.1 *Reference model*

This Recommendation provides network performance objectives for connection processing delays. The reference model provided in Recommendation I.340 was used to provide a baseline reference configuration. In addition, Recommendation Q.709 was taken into account in the determination of values.

Note – This Recommendation does not take into account the performance of private networks. In case of private networks connected to the ISDN, the recommended values refer to reference point T. Reference point S applies in cases where S and T are coincident.

1.2 *Measurement*

All parameter values are specified at network boundaries. These values are measured at the ISDN S/T reference points using all processing message transfer events (MTEs) (Recommendation Q.931 messages or the corresponding Signalling System No. 7 messages), where appropriate.

1.3 *Network conditions*

The values for delay given in this Recommendation include an allowance for the effects on delay that might be introduced during a nominal busy hour. Consideration was given to the possibility that individual busy hours might not be coincident. The values also include the effects of network component failures. The specified values do not apply under conditions of network unavailability. These delays are expressed in terms of mean and 95% probability values.

1.4 *User delay*

Values are provided for measurements made at a single connection element boundary as well as measurements made between two connection element boundaries. This allows for calculations that would avoid inclusion of any delay that might be introduced by users or user equipment.

1.5 *Allocation*

Overall connection processing delays between S/T reference points can be divided into sub-values for each connection element including the national and international portions.

1.6 *Basic connection*

Connection processing delays are only defined for a basic connection and therefore do not provide for any effects that might be introduced by supplementary services (see Figure 1/I.352).

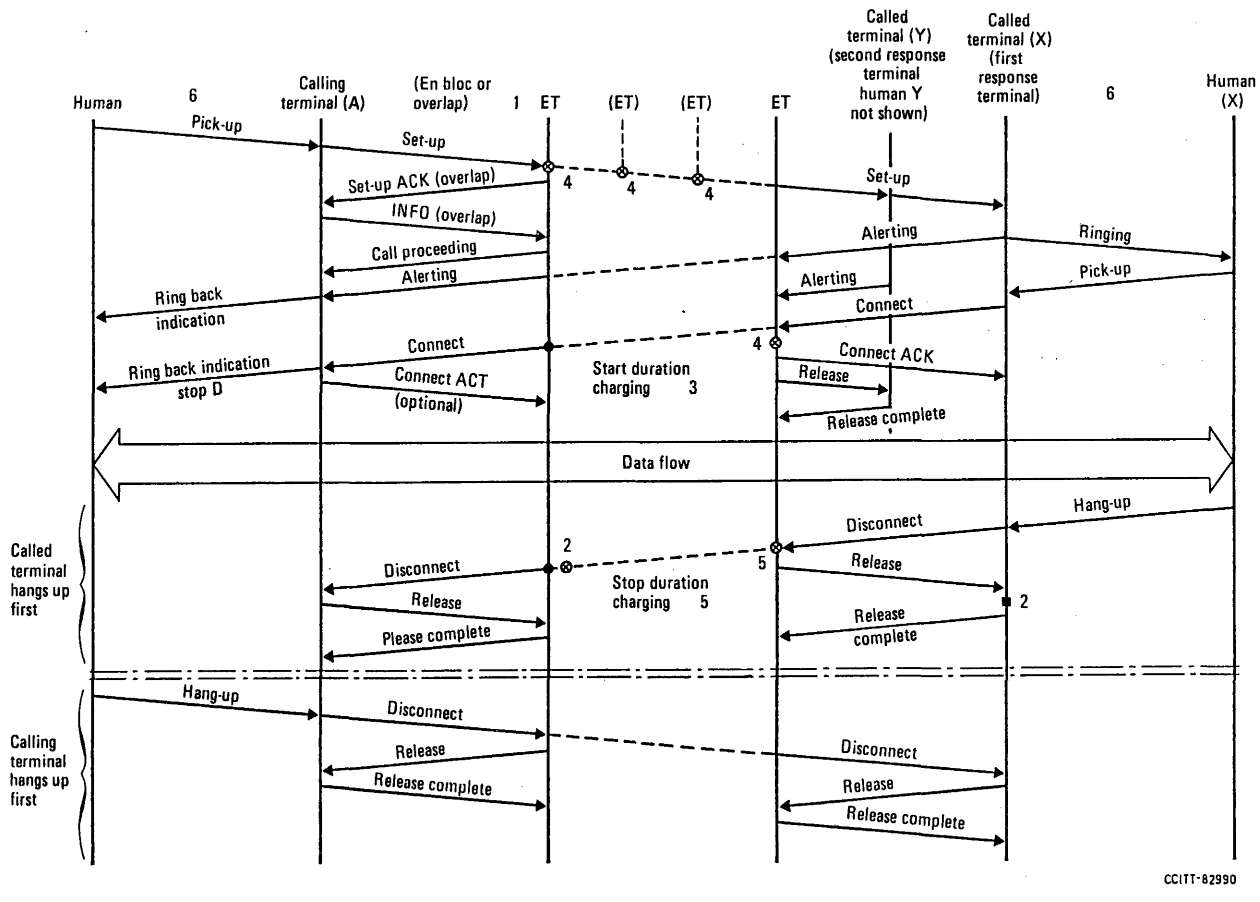

FIGURE 1/I.352

Procedure for a simple circuit switched call (example)

1.7 *Phases*

Connection processing delay values are specified for the connection set-up and disconnection phase.

2 Purpose

The purpose of this Recommendation is to provide values for connection processing delays that can be used as design objectives in network planning and system design. Quality of Service information should be provided to the user after mapping Network Performance into user-oriented expressions.

3 Connection processing delays in ISDN circuit switched connections

The values for the connection processing delay parameters have been determined taking into account that:

- the calling access link;
- the connection processing at the originating local exchange,
- the connection processing at transit exchanges,
- the usage of signalling transfer points (STP),
- the internodal links,
- the connection processing at the terminating local exchange, and
- the connected access link

cause delay.

These values are representative for all terrestrial connections and also for connections involving a satellite in an internodal link allowing a smaller number of transit exchanges in that connection.

3.1 *Connect phase parameters*

3.1.1 *Connection set-up delay*

Connection set-up delay is defined initially, based on observations at a single connection element boundary, B_i as shown in Figure 2/I.352, and then between two connection element boundaries (B_i, B_j). In the former case, the connection set-up delay includes the delay for all connection elements on the called user side of B_i and the terminal device. In the latter case, the connection set-up delay includes only the delay between B_i and B_j.

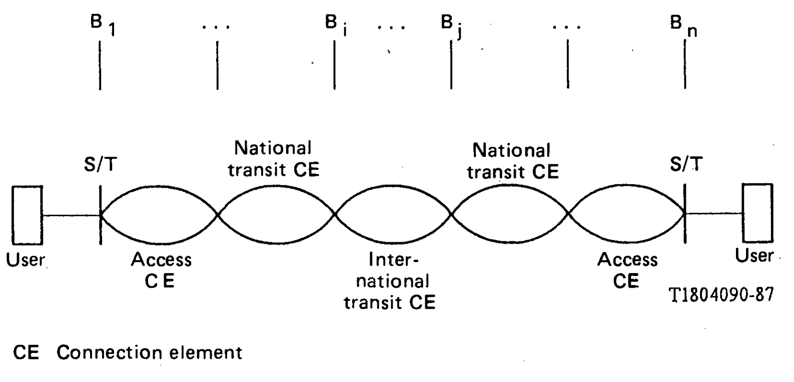

FIGURE 2/I.352

General reference configuration
(based on reference configuration in Recommendation I.352)

3.1.1.1 *Definition of connection set-up delay observed at a single connection element boundary*

connection set-up delay at a single connection element boundary, B_i, is defined using two call processing message transfer events (MTEs). Table 1/I.352 identifies the message transfer events and the resulting call states for I.451(Q.931) connection processing messages. Table 2/I.352 identifies the message transfer events and the resulting call states for the relating Signalling System No. 7 user-part messages defined in Recommendation Q.762. Connection set-up delay is the length of time that starts when a SETUP or the last address information message creates a message transfer event at B_i; and ends when the corresponding CONNECT message returns and creates its message transfer event at B_i.

Connection set-up delay observed at a single connection element boundary = $(t_2 - t_1)$.

where

t_1 is the time of occurrence of the starting message transfer event

t_2 is the time of occurrence of the ending message transfer event.

The transfer of the I.451(I.931) messages and their corresponding user-part messages of Signalling System No. 7 is shown in Figure 3/I.352 along with connection element boundaries. The specific message transfer events used in measuring connection set-up delay are shown in Table 3/I.352.

Note – "Set-up" does not imply a through connection or that capability for information transfer has been established.

3.1.1.2 *Definition of connection set-up delay between two connection element boundaries*

The **connection set-up delay between two connection element boundaries** can be measured at one connection element boundary, B_1, and then measured at another boundary, B_2, from the distant calling S/T interface. The difference in the values obtained is the connection set-up delay contributed by the connection elements between two boundaries.

Connection set-up delay between two boundaries = $(d_1 - d_2)$

where

d_1 is the connection set-up delay at B_1,

d_2 is the connection set-up delay at B_2.

The overall connection set-up delay is the connection set-up delay between the two S/T interfaces, e.g. B_1 and B_n in Figure 2/I.352. This overall connection delay excludes the called user response time. The connection set-up delay for a connection element is the connection set-up delay between the boundaries delimiting that connection element.

3.1.1.3 *Connection set-up delay specification*

The overall connection set-up delay should not exceed the values given in Table 4/I.352.

The allocation of the connection set-up delay among the elements of the connections are for further study.

3.1.2 *Alerting delay (applicable in case of manual answering terminals and some automatic answering terminals)*

Alerting delay is defined using an approach similar to that described in § 3.1.1 for connection set-up delay.

3.1.2.1 *Definition of alerting delay observed at a single connection element boundary*

alerting delay at a single element boundary, B_i, is defined as the length of time that starts when a SETUP or the last address information message creates a message transfer event at B_i, and ends when the corresponding ALERTing message returns and creates its message transfer event at B_i.

Alerting delay observed at a single connection element boundary = $(t_2 - t_1)$

where

t_1 is the time of occurrence for the starting message transfer event,

t_2 is the time of occurrence for the ending message transfer event.

The specific message transer events used in measuring alerting delay are shown in Table 5/I.352.

TABLE 1/I.352

Message transfer events based on Rec. I.451 layer 3 messages

No.	Layer 3 message	Message flow	Event	Resulting state
1	SET-UP	u - n	Entry	N1 (Call initiated)
2	SET-UP	n - u	Exit	N6 (Call present)
3	SET-UP ACKnowledge	u - n	Entry	N25 (Overlap receiving)
4	SET-UP ACKnowledge	n - u	Exit	N2 (Overlap sending)
5	INFOrmation	u - n	Entry	N2 (Overlap sending)
6	CALL PROCeeding	u - n	Entry	N9 (Incoming call proceeding)
7	CALL PROCeeding	n - u	Exit	N3 (Outgoing call proceeding)
8	ALERTing	u - n	Entry	N7 (Call receive)
9	ALERTing	n - u	Exit	N4 (Call delivered)
10	CONNect	u - n	Entry	N8 (Connect request)
11	CONNect	n - u	Exit	N10 (Active)
12	CONNect ACKnowledge	u - n	Entry	N10 (Active)
13	CONNect ACKnowledge	n - u	Exit	N10 (Active)
14	DISConnect	u - n	Entry	N11 (Disconnect request)
15	DISConnect	n - u	Exit	N12 (Disconnect indication)
16	RELease	n - u	Exit	N19 (Release request)
17	RELease COMplete	u - n	Entry	N0 (Null)
18	RELease COMplete	n - u	Exit	N0 (Null)

u - n user to network

n - u network to user

Note – The terminology for message flow is given in Rec. I.451.

TABLE 2/I.352

Message transfer events based on Rec. Q.764

No.	Signalling System No. 7 message	Direction [a]	Event	Resulting state
S1	Initial address (IAM)	Outgoing	Entry	Wait for ACM (2)
S2	Initial address (IAM)	Incoming	Exit	Wait for OGC select (2)
S3	Address complete (ACM)	Outgoing	Exit	Wait for answer (3)
S4	Address complete (ACM)	Incoming	Entry	Wait for answer (5)
S5	Answer (ANS)	Outgoing	Exit	OGC answered (4)
S6	Answer (ANS)	Incoming	Entry	ICC answered (4)
S7	Release (REL)	Outgoing	Entry	Wait for RLC (7)
S8	Release (REL)	Incoming	Exit	Wait for RLC (9)
S9	Release complete (RLC)	Outgoing	Exit	Idle (0)
S10	Release complete (RLC)	Incoming	Entry	Idle (0)

OGC Outgoing trunk circuit

ICC Incoming trunk circuit

[a] The connection processing control states have been divided into those used in incoming and outgoing circuit handling. The usage of the term direction in this contex refers to the direction of the connection

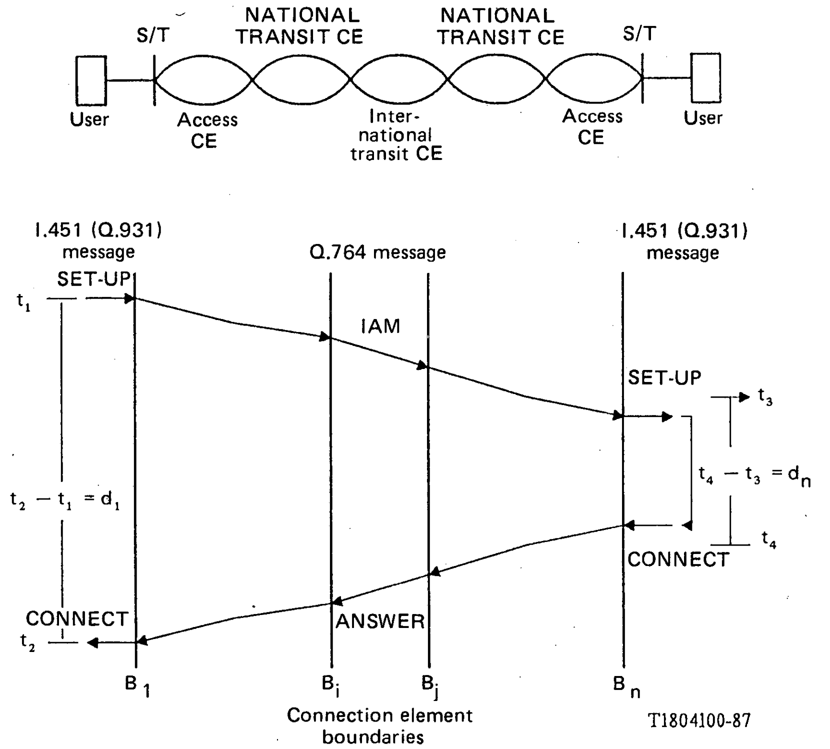

FIGURE 3/I.352

Connection set-up delay events (example)

TABLE 3/I.352

Message transfer events for measuring connection set-up delay

Connection element boundary	Message transfer event	
	Starting event number	Ending event number
Calling S/T interface	1 (en bloc) or 5 (overlap sending)	11
Called S/T interface	2	10
Access/national transit (originating)	S1	S5
Access/national transit (terminating)	S2	S6
National/international transit (originating)	S2	S6
National/international transit (terminating)	S1	S5

Note – En bloc and overlap sending options at the calling S/T interface.

TABLE 4/I.352

Overall connection set-up delay

ISDN connection type	Statistic	Connection set-up delay
No. 1: 64 kbit/s unrestricted switched	Mean	4500 ms [a]
	95%	8350 ms[a]

[a] Provisional values; the actuel target values are for further study.

Note 1 – The values take into account worst case situations such as the longest length reference connection (27 500 km) as specified in Recommendation G.104.

The values observed will be dominated by the number of exchanges in a connection. For the moderate length reference connection (11 000 km), the observed values will be lower.

Note 2 – Delays are specified for a nominal busy hour.

Note 3 – Connection set-up attempts which exceed a specified timeout value are excluded in computing these statistics and are counted separately as connection set-up denials.

Note 4 – In this table, the relevant ISDN connection types given in Table 2/I.340 are specified.

Note 5 – Those message processing delays that are dependent on a user equipment network are not included. In addition, when transmitting a signal message defined in Recommendation Q.931 from the network to a user, before the message actually passes across the S/T reference point, it may have to wait in the exchange or signalling system while another message (signal or user packet) is being transmitted to the user. Since this waiting time depends on the volume of user packet (message) traffic over the D-channel, the resulting delay is beyond the responsibility of the network provider.

Note 6 – The values take into account the additional signalling points for the 95% case of the hypothetical signalling reference connection in Recommendation Q.709.

Note 7 – The delay objectives in the table are primarily applicable to connections provided exclusively over ISDNs, i.e. no interworking.

Note 8 – The connection set-up and disconnected procedures in ISDNs for circuit-mode voice and data are essentially the same; therefore, the delay definitions are applicable for circuit-mode voice and circuit-mode data. The provisional values in the tables are applicable for both circuit-mode voice and circuit-mode data with no interworking. However, the observed delay performance may not be identical due to network architectural differences and interworking.

TABLEAU 5/I.352

Message transfer events for measuring alerting delay

Connection element boundary	Message transfer event	
	Starting event number	Ending event number
Calling S/T interface	1 (en bloc) or 5 (overlap sending)	9
Called S/T interface	2	6
Access/national transit (originating)	S1	S3
Access/national transit (terminating)	S2	S4
National/international transit (originating)	S2	S4
National/international transit (terminating)	S1	S3

Note – En bloc and overlap sending options at the calling S/T interface.

3.1.2.2 *Definition of alerting delay between two connection element boundaries*

The **alerting delay between two connection element boundaries** can be measured at one connection element boundary, B_i, and then measured at another boundary, B_j, further from the calling S/T interface. The difference in the values obtained is the alerting delay contributed by the connection elements between the two boundaries.

Alerting delay between two connection element boundaries $= (d_i - d_j)$

where

d_i is the alerting delay measured at B_i,

d_j is the alerting delay measured at B_j.

The overall alerting delay is the alerting delay between the two S/T interfaces, B_1 and B_n in Figure 1/I.352 for the reference configuration types in Recommendation I.340. This overall alerting delay excludes the called user response time. The alerting delay for a connection element is the alerting delay between the boundaries delimiting that connection element.

3.1.2.3 *Alerting delay specification*

The overall alerting delay should not exceed the values given in Table 6/I.352.

The allocation of the alerting delay among the elements of the connections are for further study.

TABLE 6/I.352

Overall alerting delay

ISDN connection type	Statistic	Alerting delay
No. 1: 64 kbit/s unrestricted switched	Mean	4500 ms [a]
	95%	8350 ms [a]

[a] Provisional values; the actual target values are for further study.

Note 1 – The values take into account worst case situations such as the longest length reference connection (27 500 km) as specified in Recommendation G.104.

The values observed will be dominated by the number of exchanges in a connection. For the moderate length reference connection (11 000 km) the observed values will be lower.

Note 2 – Delays are specified for a nominal busy hour.

Note 3 – Connection set-up attempts which exceed a specified timeout value are excluded in computing these statistics and are counted separately as connection set-up denials.

Note 4 – In this table the relevant ISDN connection types given in Table 2/I.340 are specified.

Note 5 – Those message processing delays that are dependent on a user equipment/network are not included. In addition, when transmitting a signal message defined in Recommendation Q.931 from the network to a user, before the message actually passes across the S/T reference-point, it may have to wait in the exchange or signalling system while another message (signal or user packet) is being transmitted to the user. Since this waiting time depends on the volume of user packet (message) traffic over the D-channel, the resulting delay is beyond the responsibility of the network provider.

Note 6 – The values take into account the additional signalling points for the 95% case of the hypothetical signalling reference connection in Recommendation Q.709.

Note 7 – The delay objectives in the table are primarily applicable to connections provided exclusively over ISDNs, i.e. no interworking.

Note 8 – The connection set-up and disconnect procedures in ISDNs for circuit-mode voice and data are essentially the same. Therefore, the delay definitions are applicable for circuit-mode voice and circuit-mode data. The provisional values in the tables are applicable for both circuit-mode voice and circuit-mode data with no interworking. However, the observed delay performance may not be identical due to network architectural differences and interworking.

3.2 *Disconnect phase parameters*

3.2.1 *Disconnect delay*

Disconnect definition is based only on a one-way message transport from the clearing party to be cleared party. Therefore, this parameter requires observations at two connection element boundaries.

3.2.1.1 *Definition of disconnect delay between two connection element boundaries*

Disconnect delay between two connection element boundaries, B_i and B_j, is defined as the length of time that starts when a DISConnect message creates a message transfer event at B_i and ends when that DISConnect message creates a message transfer event at B_j, further from the clearing party S/T interface.

Disconnect delay between two connection element boundaries = $(t_2 - t_1)$

where

t_1 is the time of occurrence for the message transfer event at B_i,

t_2 is the time of occurrence for the message transfer event at B_j.

The overall disconnect delay is the disconnect delay between two S/T interfaces, B_1 and B_n in Figure 1/I.352 for the reference configuration types in Recommendation I.340. The disconnect delay for a connection element is the disconnect delay between the boundaries delimiting that connection element. The specific message transfer events used in measuring disconnect delay are shown in Table 7/I.352.

TABLE 7/I.352

Message transfer events for measuring disconnect delay

Connection element(s)	Message transfer event (at connection element boundary)	
	Starting event number	Ending event number
S/T to S/T interface	14 (Clearing end)	15 (Cleared end)
National transit	S7 (Access/national transit)	S8 (National/international transit)
International transit	S8 (National/international transit)	S7 (International/national transit)

3.2.1.2 *Disconnect delay specification*

The overall disconnect delay should not exceed the values given in Table 8/I.352.

The disconnect delay values for connection elements are for further study.

3.2.2 *Release delay*

Release delay is defined only at the clearing party S/T interface.

3.2.2.1 *Definition of release delay*

release delay is defined as the length of time that starts when a DISConnect message from the clearing party creates a message transfer event at the clearing party S/T interface and ends when the RELease message creates a message transfer event at the same interface.

Release delay at the clearing part S/T interface = $(t_2 - t_1)$

where

t_1 is the time of occurrence for the starting message transfer event,

t_2 is the time of occurrence for the ending message transfer event.

Since the release message sent by the exchange at the clearing end is only transported over the access connection element at that end, the distinction between overall delay and connection element delay is not relevant. The specific message transfer events used in measuring release delay are shown in Table 9/I.352.

TABLE 8/I.352

Disconnect delay

ISDN connection type	Statistic	Disconnect delay
No. 1: 64 kbit/s unrestricted switched	Mean	2700 ms[a)]
	95 %	4700 ms[a)]

[a)] Provisional values; the actual target values are for further study.

Note 1 – The values take into account worst case situation such as the longest length reference connection (27 500 km) as specified in Recommendation G.104.

The values observed will be dominated by the number of exchanges in a connection. For the moderate length reference connection (11 000 km) the observed values will be lower.

Note 2 – Delays are specified for a nominal busy hour.

Note 3 – In this table the relevant ISDN connection types given in Table 2/I.340 are specified.

Note 4 – The values take into account the additional signalling points for the 95% case of the hypothetical signalling reference connection in Recommendation Q.709.

Note 5 – The delay objectives in the table are primarily applicable to connections provided exclusively over ISDNs, i.e. no interworking.

Note 6 – The connection set-up and disconnect procedures in ISDNs for circuit-mode voice and data are essentially the same. Therefore, the delay definitions are applicable for circuit-mode voice and circuit-mode data. The provisional values in the tables are applicable for both circuit-mode voice and circuit-mode data with no interworking. However, the observed delay performance may not be identical due to network architectural differences and interworking.

TABLE 9/I.352

Message transfer events for measuring release delay

Connection element boundary	Message transfer event	
	Starting event number	Ending event number
Clearing party S/T	14	16
Cleared party S/T	Not applicable	Not applicable
Access/National transit	Not applicable	Not applicable
National/international transit	Not applicable	Not applicable

3.2.2.2 *Release delay specification*

The release delay should not exceed the values given in Table 10/I.352.

TABLE 10/I.352

Release delay

ISDN connection type	Statistic	Release delay
No. 1: 64 kbit/s unrestricted switched	Mean	300 ms [a)]
	95%	850 ms [a)]

[a)] Provisional values; the actual target values are for further study.

Note 1 – The delay objectives in the table are primarily applicable to connections provided exclusively over ISDNs, i.e. no interworking.

Note 2 – The connection set-up and disconnect procedures in ISDNs for circuit-mode voice and data are essentially the same. Therefore, the delay definitions are applicable for circuit-mode voice and circuit-mode data. The provisional values in the tables are applicable for both circuit-mode voice and circuit-mode data with no interworking. However, the observed delay performance may not be identical due to network architectural differences and interworking.

PART IV

I.400-Series Recommendations

ISDN USER-NETWORK INTERFACES

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SECTION 1

ISDN USER-NETWORK INTERFACES

Recommendation I.410

GENERAL ASPECTS AND PRINCIPLES RELATING TO RECOMMENDATIONS ON ISDN USER-NETWORK INTERFACES

(Malaga-Torremolinos, 1984)

1 General

1.1 Recommendation I.120 gives the conceptual principles on which an ISDN should be based. The main feature of an ISDN is the support of a wide range of service capabilities, including voice and nonvoice applications, in the same network by offering end-to-end digital connectivity.

1.2 A key element of service integration for an ISDN is the provision of a limited set of standard multipurpose user-network interfaces. These interfaces represent a focal point both for the development of ISDN network components and configurations and for the development of ISDN terminal equipment and applications.

1.3 An ISDN is recognized by the service characteristics available through user-network interfaces, rather than by its internal architecture, configuration or technology. This concert plays a key role in permitting user and network technologies and configurations to evolve separately.

2 Interface applications

Figure 1/I.410 shows some examples of ISDN user-network interfaces. The following cases are identified, corresponding to:

1) access of a single ISDN terminal;
2) access of a multiple ISDN terminal installation;
3) access of multiservice PBXs, or local area networks, or, more generally, of private networks;
4) access of specialized storage and information processing centres.

In addition, depending on the particular national regulatory arrangements, either ISDN user-network interfaces or internetwork interfaces may be used for access of:

5) dedicated service networks;
6) other multiple services networks, including ISDNs.

3 Interface Recommendation objectives

User-network interface Recommendations should allow:

1) different types of terminals and applications to use the same interface;
2) portability of terminals from one location to another (office, home, public access points) within one country and from one country to another country;
3) separate evolution of both terminal and network equipment, technologies and configurations;
4) efficient connection with specialized storage and information processing centres and other networks.

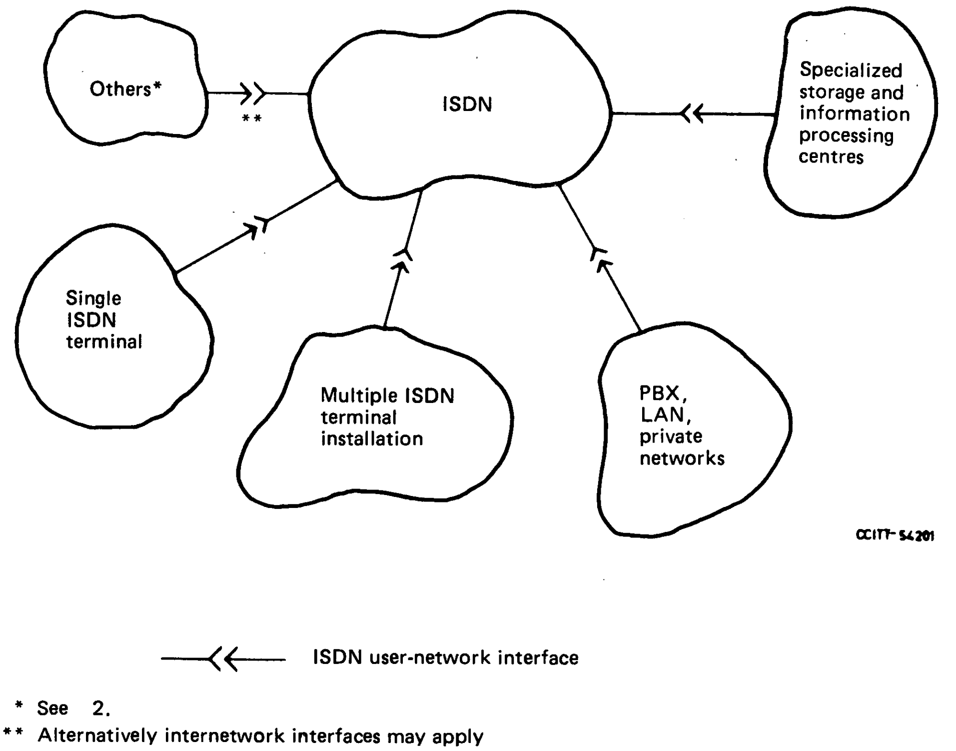


FIGURE 1/I.410

ISDN user-network interface examples

User-network interfaces should be designed to provide an appropriate balance between service capabilities and cost/tariffs, in order to meet service demand easily.

4 Interface characteristics

User-network interfaces are specified by a comprehensive set of characteristics, including:

1) physical and electromagnetic (including optical) characteristics;
2) channel structures and access capabilities;
3) user-network protocols;
4) maintenance and operation characteristics;
5) performance characteristics;
6) service characteristics.

A layered approach has been adopted for the definition of ISDN user-network interfaces according to the ISDN protocol reference model, Recommendation I.320.

5 Interface capabilities

In addition to the multiservice capability, an ISDN user-network interface may allow for capabilities such as the following:

1) multidrop and other multiple terminal arrangements;
2) choice of information bit rate, switching mode, coding method, etc., on a call-by-call or other (e.g. semi-permanent or subscription time option) basis, over the same interface according to the user's need;
3) capability for compatibility checking in order to check whether calling and called terminals can communicate with each other.

6 Other I-Series Recommendations

6.1 The reference configurations for ISDN user-network interfaces define the terminology for various reference points and the types of functions that can be provided between reference points. Recommendation I.411 contains the reference configurations and shows significant applications.

6.2 The number of different interfaces is kept to a minimum. Recommendation I.412 defines a limited set of interface structures, and possible access capabilities for the ISDN user-network interfaces. A distinction is necessary between the interface structure and the access capability supported by the particular network access arrangement.

6.3 The user-network interfaces, as defined in Recommendations I.420 and I.421, are applicable to a wide range of situations without modification (e.g. to both reference points S and T, as defined in Recommendation I.411).

Recommendation I.411

ISDN USER-NETWORK INTERFACES – REFERENCE CONFIGURATIONS

(Malaga-Torremolinos, 1984)

1 General

1.1 This Recommendation provides the reference configurations for ISDN user-network interfaces.

1.2 From the user's perspective, an ISDN is completely described by the attributes that can be observed at an ISDN user-network interface, including physical, electromagnetic, protocol, service, capability, maintenance, operation and performance characteristics. The key to defining, and even recognizing, an ISDN is the specification of these characteristics.

1.3 An objective of ISDN is that a small set of compatible user-network interfaces can economically support a wide range of user applications, equipment and configurations. The number of different user-network interfaces is minimized to maximize user flexibility through terminal compatibility (from one application to another, one location to another, and one service to another) and to reduce costs through economies in production of equipment and operation of both ISDN and user equipment. However, different interfaces are required for applications with widely different information rates, complexity, or other characteristics, as well as for applications in the evolutionary stages. In this way, simple applications need not to be burdened with the cost of accommodating features employed by complex applications.

1.4 Another objective is to have the same interfaces used even though there are different configurations (e.g. single terminal versus multiple terminal connections, connections to a PABX versus direct connections into the network, etc.) or different national regulations.

2 Definitions

2.1 **Reference configurations** are conceptual configurations useful in identifying various possible physical user access arrangements to an ISDN. Two concepts are used in defining reference configurations: reference points and functional groupings. Layout and application examples of reference configurations are given in § 3.

2.2 **Functional groups** are sets of functions which may be needed in ISDN user access arrangements. In a particular access arrangement, specific functions in a functional group may or may not be present. Note that specific functions in a functional group may be performed in one or more pieces of equipment.

2.3 **Reference points** are the conceptual points dividing functional groups. In a specific access arrangement, a reference point may correspond to a physical interface between pieces of equipment, or there may not be any physical interface corresponding to the reference point. Physical interfaces that do not correspond to a reference point (e.g. transmission line interfaces) will not be the subject of ISDN user-network interface Recommendations.

3 Reference configuration

3.1 The reference configurations for ISDN user-network interfaces define reference points and types of functions that can be provided between reference points. Figure 1/I.411 shows the reference configurations, while Figures 2/I.411, 3/I.411 and 4/I.411 show examples of applications of such configurations.

3.2 The ISDN user-network interface Recommendations in the I-Series apply to physical interfaces at reference points S and T, using the recommended interface structures according to Recommendation I.412. At reference point R, physical interfaces in accordance with other Recommendations (e.g. the X-Series interface Recommendations) may be used.

Note 1 – Physical interfaces not included in CCITT Recommendations may appear at reference point R.

Note 2 – There is no reference point assigned to the transmission line, since an ISDN user-network interface is not envisaged at this location.

3.3 Figure 1a/I.411 defines the reference configuration with the functional groups NT1, NT2 and TE1. Figure 1b/I.411 illustrates that TE1 may be replaced by the combination of TE2 and TA.

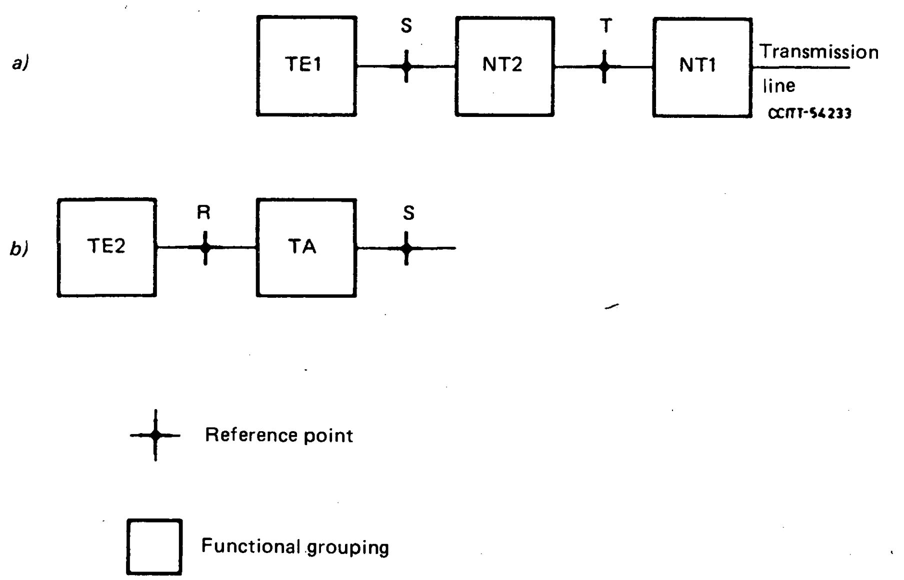


FIGURE 1/I.411

Reference configurations for the ISDN user-network interfaces

3.4 Lists of functions for each functional group are given below. Each particular function is not necessarily restricted to a single functional group. For example, "interface termination" functions are included in the function lists of NT1, NT2 and TE. The function lists for NT2, TE and TA are not exhaustive. For a particular access arrangement, specific functions in a functional group are either present or absent.

The functional groups are described in relation to the ISDN protocol reference model in Recommendation I.320.

3.4.1 *Network termination 1 (NT1)*

This functional group includes functions broadly equivalent to layer 1 (physical) of the OSI reference model. These functions are associated with the proper physical and electromagnetic termination of the network. NT1 functions are:

- line transmission termination;
- layer 1 line maintenance functions and performance monitoring;
- timing;
- power transfer;
- layer 1 multiplexing;
- interface termination, including multidrop termination employing layer 1 contention resolution.

3.4.2 *Network termination 2 (NT2)*

This functional group includes functions broadly equivalent to layer 1 and higher layers of the Recommendation X.200 reference model. PABXs, local area networks, and terminal controllers are examples of equipment or combinations of equipment that provide NT2 functions. NT2 functions include:

- layers 2 and 3 protocol handling;
- layers 2 and 3 multiplexing;
- switching;
- concentration;
- maintenance functions; and
- interface termination and other layer 1 functions.

For example, a simple PABX can provide NT2 functions at layers 1, 2 and 3. A simple terminal controller can provide NT2 functions at only layers 1 and 2. A simple time division multiplexer can provide NT2 functions at only layer 1. In a specific access arrangement, the NT2 functional group may consist of only physical connections.

3.4.3 *Terminal equipment (TE)*

This functional group includes functions broadly belonging to layer 1 and higher layers of the Recommendation X.200 reference model. Digital telephones, data terminal equipment, and integrated work stations are examples of equipment or combinations of equipment that provide the functions. The TE functions are:

- protocol handling;
- maintenance functions;
- interface functions;
- connection functions to other equipments.

3.4.3.1 *Terminal equipment type 1 (TE1)*

This functional group includes functions belonging to the functional group TE, and with an interface that complies with the ISDN user-network interface Recommendations.

3.4.3.2 *Terminal equipment type 2 (TE2)*

This functional group includes functions belonging to the functional group TE but with an interface that complies with interface Recommendations other than the ISDN interface Recommendation (e.g. the X-Series interface Recommendations) or interfaces not included in CCITT Recommendations.

3.4.4 *Terminal adaptor (TA)*

This functional group includes functions broadly belonging to layer 1 and higher layers of the Recommendation X.200 reference model that allow a TE2 terminal to be served by an ISDN user-network interface. Adaptors between physical interfaces at reference points R and S or R and T are examples of equipment or combinations of equipment that provide TA functions.

4 Physical realizations of reference configurations

4.1 Figure 2/I.411 gives examples of configurations illustrating combinations of physical interfaces at reference points R, S and T; Figures 2a/I.411 and 2b/I.411 show separate interfaces at S and T; Figures 2c/I.411 and 2d/I.411 show an interface at S but not T; Figures 2e/I.411 and 2f/I.411 show an interface at T but not S; Figures 2g/I.411 and 2h/I.411 show an interface at S and T where they coincide. Additionally, Figures 2b/I.411, 2d/I.411, 2f/I.411 and 2h/I.411 show an interface at reference point R.

4.2 Figures 3/I.411 and 4/I.411 show examples of physical implementations. The examples given in Figure 3/I.411 show physical realizations of functional groups TE, NT1 and NT2, based on physical interfaces occurring at reference points R, S and T. The examples given in Figure 4/I.411 show applications of the reference configurations to physical configurations when multiple physical interfaces occur at a reference point.

The examples given in Figure 4/I.411 are not intended to be either exhaustive or mandatory. Square blocks in Figures 3/I.411 and 4/I.411 represent equipment implementing functional groupings.

Note – TE1 or TE2 + TA may be used interchangeably in Figure 4/I.411.

4.2.1 Figures 4a/I.411 and 4b/I.411 show applications of the reference configurations in the cases where NT2 functions consist of only physical connections. Figure 4a/I.411 describes the direct physical connection of multiple TEs (TE1s or TE2s + TAs) to NT1 using a multidrop arrangement (i.e. a bus). Figure 4b/I.411 illustrates the separate connection of a number of TEs to NT1.

In these cases, all of the characteristics of the physical interfaces applied at reference points S and T must be identical.

4.2.2 Figure 4c/I.411 shows the provision of multiple connections between NT2 and TEs. NT2 may include various types of distribution arrangements, such as star, bus or ring configuration included within the equipment. Figure 4d/I.411 shows a case where a bus distribution is used between TEs and the NT2 equipment.

4.2.3 Figures 4e/I.411 and 4f/I.411 show arrangements where multiple connections are used between NT2 and NT1 equipment. In particular, Figure 4e/I.411 illustrates the case of multiple NT1 equipment, while Figure 4f/I.411 refers to the case where NT1 provides layer 1 upward multiplexing of the multiple connections.

4.2.4 Figure 4g/I.411 illustrates the case where NT1 and NT2 functions are merged in the same equipment; the corresponding merging of NT1 and NT2 functions for other configurations in Figure 4/I.411 may also occur.

4.2.5 Figure 4h/I.411 illustrates the case where TA and NT2 functions are merged in the same equipment; the corresponding merging of TA and NT2 functions for other configurations in Figure 4/I.411 may also occur.

4.2.6 In addition to the examples of physical implementation shown in Figures 3/I.411 and 4/I.411, a possible combination of NT1, NT2 and TA into one physical entity could be considered, in which both reference points S and T exist but are not realized as physical interfaces. Such an implementation is to be considered an interim means of providing connection to an ISDN and might be used to complement the recommended means of connecting terminals via physical interfaces at reference points S and T in the early stages of ISDN implementation. This should not be considered as a reference configuration because it poses significant problems in relation to the models of ISDN presently being studied.

4.2.7 These physical implementations are limited in their arrangements and combinations by the electrical and other characteristics of the interface specifications and equipment.

4.3 The reference-configurations given in Figure 1/I.411 apply for the specification of the interface structures and access arrangements given in Recommendation I.412.

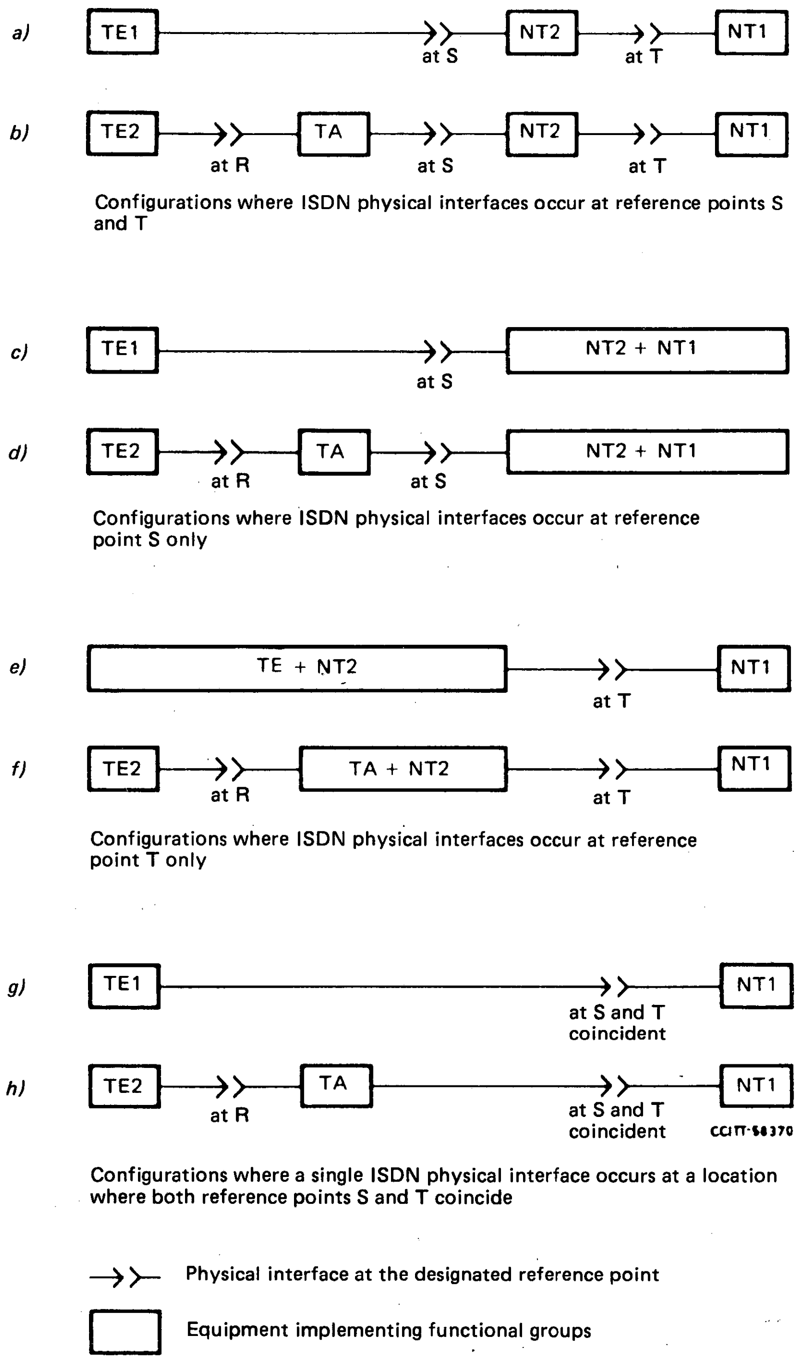
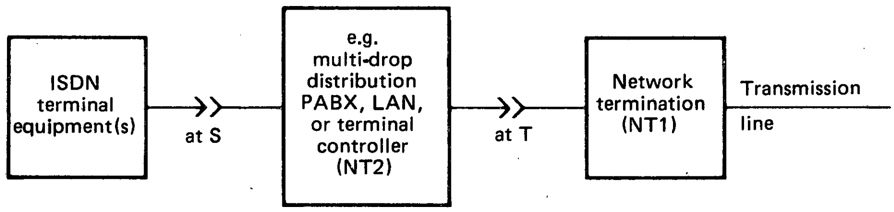


FIGURE 2/I.411

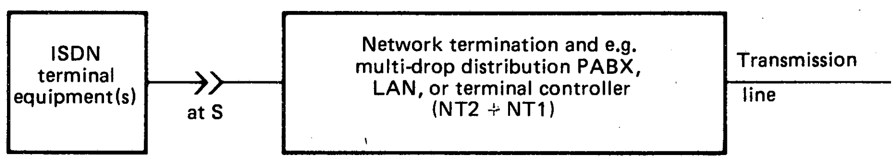
Examples of physical configurations

a)



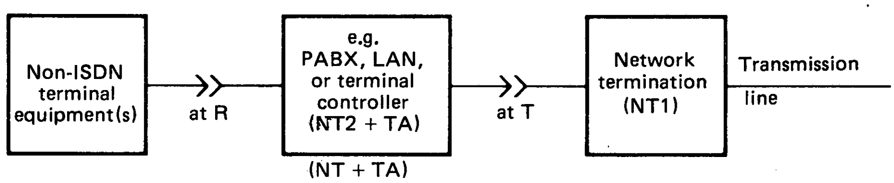
An implementation (see Figure 2a/I.411) where ISDN physical interfaces occur at reference points S and T.

b)



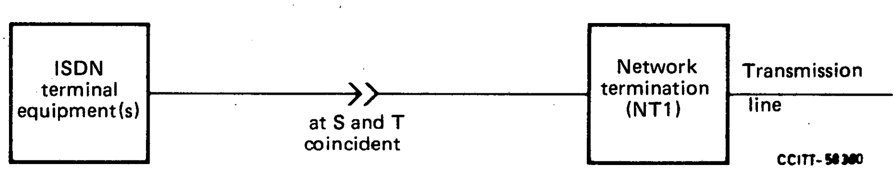
An implementation (see Figure 2c/I.411) where an ISDN physical interface occurs at reference point S but not T.

c)



An implementation (see Figure 2f/I.411) where an ISDN physical interface occurs at reference point T but not S.

d)



An implementation (see Figure 2g/I.411) where a single ISDN physical interface occurs at a location where both reference points S and T coincide.

Physical interface at the designated reference point.

Equipment implementing functional groups.

FIGURE 3/I.411

Examples of implementation of NT1 and NT2 functions

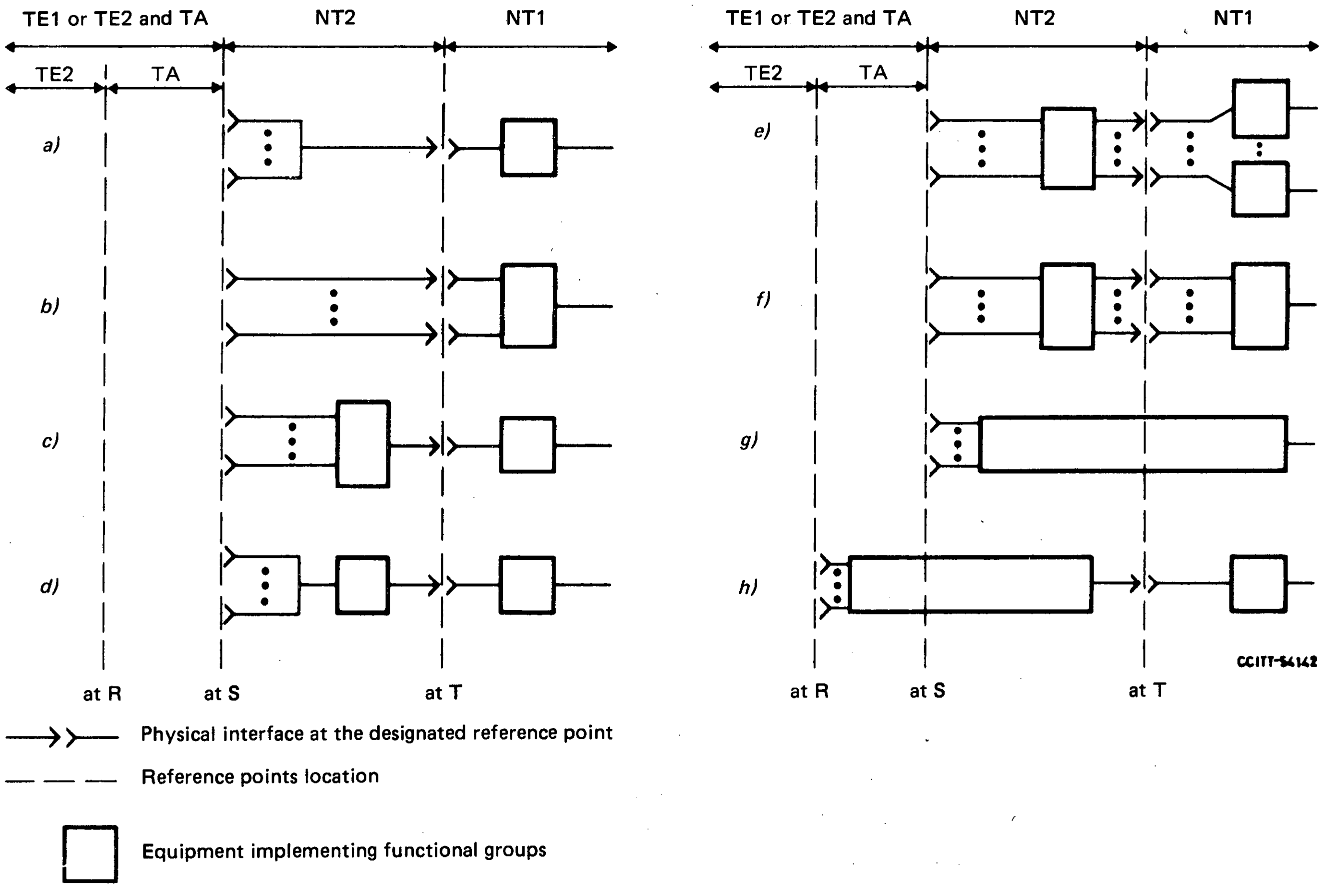


FIGURE 4/I.411

Examples of physical configurations employing multiple connections

Recommendation I.412

ISDN USER-NETWORK INTERFACES INTERFACE STRUCTURES AND ACCESS CAPABILITIES

(Malaga-Torremolinos, 1984; amended at Melbourne, 1988)

1 General

This Recommendation defines limited sets of both channel types and interface structures for ISDN user-network physical interfaces.

2 Definitions

2.1 A channel represents a specified portion of the information-carrying capacity of an interface.

2.2 Channels are classified by channel types, which have common characteristics. Channel types are specified in § 3.

2.3 The channels are combined into interface structures, specified in § 4. An interface structure defines the maximum digital information-carrying capacity across a physical interface.

2.4 In an actual access arrangement some of the channels available across an ISDN user-networks physical interface, as defined in the applicable interface structure, may not be supported by the network. Some ISDN services will not require the full capacity of a B-channel; in those cases in which users require only such services, the access capability might be further reduced. The capability provided by those channels that are actually available for communication purposes, is referred to as the access capability provided through the interface.

3 Channel types and their use

3.1 *B-channel*

3.1.1 The B-channel is a 64 kbit/s channel accompanied by timing.

Note – The method for providing this timing is a subject of the individual interface Recommendations.

A B-channel is intended to carry a wide variety of user information streams. A distinguishing characteristic is that a B-channel does not carry signalling information for circuit switching by the ISDN. Signalling information used for circuit switching by the ISDN is carried over other types of channels, e.g. a D-channel.

3.1.2 User information streams may be carried on a B-channel on a dedicated, alternate (within one call or as separate calls), or simultaneous basis, consistent with the B-channel bit rate. The following are samples of user information streams:

- i) voice encoded at 64 kbit/s according to Recommendation G.711;
- ii) data information corresponding to circuit or packet-switching user classes of service at bit rates less than or equal to 64 kbit/s, according to Recommendation X.1;
- iii) wideband voice encoded at 64 kbit/s according to Recommendation G.722;
- iv) voice encoded at bit rates lower than 64 kbit/s alone, or combined with other digital information streams.

It is recognized that a B-channel may also be used to carry user information streams not covered by CCITT Recommendations.

3.1.3 B-channels may be used to provide access to a variety of communication modes within the ISDN. Examples of these modes are:

- i) circuit switching;
- ii) packet switching, supporting packet mode terminals; and
- iii) semi-permanent connections.

In case i), the ISDN can provide either a transparent end-to-end 64 kbit/s connection or a connection specifically suited to a particular service, such as telephony, in which case a transparent 64 kbit/s connection may not be provided.

In case ii), the B-channel will carry protocols at layers 2 and 3 according to Recommendation X.25 which have to be handled by the network. The application of D-channel protocols for this case is for further study.

In case iii), the semi-permanent connection can be provided, for example by using circuit or packet switching modes.

3.1.4 Single information streams at bit rates less than 64 kbit/s should be rate adapted to be carried on the B-channel as described in Recommendation I.460.

3.1.5 Multiple information streams from a given user may be multiplexed together in the same B-channel, but for circuit switching, an entire B-channel will be switched to a single user-network interface. This multiplexing should be in accordance with Recommendation I.460.

Note – Independent routing of subrate channels circuit switched to different destinations is for further study.

3.2 *D-channel*

3.2.1 The D-channel may have different bit rates as specified in § 4.

A D-channel is primarily intended to carry signalling information for circuit switching by the ISDN.

A D-channel uses a layered protocol according to Recommendations I.440, I.441, I.450 and I.451. In particular the link access procedure is frame oriented (Note).

Note – The use of Signalling System No. 7 at a user-network interface is for further study.

3.2.2 In addition to signalling information for circuit switching, a D-channel may also be used to carry teleaction information and packet-switched data.

In certain cases where such signalling is not being utilized, the D-channel may support only teleaction information or packet-switched data.

3.3 *H-channels*

3.3.1 H-channels have the following bit rates, accompanied by timing:

H_0 channel: 384 kbit/s
H_1 channels: 1536 (H_{11}) and 1920 (H_{12}) kbit/s.

Note – The method for providing this timing is a subject of the individual interface Recommendation.

Higher rate H-channels are for further study.

An H-channel is intended to carry a variety of user information streams. A distinguishing characteristic is that an H-channel does not carry signalling information for circuit switching by the ISDN.

3.3.2 User information streams may be carried on an H-channel on a dedicated, alternate (within one call or as separate calls), or simultaneous basis, consistent with the H-channel bit rates. The following are examples of user information streams:

i) fast facsimile;
ii) video: e.g. for teleconferencing;
iii) high speed data;
iv) high quality audio or sound programme material;
v) information streams, each at rates lower than the respective H-channel bit rate (e.g. voice at 64 kbit/s), which have been rate adapted or multiplexed together;
vi) packet-switched information.

3.4 *Other channels*

For further study.

4 Interface structures

ISDN user-network physical interfaces at ISDN reference points S and T shall comply with one of the interface structures defined below.

4.1 *B-channel interface structures*

4.1.1 *Basic interface structure*

4.1.1.1 The basic interface structure is composed of two B-channels and one D-channel, 2 B + D. The bit rate of the D-channel in this interface structure is 16 kbit/s.

4.1.1.2 The B-channels may be used independently; i.e. in different connections at the same time.

4.1.1.3 With the basic interface structure, two B-channels and one D-channel are always present at the ISDN user-network physical interface. One or both B-channels, however, may not be supported by the network. See Appendix I.

4.1.2 *Primary rate B-channel interface structures*

These structures correspond to the primary rates of 1544 kbit/s and 2048 kbit/s.

4.1.2.1 The primary rate B-channel interface structures are composed of B-channels and one D-channel. The bit rate of this D-channel is 64 kbit/s.

4.1.2.2 At the 1544 kbit/s primary rate the interface structure is 23 B + D.

4.1.2.3 At the 2048 kbit/s primary rate the interface structure is 30 B + D.

4.1.2.4 With the primary rate B-channel interface structures, the designated number of B-channels is always present at the ISDN user-network physical interface. One or more of the B-channels may not be supported by the network.

4.1.2.5 In the case of a user-network access arrangement containing multiple interfaces, it is possible for the D-channel in one structure to carry the signalling for B-channels in another primary rate structure without an activated D-channel. When a D-channel is not activated, the designated time slot may or may not be used to provide an additional B-channel, depending on the situation; e.g., 24 B for a 1544 kbit/s interface.

4.2 *H-channel interface structure*

4.2.1 *Primary rate interface H_0-channel structures*

4.2.1.1 The primary rate interface H_0-channel structures are composed of H_0-channels with or without a D-channel, as indicated below. When present in the same interface structure the bit rate of the D-channel is 64 kbit/s. Additional primary rate interface H_0-channel structures are for further study.

4.2.1.2 At the 1544 kbit/s primary rate interface the H_0-channel structures are 4 H_0 and 3 H_0 + D. The use of the additional capacity across the interface is for further study. When the D-channel is not provided, signalling for the H_0-channels is provided by the D-channel in another interface.

4.2.1.3 At the 2048 kbit/s primary rate interface the H_0-channel structure is 5 H_0 + D. In the case of a user-network access arrangement containing multiple interfaces, it is possible for the D-channel in one structure to carry the signalling for H_0-channels in another primary rate interface without a D-channel in use.

4.2.1.4 With the primary rate interface H_0-channel structures, the designated number of H_0-channels is always present at the user-network physical interface. One or more of the H_0-channels may not be supported by the network.

4.2.1.5 In the case of a user-network access arrangement containing multiple interfaces it is possible for the D-channel of one structure to carry the signalling for H_0-channels in another primary rate interface structure without an activated D-channel. When a D-channel is not required in a 1544 kbit/s interface, the 4 H_0-channel structure may be used.

4.2.2. *Primary rate interface H_1-channel structures*

4.2.2.1 *1536 kbit/s H_{11}-channel Structure*

The 1536 kbit/s H_{11}-channel structure is composed of one 1536 kbit/s H_{11}-channel. Signalling for the H_{11}-channel, if required, is carried in a D-channel on another interface structure within the same user-network access arrangement.

4.2.2.2 *1920 kbit/s H_{12}-channel Structure*

The 1920 kbit/s H_{12}-channel structure is composed of one 1920 kbit/s H_{12}-channel and a D-channel. The bit rate of the D-channel is 64 kbit/s. Signalling for the H_{12}-channel, if required, is carried in this D-channel or the D-channel of another interface structure within the same user-network access arrangement.

4.3 *Primary rate interface structures for mixtures of B- and H_0-channels*

A primary rate interface may have a structure consisting of a single D-channel and any mixture of B- and H_0-channels. The bit rate of the D-channel is 64 kbit/s. In the case of a user-network access arrangement containing multiple interfaces, a D-channel in one interface structure may also carry signalling for channels in another interface structure. When a D-channel is not activated, its 64 kbit/s capacity may or may not be used for the mixture of B- and H_0-channels, depending on the situation, e.g. 3 H_0 + 6 B for a 1544 kbit/s interface.

4.4 *Other interface structure(s)*

For further study.

5 Examples of application of interface structures

5.1 *Access arrangement for PABX, terminal controller, local area network, etc.*

Figure 1/I.412 illustrates a typical PABX, or LAN access arrangement. For this particular configuration it is not necessary to apply the same interface structure at both S and T reference points. For example, basic interface structures may be used for interfaces located at reference point S. Either basic or primary rate or other interface structures may be used at interfaces located at reference point T.

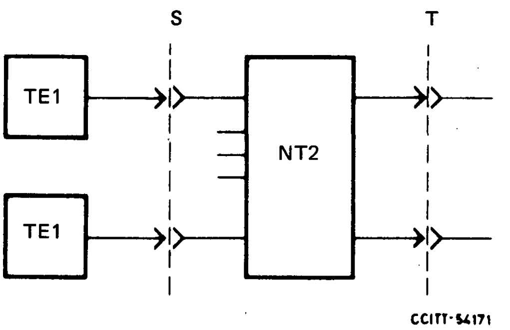


FIGURE 1/I.412

Example of the reference configurations for ISDN user-network interfaces applied to a physical configuration employing multiple connections

APPENDIX I

(to Recommendation I.412)

Access capabilities

I.1 As stated in § 2.4, not all of the channels present in an ISDN user-network physical interface are necessarily supported by the network. The resulting capability provided in an ISDN user-network access arrangement is defined as the access capability.

To assist in guiding the implementations of ISDN equipment and services around the world, several preferred access capabilities are identified here. While these preferred arrangements do not preclude the implementation of other access capabilities, they are intended to assist in the worldwide commonality which is a key objective of ISDN.

I.2 *Preferred access capabilities*

a) *Preferred basic access capabilities*

- 2 B + D
- B + D
- D

b) *Primary rate – B-channel access capabilities*

- n B + D

  $n \leqslant 23$ for 1544 kbit/s primary rate, unless signalling is provided in another physical interface (see § 4.1.2.5); then $n = 24$ may be allowed.

  $n \leqslant 30$ for 2048 kbit/s primary rate, unless signalling is provided in another physical interface (see § 4.1.2.5) then $n = 31$ may be allowed.

c) *Primary rate – H_0-channel access capabilities*

- n H_0 + D

  $n \leqslant 3$ for 1544 kbit/s primary rate

  $n \leqslant 5$ for 2048 kbit/s primary rate

- n H_0

  $n \leqslant 4$ for 1544 kbit/s primary rate

d) *Other channel structure access capabilities*

For further study.

SECTION 2

APPLICATION OF I-SERIES RECOMMENDATIONS TO ISDN USER-NETWORK INTERFACES

Recommendation I.420

BASIC USER-NETWORK INTERFACE

(Malaga-Torremolinos, 1984)

The basic user-network interface structure is defined in Recommendation I.412. The detailed specifications are contained in Recommendations I.430 (layer 1), I.440 and I.441 (layer 2), I.450, I.451 and I.452 (layer 3).

Recommendation I.421

PRIMARY RATE USER-NETWORK INTERFACE

(Malaga-Torremolinos, 1984)

The primary rate user-network interface structures are defined in Recommendation I.412. The detailed specifications are contained in Recommendations I.431 (layer 1), I.440 and I.441 (layer 2), I.450, I.451 and I.452 (layer 3).

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SECTION 3

ISDN USER-NETWORK INTERFACES: LAYER 1 RECOMMENDATIONS

Recommendation I.430

BASIC USER-NETWORK INTERFACE – LAYER 1 SPECIFICATION

(Malaga-Torremolinos, 1984; amended at Melbourne, 1988)

1 General

This Recommendation defines the layer 1 characteristics of the user-network interface to be applied at the S or T reference points for the basic interface structure defined in Recommendation I.412. The reference configurations for the interface is defined in Recommendation I.411 and is reproduced in Figure 1/I.430.

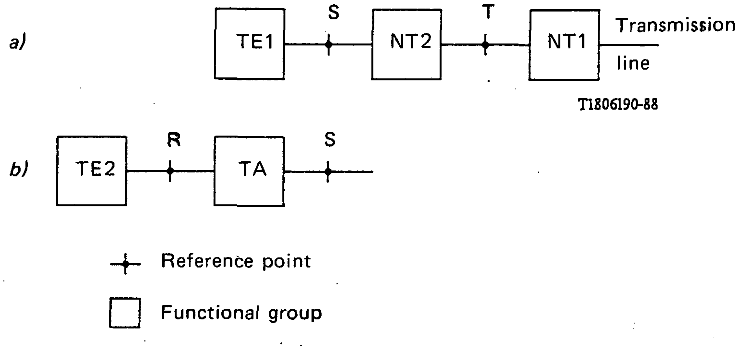


FIGURE 1/I.430

Reference configurations for the ISDN user-network interfaces

In this Recommendation, the term "NT" is used to indicate network terminating layer 1 aspects of NT1 and NT2 functional groups, and the term "TE" is used to indicate terminal terminating layer 1 aspects of TE1, TA and NT2 functional groups, unless otherwise indicated. However, in § 6.2 only, the terms "NT" and "TE" have the following meaning: the term "NT" is used to indicate the layer 1 network side of the basic access interface; the term "TE" is used to indicate the layer 1 terminal side of the basic access interface.

The terminology used in this Recommendation is very specific and not contained in the relevant terminology Recommendations. Therefore Annex E to this Recommendation provides terms and definitions used in this Recommendation.

2 Service characteristics

2.1 *Services required from the physical medium*

Layer 1 of this interface requires a balanced metallic transmission medium, for each direction of transmission, capable of supporting 192 kbit/s.

2.2 *Service provided to layer 2*

Layer 1 provides the following services to layer 2 and the management entity:

2.2.1 *Transmission capability*

Layer 1 provides the transmission capability, by means of appropriately encoded bit streams, for the B- and D-channels and the related timing and synchronization functions.

2.2.2 *Activation/deactivation*

Layer 1 provides the signalling capability and the necessary procedures to enable customer TEs and/or NTs to be deactivated when required and reactivated when required. The activation and deactivation procedures are defined in § 6.2.

2.2.3 *D-channel access*

Layer 1 provides the signalling capability and the necessary procedures to allow TEs to gain access to the common resource of the D-channel in an orderly fashion while meeting the performance requirement of the D-channel signalling system. These D-channel access control procedures are defined in § 6.1.

2.2.4 *Maintenance*

Layer 1 provides the signalling capability, procedures and necessary functions at layer 1 to enable the maintenance functions to be performed.

2.2.5 *Status indication*

Layer 1 provides an indication to the higher layers of the status of layer 1.

2.3 *Primitives between layer 1 and the other entities*

Primitives represent, in an abstract way, the logical exchange of information and control between layer 1 and other entities. They neither specify nor constrain the implementation of entities or interfaces.

The primitives to be passed across the layer 1/2 boundary or to the management entity and parameter values associated with these primitives are defined and summarized in Table 1/I.430. For description of the syntax and use of the primitives, refer to Recommendation X.211 and relevant detailed descriptions in § 6.

3 Modes of operation

Both point-to-point and point-to-multipoint modes of operation, as described below, are intended to be accommodated by the layer 1 characteristics of the user-network interface. In this Recommendation, the modes of operation apply only to the layer 1 procedural characteristics of the interface and do not imply any constraints on modes of operation at higher layers.

3.1 *Point-to-point operation*

Point-to-point operation at layer 1 implies that only one source (transmitter) and one sink (receiver) are active at any one time in each direction of transmission at an S or T reference point. (Such operation is independent of the number of interfaces which may be provided on a particular wiring configuration – see § 4).

TABLE 1/I.430

Primitives associated with layer 1

Generic name	Specific name		Parameter		Message unit contents
	REQUEST	INDICATION	Priority indicator	Message unit	
L1 ⟷ L2					
PH-DATA	X (Note 1)	X	X (Note 2)	X	Layer 2 peer-to-peer message
PH-ACTIVATE	X	X	–	–	
PH-DEACTIVATE	–	X	–	–	
M ⟷ L1					
MPH-ERROR	–	X	–	X	Type of error or recovery from a previously reported error
MPH-ACTIVATE	–	X	–	–	
MPH-DEACTIVATE	X	X	–	–	
MPH-INFORMATION	–	X	–	X	Connected/disconnected

Note 1 – PH-DATA REQUEST implies underlying negotiation between layer 1 and layer 2 for the acceptance of the data.

Note 2 – Priority indication applies only to the request type.

3.2 *Point-to-multipoint operation*

Point-to-multipoint operation at layer 1 allows more than one TE (source and sink pair) to be simultaneously active at an S or T reference point. (The multipoint mode of operation may be accommodated, as discussed in § 4, with point-to-point or point-to-multipoint wiring configurations.)

4 **Types of wiring configuration**

The electrical characteristics of the user-network interface are determined on the basis of certain assumptions about the various wiring configurations which may exist in the user premises. These assumptions are identified in two major configuration descriptions, § 4.1 and § 4.2, together with additional material contained in Annex A. Figure 2/I.430 shows a general Reference Configuration for wiring in the user premises.

4.1 *Point-to-point configuration*

A point-to-point wiring configuration implies that only one source (transmitter) and one sink (receiver) are interconnected on an interchange circuit.

4.2 *Point-to-multipoint configuration*

A point-to-multipoint wiring configuration allows more than one source to be connected to the same sink or more than one sink to be connected to the same source on an interchange circuit. Such distribution systems are characterized by the fact that they contain no active logic elements performing functions (other than possibly amplification or regeneration of the signal).

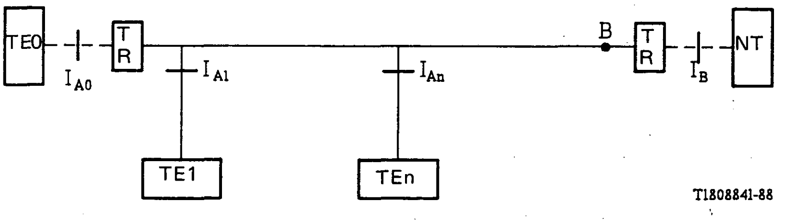
4.3 *Wiring polarity integrity*

For a point-to-point wiring configuration, the two wires of the interchange circuit pair may be reversed. However, for a point-to-multipoint wiring configuration, the wiring polarity integrity of the interchange circuit (TE-to-NT direction) must be maintained between TEs (see the reference configuration in Figure 20/I.430).

In addition, the wires of the optional pairs, which may be provided for powering, may not be reversed in either configuration.

4.4 *Location of the interfaces*

The wiring in the user premises is considered to be one continuous cable run with jacks for the TEs and NT attached directly to the cable or using stubs less than 1 metre in length. The jacks are located at interface points I_A and I_B (see Figure 2/I.430). One interface point, I_A, is adjacent to each TE. The other interface point I_B, is adjacent to the NT. However, in some applications, the NT may be connected to the wiring without the use of a jack or with a jack which accommodates multiple interfaces (e.g., when the NT is a port on a PBX). The required electrical characteristics (described in § 8) for I_A and I_B are different in some aspects.



TR Terminating resistor
I Electrical interface
B Location of I_B when the terminating resistor (TR) is included in the NT

FIGURE 2/I.430

Reference configuration for wiring in the user premises location

4.5 *NT and TE associated wiring*

The wiring from the TE or the NT to its appropriate jack affects the interface electrical characteristics. A TE, or an NT that is not permanently connected to the interface wiring, may be equipped with either of the following for connection to the interface point (I_A and I_B, respectively):

- a hard wired connecting cord (of not more than 10 metres in the case of a TE, and not more than 3 metres in the case of an NT) and a suitable plug, or;
- a jack with a connecting cord (of not more than 10 metres in the case of a TE, and not more than 3 metres in the case of an NT) which has a suitable plug at each end.

Normally, the requirements of I.430 apply to the interface point (I_A and I_B, respectively), and the cord forms part of the associted TE or NT. However, as a national option, where the terminating resistors are connected internally to the NT, the connecting cord may be considered as an integral part of the interface wiring. In this case, the requirements of this Recommendation may be applied to the NT at the connection of the connecting cord to the NT. Note that the NT may attach directly to the interface wiring without a detachable cord. Also note that the connector, plug and jack used for the connection of the detachable cord to the NT is not subject to standardization.

Although a TE may be provided with a cord of less than 5 metres in length, it shall meet the requirements of this Recommendation with a cord having a minimum length of 5 metres. As specified above, the TE cord may be detachable. Such a cord may be provided as a part of the TE, or the TE may be designed to conform to the electrical characteristics specified in § 8 with a "standard ISDN basic access TE cord" conforming to the requirements specified in § 8.9 of this Recommendation and having the maximum permitted capacitance.

The use of an extension cord, of up to 25 metres in length, with a TE is permitted but only on point-to-point wiring configurations. (The total attenuation of the wiring and of the cord in this case should not exceed 6 dB.)

5 Functional characteristics

The following paragraphs show the functions for the interface.

5.1 *Interface functions*

5.1.1 *B-channel*

This function provides, for each direction of transmission, two independent 64 kbit/s channels for use as B-channels (as defined in Recommendation I.412).

5.1.2 *Bit timing*

This function provides bit (signal element) timing at 192 kbit/s to enable the TE and NT recover information from the aggregate bit stream.

5.1.3 *Octet timing*

This function provides 8 kHz octet timing for the NT and TE.

5.1.4 *Frame alignment*

This function provides information to enable NT and TE to recover the time division multiplexed channels.

5.1.5 *D-channel*

This function provides, for each direction of transmission, one D-channel at a bit rate of 16 kbit/s, as defined in Recommendation I.412.

5.1.6 *D-channel access procedure*

This function is specified to enable TEs to gain access to the common resource of the D-channel in an orderly controlled fashion. The functions necessary for these procedures include an echoed D-channel at a bit rate of 16 kbit/s in the direction NT to TE. For the definition of the procedures relating to D-channel access see § 6.1.

5.1.7 *Power feeding*

This function provides for the capability to transfer power across the interface. The direction of power transfer depends on the application. In a typical application, it may be desirable to provide for power transfer from the NT towards the TEs in order to, for example, maintain a basic telephony service in the event of failure of the locally provided power. (In some applications unidirectional power feeding or no power feeding at all, across the interface, may apply.) The detailed specification of power feeding capability is contained in § 9.

5.1.8 *Deactivation*

This function is specified in order to permit the TE and NT to be placed in a low power consumption mode when no calls are in progress. For TEs that are power fed across the interface from power source 1 and for remotely power fed NTs, deactivation places the functions that are so powered into a low power consumption mode (see § 9). The procedures and precise conditions under which deactivation takes place are specified in § 6.2. (For some applications it will be appropriate for NTs to remain in the active state all the time.)

5.1.9 *Activation*

This function restores all the functions of a TE or an NT, which may have been placed into a low power consumption mode during deactivation, to an operating power mode (see § 9), whether under normal or restricted power conditions. The procedures and precise conditions under which activation takes place are defined in § 6.2. (For some applications it will be appropriate for NTs to remain in the active state all the time.)

5.2 *Interchange circuits*

Two interchange circuits, one for each direction of transmission, shall be used to transfer digital signals across the interface. All of the functions described in § 5.1, except for power feeding, shall be carried by means of a digitally multiplexed signal structured as defined in § 5.4.

5.3 *Connected/disconnected indication*

The appearance/disapearance of power is the criterion used by a TE to determine whether it is connected/disconnected at the interface. This is necessary for TEI (Terminal Endpoint Identifier) assignments according to the procedures described in Recommendation I.441.

A TE which considers itself connected, when unplugged, can cause duplication of TEI values after reconnection. When duplication occurs, procedures described in Recommendation I.441 will permit recovery.

5.3.1 *TEs powered across the interface*

A TE which is powered from power source 1 or 2 across the interface shall use the detection of power source 1 or 2, respectively, to establish the connection status. (See § 9 and Figure 20/I.430 for a description of the power sources.)

5.3.2 *TEs not powered across the interface*

A TE which is not powered across the interface may use either:

a) the detection of power source 1 or power source 2, whichever may be provided, to establish the connection status; or

b) the presence/absence of local power to establish the connection status.

TEs which are not powered across the interface and are unable to detect the presence of power source 1 or 2 shall consider themselves connected/disconnected when local power is applied/removed.

Note – It is desirable to use the detection of power source 1 or source 2 to establish the connection status when automatic TEI selection procedures are used within the management entity.

5.3.3 *Indication of connection status*

TEs which use the detection of power source 1 or 2, whichever is used to determine connection/disconnection, to establish the connection status shall inform the management entity (for TEI purposes) using:

a) MPH-INFORMATION INDICATION (connected)

   when operational power and the presence of power source 1 or 2, whichever is used to determine connection/disconnection, is detected; and

b) MPH-INFORMATION INDICATION (disconnected)

   when the disappearance of power source 1 or 2, whichever is used to determine connection/disconnection, is detected, or power in the TE is lost.

TEs which are unable to detect power source 1 or 2, whichever may be provided, and, therefore, use the presence/absence of local power to estabish the connection status [see § 5.3.2 b)], shall inform the management entity using:

a) MPH-INFORMATION INDICATION (disconnected)

   when power (see Note) in the TE is lost;

b) MPH-INFORMATION INDICATION (connected)

   when power (see Note) in the TE is applied.

Note – The term "power" could be the full operational power or backup power. Backup power is defined such that it is enough to hold TEI values in memory and maintain the capability of receiving and transmiting layer 2 frames associated with the TEI procedures.

5.4 *Frame structure*

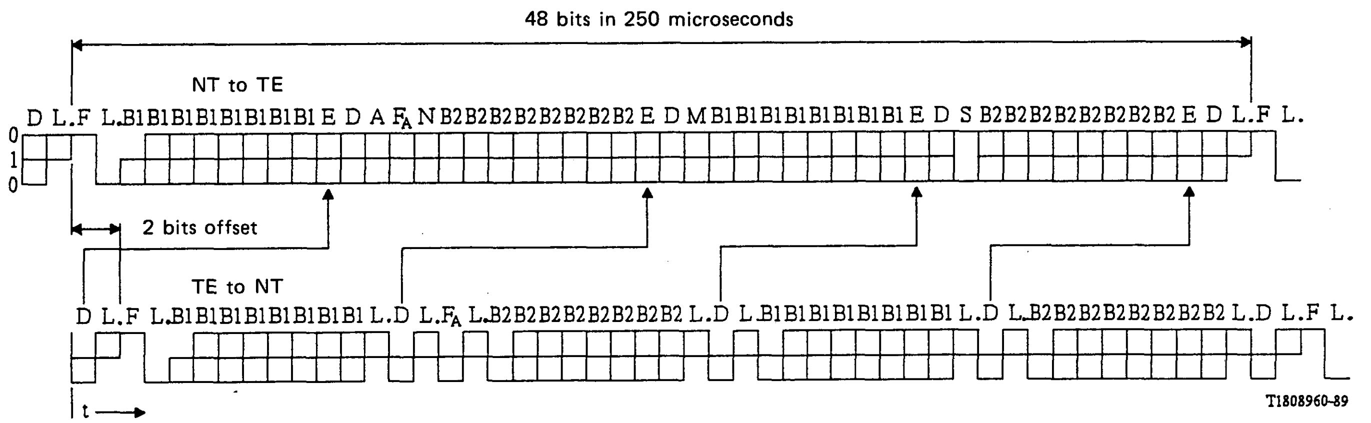
In both directions of transmission, the bits shall be grouped into frames of 48 bits each. The frame structure shall be identical for all configurations (point-to-point and point-to-multipoint).

5.4.1 *Bit rate*

The nominal transmitted bit rate at the interfaces shall be 192 kbit/s in both directions of transmission.

5.4.2 *Binary organization of the frame*

The frame structures are different for each direction of transmission. Both structures are illustrated diagrammatically in Figure 3/I.430.



F	Framing bit	N	Bit set to a binary value N = $\overline{F}_A$ (NT to TE)
L	D.C. balancing bit	B1	Bit within B-channel 1
D	D-channel bit	B2	Bit within B-channel 2
E	D-echo-channel bit	A	Bit used for activation
F_A	Auxiliary framing bit (see § 6.3)	S	Use of this bit is for further study
		M	Multiframing bit

Note 1 – Dots demarcate those parts of the frame that are independently d.c.-balanced.

Note 2 – The F_A bit in the direction TE to NT is used as a Q bit in every fifth frame if the Q-channel capability is applied (see § 6.3.3).

Note 3 – The nominal 2-bit offset is as seen from the TE (I_A in Figure 2/I.430). The corresponding offset at the NT may be greater due to delay in the interface cable and varies by configuration.

FIGURE 3/I.430

Frame structure at reference points S and T

5.4.2.1 *TE to NT*

Each frame consists of the groups of bits shown in Table 2/I.430; each individual group is d.c.-balanced by its last bit (L bit).

5.4.2.2 *NT to TE*

Frames transmitted by the NT contain an echo channel (E bits) used to retransmit the D bits received from the TEs. The D-echo channel is used for D-channel access control. The last bit of the frame (L bit) is used for balancing each complete frame.

The bits are grouped as shown in Table 3/I.430.

TABLE 2/I.430

Bit position	Group
1 and 2	Framing signal with balance bit
3 - 11	B1-channel (first octet) with balance bit
12 and 13	D-channel bit with balance bit
14 and 15	F_A auxiliary framing bit or Q bit with balance bit
16 - 24	B2-channel (first octet) with balance bit
25 and 26	D-channel bit with balance bit
27 - 35	B1-channel (second octet) with balance bit
36 and 37	D-channel bit with balance bit
38 - 46	B2-channel (second octet) with balance bit
47 and 48	D-channel bit with balance bit

TABLE 3/I.430

Bit position	Group
1 and 2	Framing signal with balance bit
3 - 10	B1-channel (first octet)
11	E, D-echo-channel bit
12	D-channel bit
13	Bit A used for activation
14	F_A auxiliary framing bit
15	N bit (coded as defined in § 6.3)
16 - 23	B2-channel (first octet)
24	E, D-echo-channel bit
25	D-channel bit
26	M, multiframing bit
27 - 34	B1-channel (second octet)
35	E, D-echo-channel bit
36	D-channel bit
37	S, The use of this bit is for further study
38 - 45	B2-channel (second octet)
46	E, D-echo-channel bit
47	D-channel bit
48	Frame balance bit

Note – S is set to binary ZERO.

5.4.2.3 *Relative bit positions*

At the TEs, timing in the direction TE to NT shall be derived from the frames received from the NT.

The first bit of each frame transmitted from a TE towards the NT shall be delayed, nominally, by two bit periods with respect to the first bit of the frame received from the NT. Figure 3/I.430 illustrates the relative bit positions for both transmitted and received frames.

5.5 *Line code*

For both directions of transmission, pseudo-ternary coding is used with 100% pulse width as shown in Figure 4/I.430. Coding is performed in such a way that a binary ONE is represented by no line signal; whereas, a binary ZERO is represented by a positive or negative pulse. The first binary ZERO following the framing bit-balance bit is of the same polarity as the framing bit-balance bit. Subsequent binary ZEROs must alternate in polarity. A balance bit is a binary ZERO if the number of binary ZEROs following the previous balance bit is odd. A balance bit is a binary ONE if the number of binary ZEROs following the previous balance bit is even.

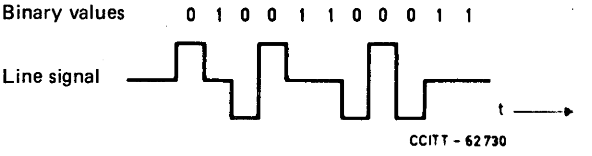


FIGURE 4/I.430

Pseudo-ternary code – example of application

5.6 *Timing considerations*

The NT shall derive its timing from the network clock. A TE shall derive its timing (bit, octet, frame) from the signal received from the NT and use this derived timing to synchronize its transmitted signal.

6 Interface procedures

6.1 *D-channel access procedure*

The following procedure allows for a number of TEs connected in a multipoint configuration to gain access to the D-channel in an orderly fashion. The procedure always ensures that, even in cases where two or more TEs attempt to access the D-channel simultaneously, one, but only one, of the TEs will be successful in completing transmission of its information. This procedure relies upon the use of layer 2 frames delimited by flags consisting of the binary pattern "01111110" and the use of zero bit insertion to prevent flag imitation (see Recommendation I.441).

The procedure also permits TEs to operate in a point-to-point manner.

6.1.1 *Interframe (layer 2) time fill*

When a TE has no layer 2 frames to transmit, it shall send binary ONEs on the D-channel, i.e., the interframe time fill in the TE-to-NT direction shall be binary ONEs.

When an NT has no layer 2 frames to transmit, it shall send binary ONEs or HDLC flags, i.e., the interframe time fill in the NT-to-TE direction shall be either all binary ONEs or repetitions of the octet "01111110". When the interframe time fill is HDLC flags, the flag which defines the end of a frame may define the start of the next frame.

6.1.2 *D-echo channel*

The NT, on receipt of a D-channel bit from TE or TEs, shall reflect the binary value in the next available D-echo channel bit position towards the TE. (It may be necessary to force the D-echo channel bits to all binary ZEROs during certain loopbacks – see Note 4 of Table I.1/I.430 and § 5 of Recommendation G.960).

6.1.3 *D-channel monitoring*

A TE, while in the active condition, shall monitor the D-echo channel, counting the number of consecutive binary ONEs. If a ZERO bit is detected, the TE shall restart counting the number of consecutive ONE bits. The current value of the count is called C.

Note – C need not be incremented after the value eleven has been reached.

6.1.4 *Priority mechanism*

Layer 2 frames are transmitted in such a way that signalling information is given priority (priority class 1) over all other types of information (priority class 2). Furthermore, to ensure that within each priority class all competing TEs are given a fair access to the D-channel, once a TE has successfully completed the transmission of a frame, it is given a lower level of priority within that class. The TE is given back its normal level within a priority class when all TEs have had an opportunity to transmit information at the normal level within that priority class.

The priority class of a particular layer 2 frame may be a characteristic of the TE which is preset at manufacture or at installation, or it may be passed down from layer 2 as a parameter of the PH-DATA REQUEST primitive.

The priority mechanism is based on the requirement that a TE may start layer 2 frame transmission only when C (see § 6.1.3) is equal to, or exceeds, the value X_1 for priority class 1 or is equal to, or exceeds, the value X_2 for priority class 2. The value of X_1 shall be eight for the normal level and nine for the lower level of priority. The value of X_2 shall be ten for the normal level and eleven for the lower level of priority.

In a priority class the value of the normal level of priority is changed into the value of the lower level of priority (i.e. higher value) when a TE has successfully transmitted a layer 2 frame of that priority class.

The value of the lower level of priority is changed back to the value of the normal level of priority when C (see § 6.1.3) equals the value of the lower level of priority, (i.e. higher value).

6.1.5 *Collision detection*

While transmitting information in the D-channel, the TE shall monitor the received D-echo channel and compare the last transmitted bit with the next available D-echo bit. If the transmitted bit is the same as the received echo, the TE shall continue its transmission. If, however, the received echo is different from the transmitted bit, the TE shall cease transmission immediately and return to the D-channel monitoring state.

6.1.6 *Priority system*

Annex B describes an example of how the priority system may be implemented.

6.2 *Activation/deactivation*

6.2.1 *Definitions*

6.2.1.1 *TE states*

6.2.1.1.1 State F1 (inactive): In this inactive state the TE is not transmitting. In the case of locally powered TEs which cannot detect the appearance/disappearance of power source 1 or 2, this state is entered when local power is not present. For TEs which can detect power source 1 or power source 2, this state is entered whenever loss of power (required to support all TEI functions) is detected, or when the absence of power from source 1 or 2, whichever power source is used for determining the connection status, is detected.

6.2.1.1.2 State F2 (sensing): This state is entered after the TE has been powered on but has not determined the type of signal (if any) that the TE is receiving.

6.2.1.1.3 State F3 (deactivated): This is the deactivated state of the physical protocol. Neither the NT nor the TE is transmitting.

6.2.1.1.4 State F4 (awaiting signal): When the TE is requested to initiate activation by means of a PH-ACTIVATE REQUEST primitive, it transmits a signal (INFO 1) and waits for a response from the NT.

6.2.1.1.5 State F5 (identifying input): At the first receipt of any signal from the NT, the TE ceases to transmit INFO 1 and awaits identification of signal INFO 2 or INFO 4.

6.2.1.1.6 State F6 (synchronized): When the TE receives an activation signal (INFO 2) from the NT, it responds with a signal (INFO 3) and waits for normal frames (INFO 4) from the NT.

6.2.1.1.7 State F7 (activated): This is the normal active state with the protocol activated in both directions. Both the NT and the TE are transmitting normal frames.

6.2.1.1.8 State F8 (lost framing): This is the condition when the TE has lost frame synchronization and is awaiting re-synchronization by receipt of INFO 2 or INFO 4 or deactivation by receipt of INFO 0.

6.2.1.2 *NT states*

6.2.1.2.1 State G1 (deactive): In this deactivated state the NT is not transmitting.

6.2.1.2.2 State G2 (pending activation): In this partially active state the NT sends INFO 2 while waiting for INFO 3. This state will be entered on request by higher layers, by means of a PH-ACTIVATE REQUEST primitive, or on the receipt of INFO 0 or lost framing while in the active state (G3). Then the choice to eventually deactivate is up to higher layers within the NT.

6.2.1.2.3 State G3 (active): This is the normal active state where the NT and TE are active with INFO 4 and INFO 3, respectively. A deactivation may be initiated by the NT system management, by means of an MPH-DEACTIVE REQUEST primitive, or the NT may be in the active state all the time, under non-fault conditions.

6.2.1.2.4 State G4 (pending deactivation): When the NT wishes to deactivate, it may wait for a timer to expire before returning to the deactivated state.

6.2.1.3 *Activate primitives*

The following primitives should be used between layers 1 and 2 and between layer 1 and the management entity in the activation procedures. For use in state diagrams, etc., abbreviations of the primitive names are also given.

PH-ACTIVATE REQUEST (PH-AR)

PH-ACTIVATE INDICATION (PH-AI)

MPH-ACTIVATE INDICATION (MPH-AI)

6.2.1.4 *Deactivate primitives*

The following primitives should be used between layers 1 and 2 and between layer 1 and the management entity in the deactivation procedures. For use in state diagrams, etc., abbreviations of the primitive names are also given.

MPH-DEACTIVATE REQUEST (MPH-DR)

MPH-DEACTIVATE INDICATION (MPH-DI)

PH-DEACTIVATE INDICATION (PH-DI)

6.2.1.5 *Management primitives*

The following primitives should be used between layer 1 and the management entity. For use in state diagrams, etc., abbreviations of the primitive names are also given.

MPH-ERROR INDICATION (MPH-EI)

Message unit contains type of error or recovery from a previously reported error.

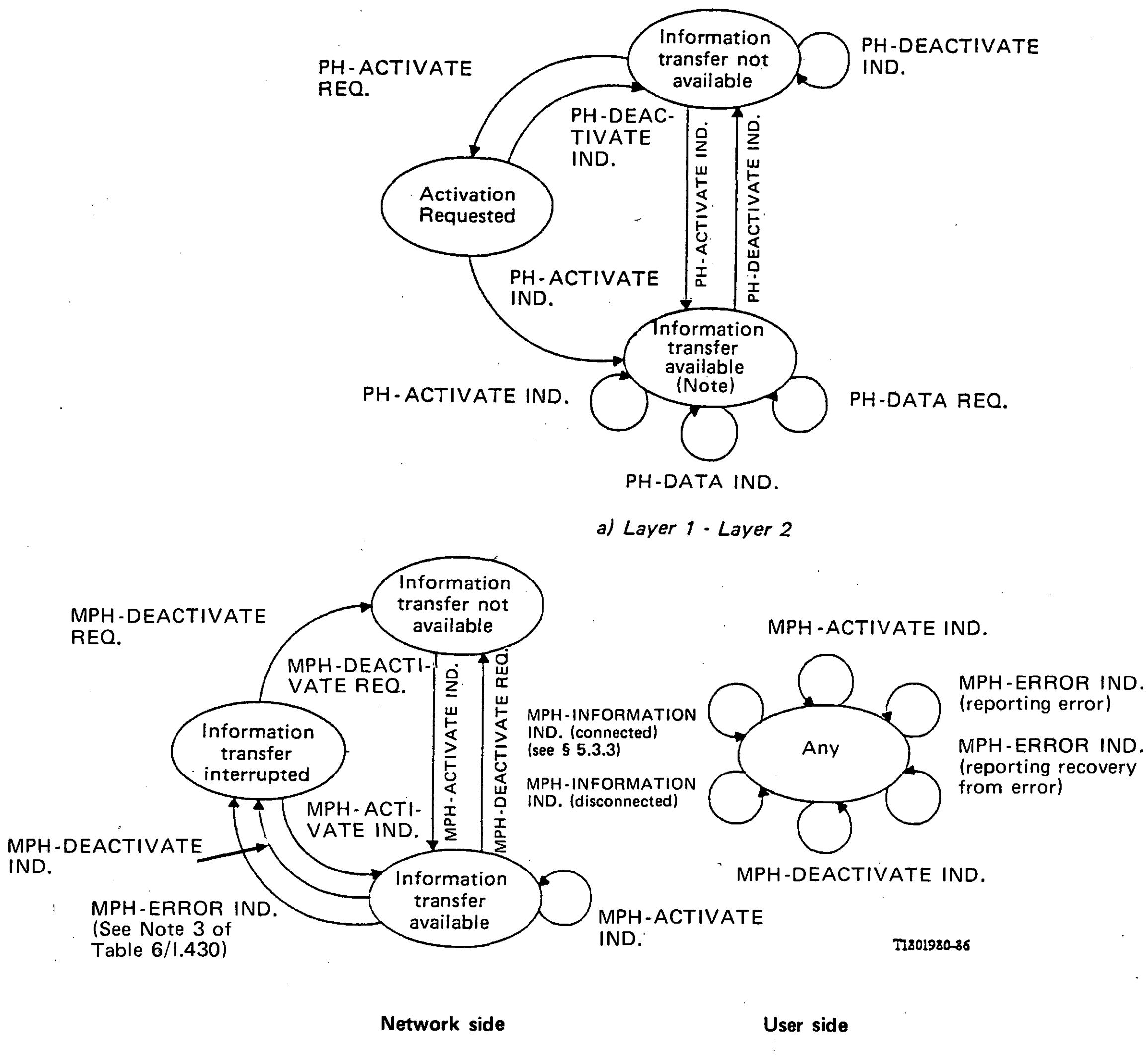
MPH-INFORMATION INDICATION (MPH-II)

Message unit contains information regarding the physical layer conditions. Two parameters are provisionally defined: connected and disconnected.

Note – Implementation of primitives in NTs and TEs is not for recommendation.

6.2.1.6 *Valid primitive sequences*

The primitives defined in § 6.2.1.3, § 6.2.1.4 and § 6.2.1.5 specify, conceptually, the service provided by layer 1 to layer 2 and the layer 1 management entity. The constraints on the sequence in which the primitives may occur are specified in Figure 5/I.430. These diagrams do not represent the states which must exist for the layer 1 entity. However, they do illustrate the condition that the layer 2 and management enities perceive layer 1 to be in at a result of the primitives transferred between entities. Furthermore, Figure 5/I.430 does not represent an interface and is used only for modelling purposes.



b) Layer 1 - Management

Note — Layer 2 is not aware if the information transfer capability is temporarily interrupted.

FIGURE 5/I.430

Valid primitive sequences as perceived by layer 2 and management entities

6.2.2 *Signals*

The identifications of specific signals across the S/T reference point are given in Table 4/I.430. Also included is the coding for these signals.

TABLE 4/I.430

Definition of INFO signals (Note 1)

Signals from NT to TE		Signals from TE to NT	
INFO 0	No signal.	INFO 0	No signal.
		INFO 1 (Note 2)	A continuous signal with the following pattern: Positive ZERO, negative ZERO, six ONEs.  CCITT-62731 Nominal bit rate = 192 kbit/s
INFO 2 (Note 3)	Frame with all bits of B, D, and D-echo channels set to binary ZERO. Bit A set to binary ZERO. N and L bits set according to the normal coding rules.		
		INFO 3	Synchronized frames with operational data on B and D channels.
INFO 4 (Note 3)	Frames with operational data on B, D, and D-echo channels. Bit A set to binary ONE.		

Note 1 – For configurations where the wiring polarity may be reversed (see § 4.3) signals may be received with the polarity of the binary ZEROs inverted. All NT and TE receivers should be designed to tolerate wiring polarity reversals.

Note 2 – TEs which do not need the capability to initiate activation of a deactivated I.430 interface (e.g., TEs required to handle only incoming calls) need not have the capability to send INFO 1. In all other respects, these TEs shall be in accordance with § 6.2. It should be noted that in the point-to-multipoint configuration more than one TE transmitting simultaneously will produce a bit pattern, as received by the NT, different form that described above, e.g., two or more overlapping (asynchronous) instances of INFO 1.

Note 3 – During the transmission of INFO 2 or INFO 4, the F_A bits and the M bits from the NT may provide the Q-bit pattern designation as described in § 6.3.3.

6.2.3 *Activation/deactivation procedure for TEs*

6.2.3.1 *General TE procedures*

All TEs conform to the following (these statements are an aid to understanding; the complete procedures are specified in § 6.2.3.2):

a) TEs, when first connected, when power is applied, or upon the loss of frame alignment (see § 6.3.1.1) shall transmit INFO 0. However, the TE that is disconnected but powered is a special situation and could be transmitting INFO 1 when connected.

b) TEs transmit INFO 3 when frame alignment is established (see § 6.3.1.2). However, the satisfactory transmission of operational data cannot be assured prior to the receipt of INFO 4.

c) TEs that are locally powered shall, when power is removed, initiate the transmission of INFO 0 before frame alignment is lost.

6.2.3.2 *Specification of the procedure*

The procedure for TEs which can detect power source 1 or 2 is shown in the form of a finite state matrix Table 5/I.430. An SDL representation of the procedure is outlined in Annex C. The finite state matrices for two other TE types are given in Annex C, Tables C-1/I.430 and C-2/I.430. The finite state matrix and SDL representations reflect the requirements necessary to assure proper interfacing of a TE with an NT conforming to the procedures described in Table 6/I.430. They also describe primitives at the layer 1/2 boundary and layer 1/management entity boundary.

6.2.4 *Activation/deactivation for NTs*

6.2.4.1 *Activating/deactivating NTs*

The procedure is shown in the form of a finite state matrix in Table 6/I.430. An SDL representation of the procedure is outlined in Annex C. The finite state matrix and SDL representations reflect the requirements necessary to assure proper interfacing of an activating/deactivating NT with a TE conforming to the procedures described in Table 5/I.430. They also describe primitives at the layer 1/2 boundary and layer 1/management entity boundary.

6.2.4.2 *Non-activating/non-deactivating NTs*

The behaviour of such NTs is the same as that of an activating/deactivating NT never receiving MPH-DEACTIVATE REQUEST from the management entity. States G1 (deactive), G4 (pending deactivation) and timers 1 and 2 may not exist from such NTs.

6.2.5 *Timer values*

The finite state matrix tables show timers on both the TE and the NT. The following values are defined for timers:

– TE: Timer 3, not to be specified (the value depends on the subscriber loop transmission technique. The worst case value is 30s).

– NT: Timer 1, not to be specified.
Timer 2, 25 to 100 ms.

6.2.6 *Activation times*

6.2.6.1 *TE activation times*

A TE in the deactivated state (F3) shall, upon the receipt of INFO 2, establish frame synchronization and initiate the transmission of INFO 3 within 100 ms. A TE shall recognize the receipt of INFO 4 within two frames (in the absence of errors).

A TE in the "waiting for signal" state (F4) shall, upon the receipt of INFO 2, cease the transmission of INFO 1 and initiate the transmission of INFO 0 within 5 ms and then respond to INFO 2, within 100 ms, as above. (Note that in Table 5/I.430, the transition from F4 to F5 is indicated as the result of the receipt of "any signal" which is in recognition of the fact that a TE may not know that the signal being received is INFO 2 until after it has recognized the presence of a signal.)

6.2.6.2 *NT activation times*

An NT in the deactivate state (G1) shall, upon the receipt of INFO 1, initiate the transmission of INFO 2 (synchronized to the network) within 1 s under normal conditions. Delays, "Da", as long as 30 s are acceptable under abnormal (non-fault) conditions, e.g., as a result of a need for retrain for an associated loop transmission system.

An NT in the "pending activation" state (G2) shall, upon the receipt of INFO 3, initiate the transmission of INFO 4 within 500 ms under normal conditions. Delays, "Db", as long as 15 s are acceptable under abnormal (non-fault) conditions provided that the sum of the delays "Da" and "Db" are not greater than 30 s.

TABLE 5/I.430

Activation/deactivation layer 1 finite state matrix for TEs
TEs powered from power source 1 ou 2

State name	Inactive	Sensing	Deactivated	Awaiting signal	Identifying input	Synchronized	Activated	Lost framing
State number	F1	F2	F3	F4	F5	F6	F7	F8
Event / INFO sent	INFO 0	INFO 0	INFO 0	INFO 1	INFO 0	INFO 3	INFO 3	INFO 0
Power on and detection of Power S (Note 1 and Note 2)	F2	–	–	–	–	–	–	–
Loss of power (Note 1)	–	F1	MPH-II(d); F1	MPH-II(d), MPH-DI, PH-DI; F1	MPH-II(d), MPH-DI, PH-DI; F1	MPH-II(d), MPH-DI, PH-DI; F1	MPH-II(d), MPH-DI, PH-DI; F1	MPH-II(d), MPH-DI, PH-DI; F1
Disappearance of power S (Note 2)	–	F1	MPH-II(d); F1	MPH-II(d), MPH-DI, PH-DI; F1	MPH-II(d), MPH-DI, PH-DI; F1	MPH-II(d), MPH-DI, PH-DI; F1	MPH-II(d), MPH-DI, PH-DI; F1	MPH-II(d), MPH-DI, PH-DI; F1
PH-ACTIVATE REQUEST	/	|	ST. T3; F4	|	|	–	|	–
Expiry T3	/	/	–	MPH-DI, PH-DI; F3	MPH-DI, PH-DI; F3	MPH-DI, PH-DI; F3	–	–
Receive INFO 0	/	MPH-II(c); F3	–	–	–	MPH-DI, PH-DI; F3	MPH-DI, PH-DI; F3	MPH-DI, PH-DI, MPH-EI2; F3
Receive any signal (Note 3)	/	–	–	F5	–	/	/	–

TABLE 5/I.430 *(cont.)*

Activation/deactivation layer 1 finite state matrix for TEs
TEs powered from power source 1 ou 2

State name	Inactive	Sensing	Deactivated	Awaiting signal	Identifying input	Synchronized	Activated	Lost framing
State number	F1	F2	F3	F4	F5	F6	F7	F8
Event / INFO sent	INFO 0	INFO 0	INFO 0	INFO 1	INFO 0	INFO 3	INFO 3	INFO 0
Receive INFO 2	/	MPH-II(c); F6	F6	/	F6 (Note 4)	–	MPH-EI1; F6	MPH-EI2; F6
Receive INFO 4	/	MPH-II(c), PH-AI, MPH-AI; F7	PH-AI, MPH-AI; F7	/	PH-AI, MPH-AI; F7 (Note 4)	PH-AI, MPH-AI, MPH-EI2; F7	–	PH-AI, MPH-AI, MPH-EI2; F7
Lost framing	/	/	/	/	/	MPH-EI1; F8	MPH-EI1; F8	–

–	No change, no action
|	Impossible by the definition of the layer 1 service
/	Impossible situation
a, b; Fn	Issue primitives "a" and "b" and then go to state "Fn"
PH-AI	Primitive PH-ACTIVATE INDICATION
PH-DI	Primitive PH-DEACTIVATE INDICATION
MPH-AI	Primitive MPH-ACTIVATE INDICATION
MPH-DI	Primitive MPH-DEACTIVATE INDICATION
MPH-EI1	Primitive MPH-ERROR INDICATION reporting error
MPH-EI2	Primitive MPH-ERROR INDICATION reporting recovery from error
MPH-II(c)	Primitive MPH-INFORMATION INDICATION (connected)
MPH-II(d)	Primitive MPH-INFORMATION INDICATION (disconnected)
ST. T3	Start timer T3
Power S	Power source 1 or power source 2.

Primitives are signals in a conceptual queue and will be cleared on recognition, while the INFO signals are continuous signals which are available all the time.

Note 1 – The term "power" could be the full operational power or backup power. Backup power is defined such that it is enough to hold the TEI value in memory and maintain the capability of receiving and transmitting layer 2 frames associated with the TEI procedures.

Note 2 – The procedures described in Table 5/I.430 require the provision of power source 1 or power source 2 to enable their complete operation. A TE which determines that it is connected to an NT not providing power source 1 or 2 should default to the procedures described in Table C-1/I.430.

Note 3 – This event reflects the case where a signal is received and the TE has not (yet) determined whether it is INFO 2 or INFO 4.

Note 4 – If INFO 2 or INFO 4 is not recognized within 5 ms after the appearance of a signal, TEs must go to F5.

TABLE 6/I.430

Activation/deactivation layer 1 finite state matrix for NTs

State name / State number / INFO sent — Event	Deactive	Pending activation	Active	Pending deactivation
State number	G1	G2	G3	G4
INFO sent	INFO 0	INFO 2	INFO 4	INFO 0
PH-ACTIVATE REQUEST	Start timer T1 G2	|	|	Start timer T1 G2
MPH-DEACTIVATE REQUEST	|	Start timer T2 PH-DI; G4	Start timer T2 PH-DI; G4	|
Expiry T1 (Note 1)	–	Start timer T2 PH-DI; G4	/	–
Expiry T2 (Note 2)	–	–	–	G1
Receiving INFO 0	–	–	MPH-DI, MPH-EI; G2 (Note 3)	G1
Receiving INFO 1	Start timer T1 G2	–	/	–
Receiving INFO 3	/	Stop timer T1 PH-AI, MPH-AI; G3 (Note 4)	–	–
Lost framing	/	/	MPH-DI, MPH-EI; G2 (Note 3)	–

–	No state change
/	Impossible by the definition of peer-to-peer physical layer procedures or system internal reasons
|	Impossible by the definition of the physical layer service
a, b; Gn	Issue primitives "a" and "b" then go to state "Gn"
PH-AI	Primitive PH-ACTIVATE INDICATION
PH-DI	Primitive PH-DEACTIVATE INDICATION
MPH-AI	Primitive MPH-ACTIVATE INDICATION
MPH-DI	Primitive MPH-DEACTIVATE INDICATION
MPH-EI	Primitive MPH-ERROR INDICATION

Primitives are signals in a conceptual queue and will be cleared on recognition, while the INFO signals are continuous signals which are available all the time.

Notes relating to Table 6/I.430:

Note 1 – Timer 1 (T1) is a supervisory timer which has to take into account the overall time to activate. This time includes the time it takes to activate both the ET-NT and the NT-TE portion of the customer access. ET is the exchange termination.

Note 2 – Timer 2 (T2) prevents unintentional reactivation. Its value is 25 ms $\leqslant$ value $\leqslant$ 100 ms. This implies that a TE has to recognize INFO 0 and to react on it within 25 ms. If the NT is able to unambiguously recognize INFO 1, then the value of timer 2 may be 0.

Note 3 – These notifications (MPH-DI, MPH-EI) need not be transferred to a management entity at the NT.

Note 4 – As an implementation option, to avoid premature transmission of information (i.e., INFO 4), layer 1 may not initiate the transmission of INFO 4 or send the primitives PH-ACTIVATE INDICATION and MPH-ACTIVATE INDICTION (to layer 2 and management, respectively) until a period of 100 ms has elapsed since the receipt of INFO 3. Such a delay time should be implemented in the ET, if required.

6.2.7 *Deactivation times*

A TE shall respond to the receipt of INFO 0 by initiating the transmission of INFO 0 within 25 ms.

An NT shall respond to the receipt of INFO 0 or the loss of frame synchronization by initiating the transmission of INFO 2 within 25 ms; however, the layer 1 entity does not deactivate in response to INFO 0 from a TE.

6.3 *Frame alignment procedures*

The first bit of each frame is the framing bit, F; it is a binary ZERO.

The frame alignement procedure makes use of the fact that the framing bit is represented by a pulse having the same polarity as the preceding pulse (line code violation). This allows rapid reframing.

According to the coding rule, both the framing bit and the first binary ZERO bit following the framing bit-balance bit (in position 2 in the same frame) produce a line code violation. To guarantee secure framing, the auxiliary framing bit pair F_A and N in the direction NT to TE or the auxiliary framing bit F_A with the associated balancing bit L in the direction TE to NT are introduced. This ensures that there is a line code violation at 14 bits or less from the framing bit F, due to F_A or N being a binary ZERO bit (NT to TE) or to F_A being a binary ZERO bit (TE to NT) if the F_A bit position is not used as a Q bit. The framing procedures do not depend on the polarity of the framing bit F, and thus are not sensitive to wiring polarity.

The coding rule for the auxiliary framing bit pair F_A and N, in the direction NT to TE, is such that N is the binary opposite of F_A ($N = \overline{F}_A$). The F_A and L bits in the direction TE to NT are always coded such that the binary values of F_A and L are equal.

6.3.1 *Frame alignment procedure in the direction NT to TE*

Frame alignment, on initial activation of the TE, shall comply with the procedures defined in § 6.2.

6.3.1.1 *Loss of frame alignment*

Loss of frame alignment may be assumed when a time period equivalent to two 48-bit frames has elapsed without having detected valid pairs of line code violations obeying the $\leqslant$ 14 bit criterion as described above. The TE shall cease transmission immediately.

6.3.1.2 *Frame alignments*

Frame alignment may be assumed to occur when three consecutive pairs of line code violations obeying the $\leqslant$ 14 bit criterion have been detected.

6.3.2 *Frame alignment in the direction TE to NT*

The criterion of a line code violation at 13 bits or less from the framing bit (F) shall apply except if the Q-channel (see § 6.3.3) is provided, in which case the 13 bit criterion applies in four out of five frames.

6.3.2.1 *Loss of frame alignment*

The NT may assume loss of frame alignment if a time period equivalent to at least two 48-bit frames has elapsed since detecting consecutive violations according to the 13 bit criterion, if all F_A bits have been set to binary ZERO. Otherwise, a time period equivalent to at least three 48-bit frames shall be allowed before assuming loss of frame alignment. On detection of loss of frame alignment the NT shall continue transmitting towards the TE.

6.3.2.2 *Frame alignment*

The NT may assume that frame alignment has been regained when three consecutive pairs of line code violations obeying the 13 bit criterion have been detected.

6.3.3 *Multi-framing*

A multi-frame described in the following paragraphs is intended to provide extra layer 1 capacity in the TE-to-NT direction through the use of an extra channel between the TE and NT (Q-channel). This extra layer 1 capacity exists only between the TE and NT, i.e., there is no requirement for the transmission of signals between NT and ET to carry the information conveyed by this extra layer 1 capacity. The use of the Q-channel is for further study. However, TEs shall provide for identification of the bit positions which provide this extra capacity, designated Q bits. TEs not using this capability shall provide for setting each Q bit to a binary ONE. The provision of this capability in NTS is optional.

The use of the Q bits shall be the same in point-to-point as in point-to-multipoint configurations. Future standardization for the use of Q bits is for further study. (There is no inherent collision detection mechanism provided, and any collision detection mechanism that is required for any application of the Q bits will be outside the scope of this Recommendation.)

6.3.3.1 *General mechanism*

a) Q bit identification: The Q bits (TE-to-NT) are defined to be the bits in the F_A bit position of every fifth frame. The Q-bit positions in the TE-to-NT direction are identified by binary inversions of the F_A/N bit pair (F_A = binary ONE, N = binary ZERO) in the NT-to-TE direction. The provision of the capability in NTs is optional. The provision for identification of the Q-bit positions in the NT-to-TE direction permits all TEs to synchronize transmission in Q-bit positions – thereby avoiding interference of F_A-bits from one TE with the Q-bits of a second TE in passive bus configurations.

b) Multi-frame identification: A multi-frame, which provides for structuring the Q bits in groups of four (Q1 – Q4), is established by setting the M bit, in position 26 of the NT-to-TE frame, to binary ONE in every twentieth frame. This structure provides for 4-bit characters in a single channel, TE-to-NT. The provision of the capability in NTs is optional.

6.3.3.2 *Q-bit position identification algorithm*

The Q-bit position identification algorithm is illustrated in Table 7/I.430. Two examples of how such an identification algorithm can be realized are as follows. The TE Q-bit identification algorithm may be simply the transmission of a Q bit in each frame in which a binary ONE is received in the F_A-bit position of the NT-to-TE frame (i.e., echoing of the received F_A bits). Alternatively, to minimize the Q-bit transmission errors that could result from errors in the F_A bits of NT-to-TE frames, a TE may synchronize a frame counter to the Q-bit rate and transmit Q bits in every fifth frame, i.e., in frames in which F_A bits should be equal to binary ONE. The F_A bit is present in every frame. Q bits would be transmitted only after counter synchronization to the frame binary ONEs in the F_A bit positions of the NT-to-TE frames is achieved (and only if such bits are received). When the counter is not synchronized (not achieved or lost), a TE which uses such algorithm shall transmit binary ZEROs in Q-bit positions. The algorithm used by a TE to determine when synchronization is defined to be achieved or the algorithm used to determine when it is defined to be lost is not described in this Recommendation, but it should be noted that the transmission of multi-framing from an NT is not mandatory.

No special Q-bit identification is required in the NT because the maximum round trip delay of NT-to-TE-to-NT is a small fraction of a frame and, therefore, Q-bit identification is inherent in the NT.

TABLE 7/I.430

Q-bit position identification and multi-frame structure

Frame Number	NT-to-TE F_A bit position	TE-to-NT F_A bit position (Notes 1 and 2)	NT-to-TE M Bit
1	ONE	Q1	ONE
2	ZERO	ZERO	ZERO
3	ZERO	ZERO	ZERO
4	ZERO	ZERO	ZERO
5	ZERO	ZERO	ZERO
6	ONE	Q2	ZERO
7	ZERO	ZERO	ZERO
8	ZERO	ZERO	ZERO
9	ZERO	ZERO	ZERO
10	ZERO	ZERO	ZERO
11	ONE	Q3	ZÉRO
12	ZERO	ZERO	ZERO
13	ZERO	ZERO	ZERO
14	ZERO	ZERO	ZERO
15	ZERO	ZERO	ZERO
16	ONE	Q4	ZERO
17	ZERO	ZERO	ZERO
18	ZERO	ZERO	ZERO
19	ZERO	ZERO	ZERO
20	ZERO	ZERO	ZERO
1	ONE	Q1	ONE
2	ZERO	ZERO	ZERO
etc.			

Note 1 – If the Q-bits are not used by a TE, the Q-bits shall be set to binary ONE.

Note 2 – Where multi-frame identification is not provided with a binary ONE in an appropriate M bit, but where Q-bit positions are identified, Q-bits 1 through 4 are not distinguished.

6.3.3.3 *TE Multi-frame identification*

The first frame of the multi-frame is identified by the M bit equal to a binary ONE. TEs that are not intended to use, nor to provide for the use of, the Q-channel are not required to identify the multi-frame. TEs that are intended to use, or to provide for the use of, the Q-channel shall use the M bit equal to a binary ONE to identify the start of the multi-frame.

The algorithm used by a TE to determine when synchronization or loss of synchronization of the multi-frame is achieved is not described in this Recommendation, however, it should be noted that the transmission of multi-framing from an NT is not mandatory.

6.3.4 *S-bit channel structuring algorithm*

The algorithm for structuring the S-bits (NT-to-TE frame bit position 37) into an S-channel will use a combination of the F_A-bit inversions and the M bit used to structure the Q-bit channel as described in § 6.3.3. The use of the S-channel and its structure are for further study.

6.4 *Idle channel code on the B-channels*

A TE shall send binary ONEs in any B-channel which is not assigned to it.

7 **Layer 1 maintenance**

The test loopbacks defined for the basic user-network interface are specified in Appendix I.

8 **Electrical characteristics**

8.1 *Bit rate*

8.1.1 *Nominal rate*

The nominal bit rate is 192 kbit/s.

8.1.2 *Tolerance*

The tolerance (free running mode) is ± 100 ppm.

8.2 *Jitter and bit-phase relationship between TE input and output*

8.2.1 *Test configurations*

The jitter and phase deviation measurements are carried with four different waveforms at the TE input, in accordance with the following configurations:

- i) point-to-point configuration with 6 dB attenuation measured between the two terminating resistors at 96 kHz (high capacitance cable);
- ii) short passive bus with 8 TEs (including the TE under test) clustered at the far end from the signal source (high capacitance cable);
- iii) short passive bus with the TE under test adjacent to the signal source and the other seven TEs clustered at the far end from the signal source. Configuration a): high capacitance cable; configuration b): low capacitance cable;
- iv) ideal test signal condition, with one source connected directly to the receiver of the TE under test (i.e., without artificial line).

Examples of waveforms that correspond to the configurations i), ii), iiia) and iiib) are given in Figure 6/I.430 to Figure 9/I.430. Test configurations which can generate these signals are given in Annex D.

8.2.2 *Timing extraction jitter*

Timing extraction jitter, as observed at the TE output, shall be within −7% to +7% of a bit period, when the jitter is measured using a high pass filter with a cut-off frequency (3 dB point) of 30 Hz under the test conditions described in § 8.2.1. The limitation applies with an output data sequence having binary ZEROs in both B-channels and with input data sequences described in a) to c) below. The limitation applies to the phase of all zero-volt crossings of all adjacent binary ZEROs in the output data sequence.

- a) A sequence consisting of continuous frames with all binary ONEs in D-, D-echo and both B-channels;
- b) a sequence, repeated continuously for at least 10 seconds, consisting of:
  - 40 frames with continous octets of "10101010" (the first bit to be transmitted is binary ONE) in both B-channels and continuous binary ONEs in D- and D-echo channels, followed by
  - 40 frames with continuous binary ZEROs in D-, D-echo and both B-channels;

c) a sequence consisting of a pseudo random pattern with a length of $2^{19} - 1$ in D-, D-echo and both B-channels. (This pattern may be generated with a shift register with 19 stages with the outputs of the first, the second, the fifth and the nineteenth stages added together (modulo 2) and fed back to the input.)

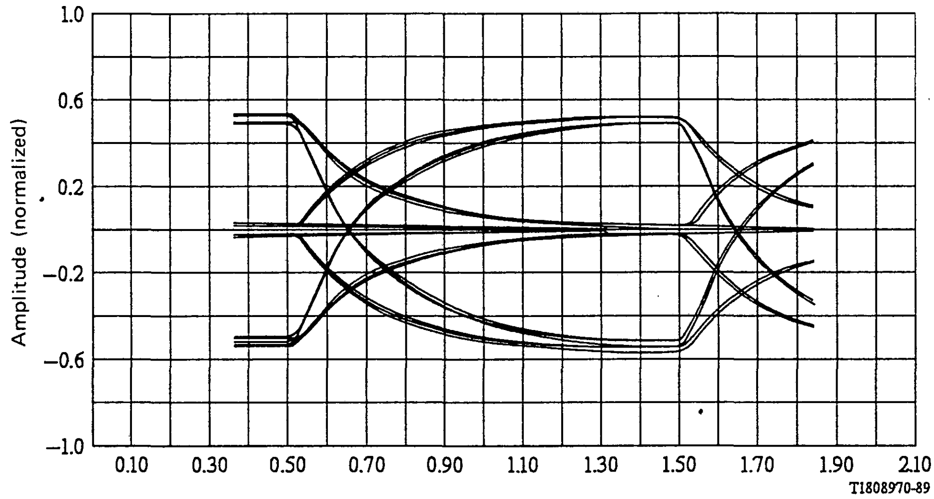


FIGURE 6/I.430

Waveform for test configuration i) – point-to-point (6 dB) (C = 120 nF/km)

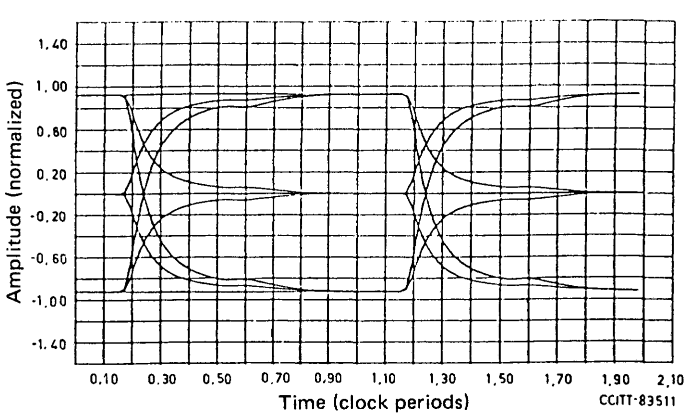


FIGURE 7/I.430

Waveform for test configuration ii) – short passive bus with eight clustered TEs at the far end (C = 120 nF/km)

8.2.3 *Total phase deviation input to output*

The total phase deviation (including effects of timing extraction jitter in the TE), between the transitions of signal elements at the output of the TE and the transitions of signal elements associated with the signal applied to the TE input, should not exceed the range of −7% to +15% of a bit period. This limitation applies to the output signal transitions of each frame with the phase reference defined as the average phase of the crossing of zero volts which occurs between the framing pulse and its associated balance pulse at the start of the frame and the corresponding crossings at the start of the three preceding frames of the input signal.

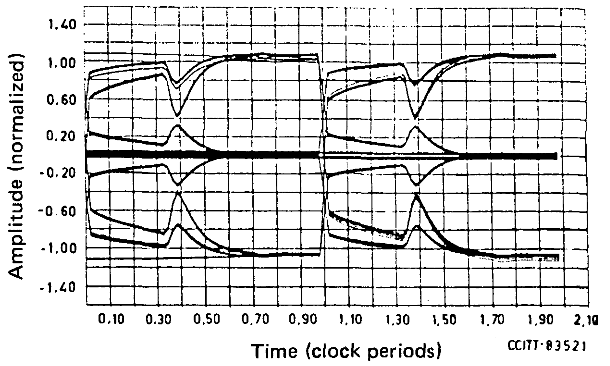


FIGURE 8/I.430

Waveform for test configuration iii a) – short passive bus with one TE near to NT, and seven TEs at the far end (C = 120 nF/km)

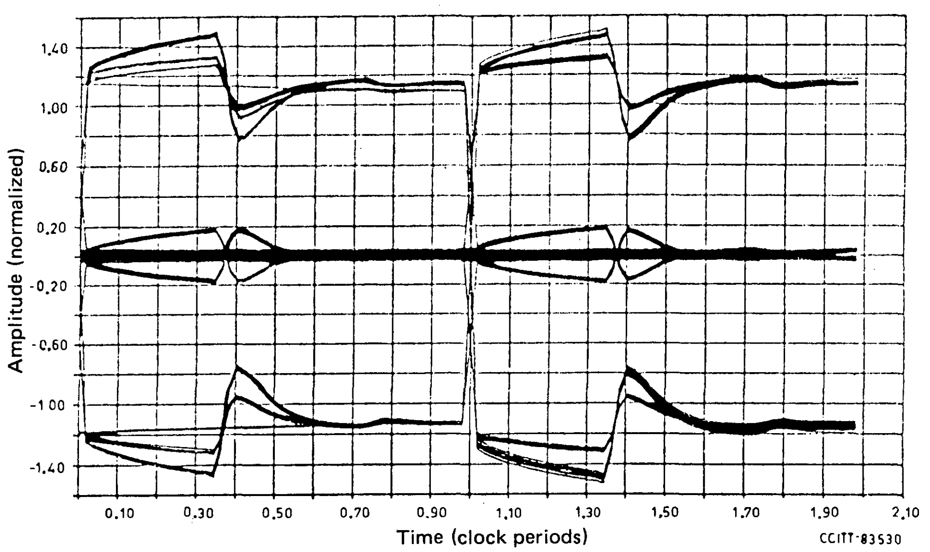


FIGURE 9/I.430

Waveform for test configuration iii) b) – short passive bus with one TE near to NT, and seven TEs at the far end (C = 30 nF/km)

For the purpose of demonstrating compliance of an equipment, it is sufficient to use (as the input signal phase reference) only the crossing of zero volts between the framing pulse and its associated balance pulse of the individual frame. This latter method, requiring a simpler test set, may create additional jitter at frequencies higher than about 1 kHz and is therefore more restrictive. The limitation applies to the phase of the zero-volt crossings of all adjacent binary ZEROs in the output data sequence, which shall be as defined in § 8.2.2. The limitation applies under all test conditions described in § 8.2.1, with the additional input signal conditions specified in a) to d) below, and with the superimposed jitter as specified in Figure 10/I.430 over the range of frequencies from 5 Hz to 2 kHz. The limitation applies for input bit rates of 192 kbit/s ± 100 ppm.

a) A sequence consisting of continuous frames with all binary ONEs in the D-, D-echo and both B-channels;

b) a sequence consisting of continuous frames with the octet "10101010" (the first bit to be transmitted is binary ONE) in both B-channels and binary ONEs in D- and D-echo channels;

c) a sequence of continuous frames with binary ZEROs in D, D-echo and both B-channels;

d) a sequence of continuous frames with a pseudo random pattern, as described in § 8.2.2 c), in D-, D-echo and both B-channels.

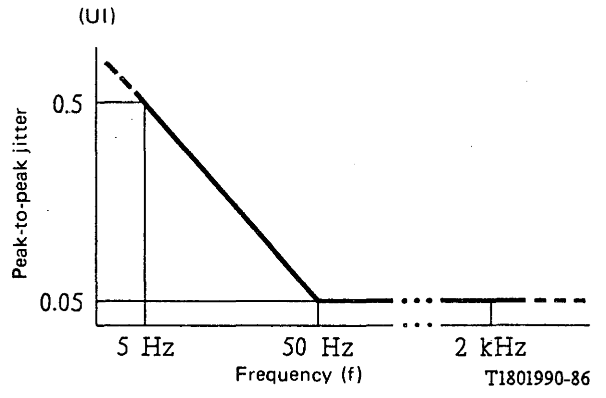


FIGURE 10/I.430

Lower limit of maximum tolerable jitter at TE input (log-log scale)

8.3 *NT jitter characteristics*

The maximum jitter (peak-to-peak) in the output sequence of an NT shall be 5% of a bit period when measured using a high pass filter having a cut-off frequency (3 dB point) of 50 Hz and an asymptotic roll off of 20 dB per decade. The limitation applies for all data sequences, but for the purpose of demonstrating the compliance of an equipment, it is sufficient to measure jitter with an output data sequence consisting of binary ONEs in D- and B-channels and with an additional sequence as described in § 8.2.2 c) in D- and B-channels. The limitation applies to the phase of all zero-volt crossings of all adjacent binary ZEROs in the output data sequence.

8.4 *Termination of the line*

The interchange circuit pair termination (resistive) should be 100 ohms ± 5% (see Figure 2/I.430).

8.5 *Transmitter output characteristics*

8.5.1 *Transmitter output impedance*

The following requirements apply at interface point I_A (see Figure 2/I.430) for TEs and at interface point I_B for NTs (see § 4.5 and § 8.9 regarding capacitance of the cord).

8.5.1.1 *NT transmitter output impedance*

a) When inactive or transmitting a binary ONE, the output impedance, in the frequency range of 2 kHz to 1 MHz, shall exceed the impedance indicated by the template in Figure 11/I.430. The requirement is applicable with an applied sinusoidal voltage of at least 100 mV (r.m.s. value).

Note – In some applications, the terminating resistor can be combined with the NT (see point B of Figure 2/I.430). The resulting impedance is the impedance needed to exceed the combination of the template and the 100-ohm termination.

b) When transmitting a binary ZERO, the output impedance shall be ⩾ 20 ohms.

Note – The output impedance limit shall apply for two nominal load impedance (resistive) conditions: 50 ohms and 400 ohms. The output impedance for each nominal load shall be defined by determining the peak pulse amplitude for loads equal to the nominal value ± 10%. The peak amplitude shall be defined as the amplitude at the midpoint of a pulse. The limitation applies for pulses of both polarities.

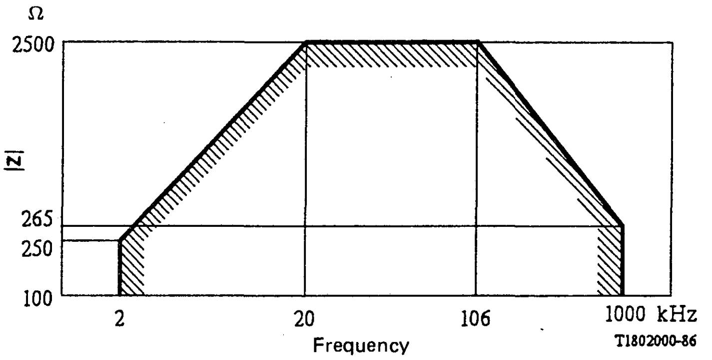


FIGURE 11/I.430

NT impedance template (log-log scale)

8.5.1.2 *TE transmitter output impedance*

a) In the inactive and powered-down states or when transmitting a binary ONE, the following requirements apply:

  i) The output impedance, in the frequency range of 2 kHz to 1 MHz, should exceed the impedance indicated by the template in Figure 12/I.430. This requirement is applicable with an applied sinusoidal voltage of at least 100 mV (r.m.s. value).

  ii) At a frequency of 96 kHz, the peak current which results from an applied voltage of up to 1.2 V (peak value) should not exceed 0.6 mA (peak value).

b) When transmitting a binary ZERO, the output impedance shall be ⩾ 20 ohms.

Note – The output impedance limit shall apply for two nominal load impedance (resistive) conditions: 50 ohms and 400 ohms. The output impedance for each nominal load shall be defined by determining the peak pulse amplitude for loads equal to the nominal value ± 10%. The peak amplitude shall be defined as the amplitude at the midpoint of a pulse. The limitation applies for pulses of both polarities.

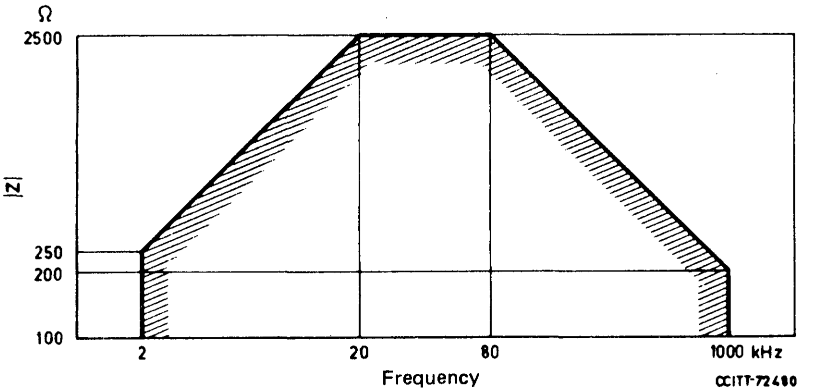


FIGURE 12/I.430

TE impedance template (log-log scale)

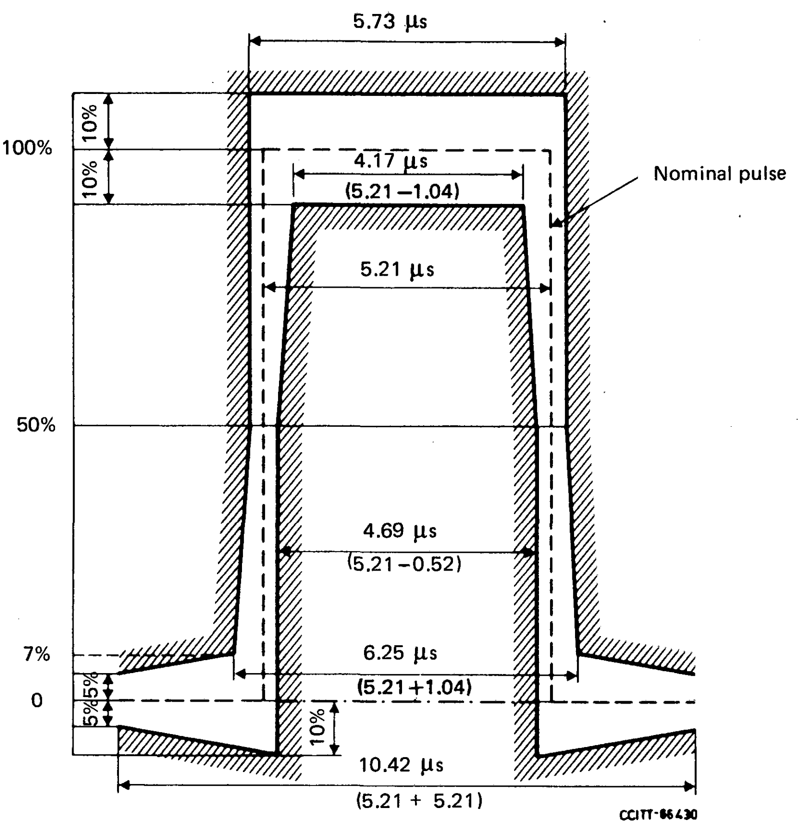
8.5.2 *Test load impedance*

The test load impedance shall be 50 ohms (unless otherwise indicated).

8.5.3 *Pulse shape and amplitude (binary ZERO)*

8.5.3.1 *Pulse shape*

Except for overshoot, limited as follows, pulses shall be within the mask of Figure 13/I.430. Overshoot, at the leading edge of pulses, of up to 5% of the pulse amplitude at the middle of a signal element, is permitted, provided that such overshoot has, at 1/2 of its amplitude, a duration of less than 0.25 μs.



Note – For clarity of presentation, the above values are based on a pulse width of 5.21 μs., See § 8.1 for a precise specification of the bit rate.

FIGURE 13/I.430

Transmitter output pulse mask

8.5.3.2 *Nominal pulse amplitude*

The nominal pulse amplitude shall be 750 mV, zero to peak.

A positive pulse (in particular, a framing pulse) at the output port of the NT and TE is defined as a positive polarity of the voltage measured between access leads e to f and d to c respectively (see Figure 20/I.430). (See Table 9/I.430 for the relationship to connector pins.)

8.5.4 *Pulse unbalance*

The "pulse unbalance", i.e., the relative difference in $\int U(t)\mathrm{d}t$ for positive pulses and $\int U(t)\mathrm{d}t$ for negative pulses shall be $\leqslant$ 5%.

8.5.5 *Voltage on other test loads* (TE only)

The following requirements are intended to assure compatibility with the condition where multiple TEs are simultaneously transmitting pulses on to a passive bus.

8.5.5.1 *400-ohm load*

A pulse (binary ZERO) shall conform to the limits of the mask shown in Figure 14/I.430 when the transmitter is terminated in a 400-ohm load.

8.5.5.2 *5.6-ohm load*

To limit the current flow with two drivers having opposite polarities, the pulse amplitude (peak) with a 5.6-ohm load shall be $\leqslant$ 20% of the nominal pulse amplitude.

8.5.6 *Unbalance about earth*

The following requirements apply under all possible power feeding conditions, under all possible connections of the equipment to ground, and with two 100-ohm terminations across the transmit and receive ports.

8.5.6.1 *Longitudinal conversion loss*

Longitudinal conversion loss (LCL) which is measured in accordance with Recommendation G.117, § 4.1.3 (see Figure 15/I.430), shall meet the following requirements:

a) 10 kHz $< f \leqslant$ 300 kHz: $\geqslant$ 54 dB

b) 300 kHz $< f \leqslant$ 1 MHz: minimum value decreasing from 54 dB at 20 dB/decade.

8.5.6.2 *Output signal balance*

Output signal balance which is measured in accordance with Recommendation G.117, § 4.3.1 (see Figure 16/I.430), shall meet the following requirements:

a) $f =$ 96 kHz: $\geqslant$ 54 dB

b) 96 kHz $< f \leqslant$ 1 MHz: minimum value decreasing from 54 dB at 20 dB/decade.

8.6 *Receiver input characteristics*

8.6.1 *Receiver input impedance*

8.6.1.1 *TE receiver input impedance*

TEs shall meet the same input impedance requirements as specified in § 8.5.1.2 a) for the input impedance.

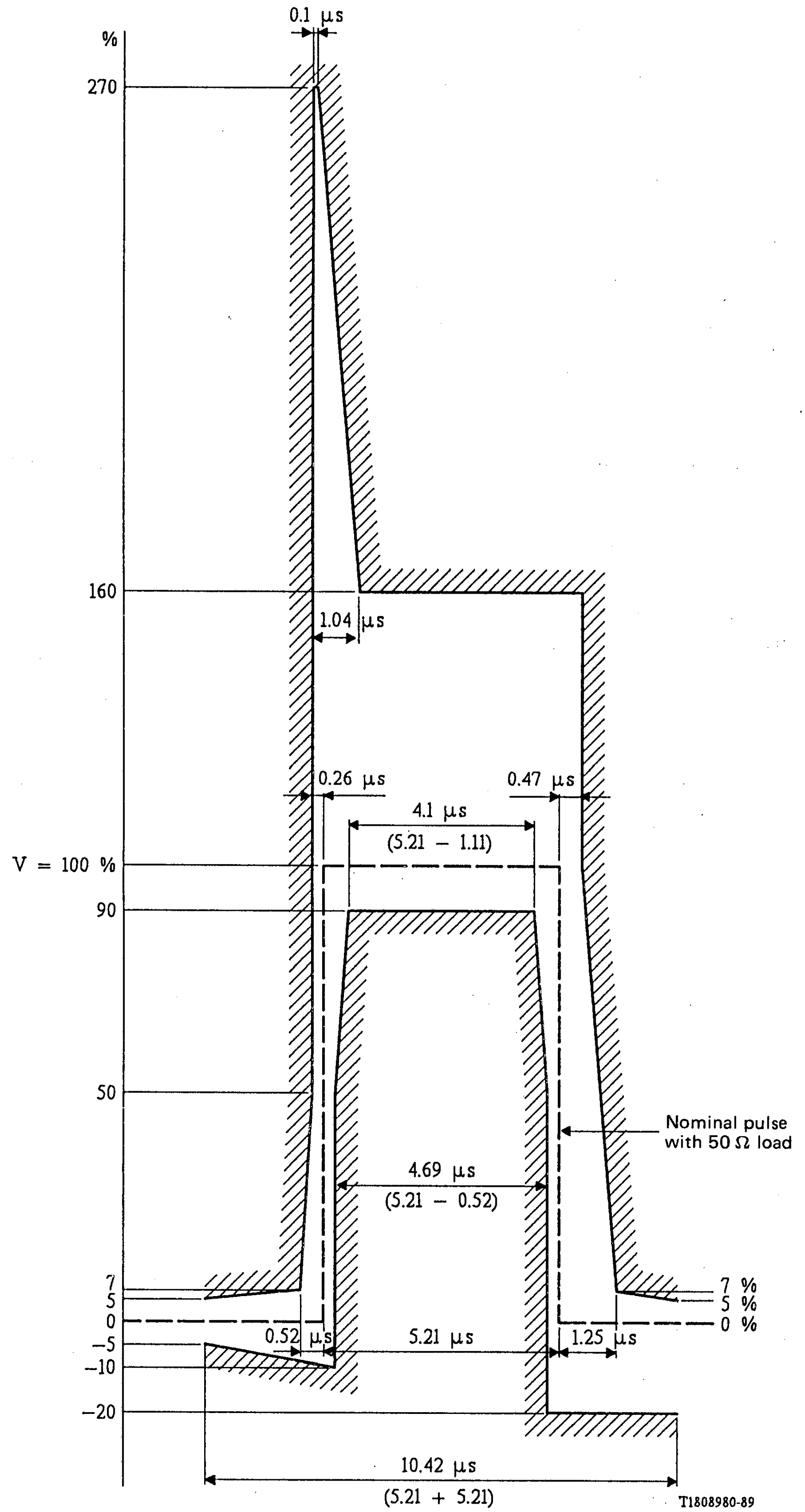
8.6.1.2 *NT receiver input impedance*

In the inactive and powered-down states, the following requirements apply:

i) the input impedance in the frequency range of 2 kHz to 1 MHz, should exceed the impedance indicated by the template in Figure 11/I.430. This requirement is applicable with an applied sinusoidal voltage of at least 100 mV (r.m.s. value);

ii) at a frequency of 96 kHz, the peak current which results from an applied voltage of up to 1.2 V (peak value) should not exceed 0.5 mA (peak value).

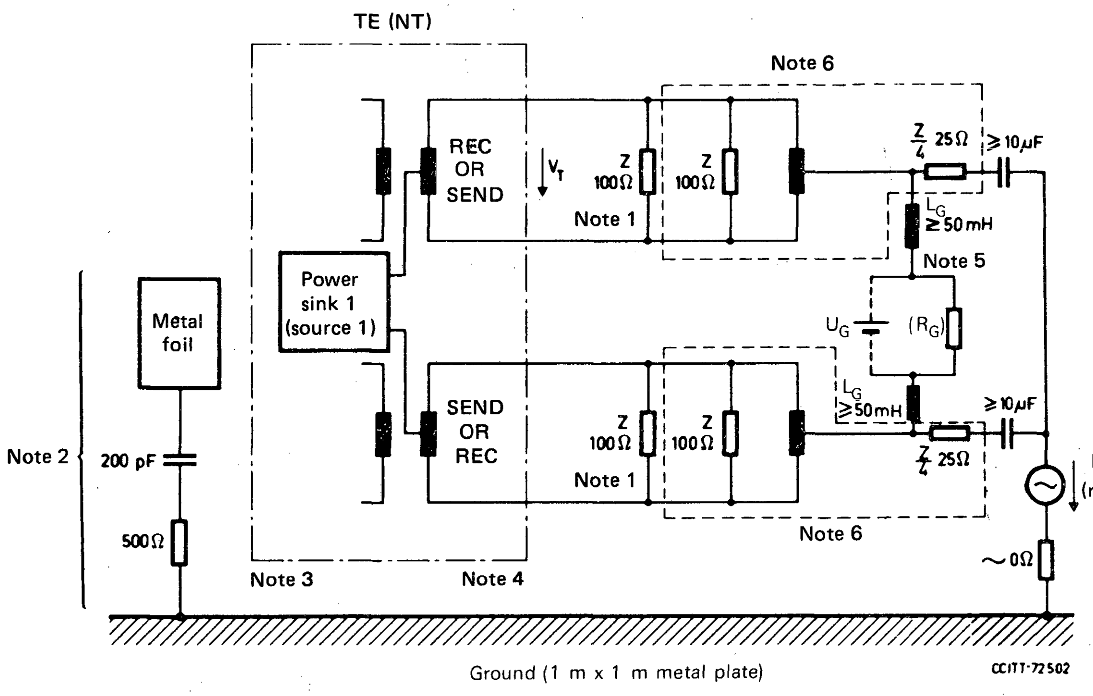
Note – In some applications, the 100-ohm terminating resistor can be combined with the NT (see point B of Figure 2/I.430). The resulting impedance is the impedance needed to exceed the combination of the template and the 100-ohm termination.



Note – For clarity of presentation, the above values are based on a pulse width of 5.21 μs. See § 8.1 for a precise specification of the bit rate.

FIGURE 14/I.430

Voltage for an isolated pulse with a test load of 400 ohms



The longitudinal conversion loss: $LCL = 20 \log_{10} \left| \frac{E_L}{V_T} \right|$ dB

The voltages V_T and E_L should be measured within the frequency range from 10 kHz up to 1 MHz using selective test measuring equipment.

The measurement should be carried out in the states:

- deactivated (receive, send),
- power off (receive, send),
- activated (receive).

The interconnecting cord shall lie on the metal plate.

Note 1 – This resistor must be omitted if the termination is already built into the TE (NT).

Note 2 – Hand imitation is a thin metal foil with approximately the size of a hand.

Note 3 – TE (NT) with a metallic housing shall have a galvanic connection to the metal plate. Other TE (NT) with non-metallic housing shall be placed on the metal plate.

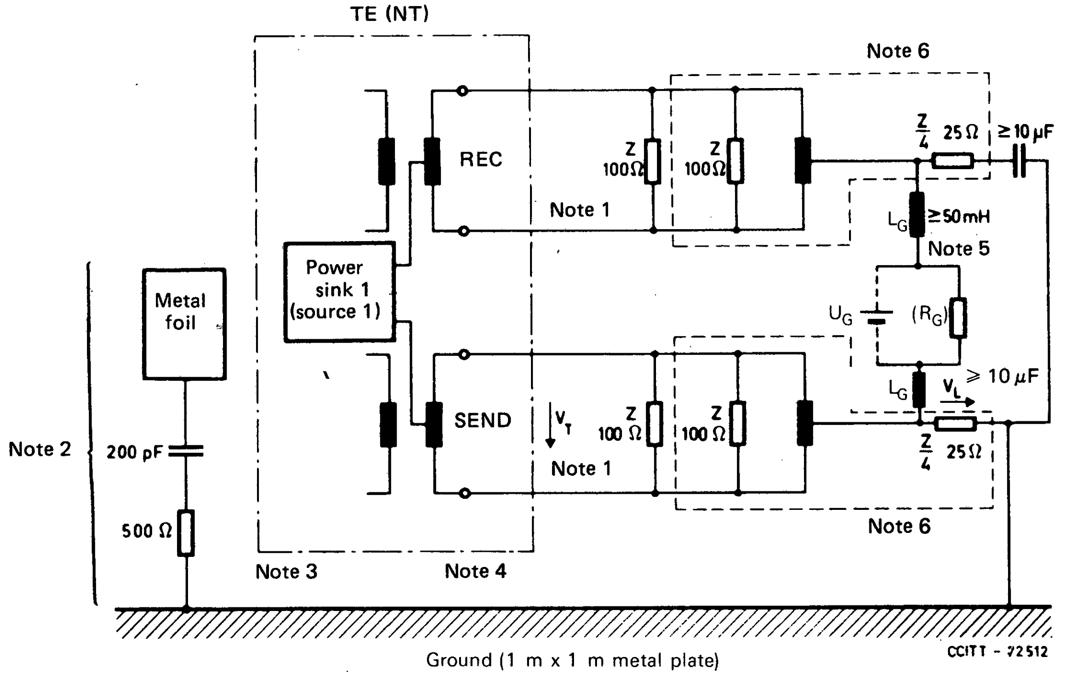
Note 4 – The power cord for mains-powered TE (NT) shall lie on the metal plate and the earth protective wire of the mains shall be connected to the metal plate.

Note 5 – If there is no power source 1 in the NT, R_G and L_G are not required.

Note 6 – This circuit provides a transverse termination of 100 ohms and a balanced longitudinal termination of 25 ohms. Any equivalent circuit is acceptable. However, for equivalent circuits given in Recommendations G.117 and O.121, powering cannot be provided.

FIGURE 15/I.430

Receiver input or transmitter output unbalance about earth



Output signal balance $= 20 \log_{10} \left| \frac{V_T}{V_L} \right|$ dB

The voltage V_T and V_L should be measured within the frequency range from 10 kHz up to 1 MHz using selective test measuring equipment. The measurement should be carried out in the active state. The pulse patterns should contain all binary ZEROs. However, for the purpose of demonstrating the compliance of an equipment, it is sufficient to measure the output signal unbalance about earth with a pulse pattern of continuous frames with at least the B1 and B2 Channels containing all binary ZEROs.

The interconnecting cord shall lie on the metal plate.

Note — See notes to this figure in Figure 15/I.430.

FIGURE 16/I.430

Transmitter output unbalance about earth

8.6.2 *Receiver sensitivity — Noise and distortion immunity*

Requirements applicable to TEs and NTs for three different interface wiring configurations are given in the following sections. TEs and/or NTs shall receive, without errors (for a period of at least one minute), an input with a pseudo-random sequence (word length ⩾ 511 bits) in all information channels (combination of B-channel, D-channel and, if applicable, the D-echo channel).

The receiver shall operate, with any input sequence, over the full range indicated by the waveform mask.

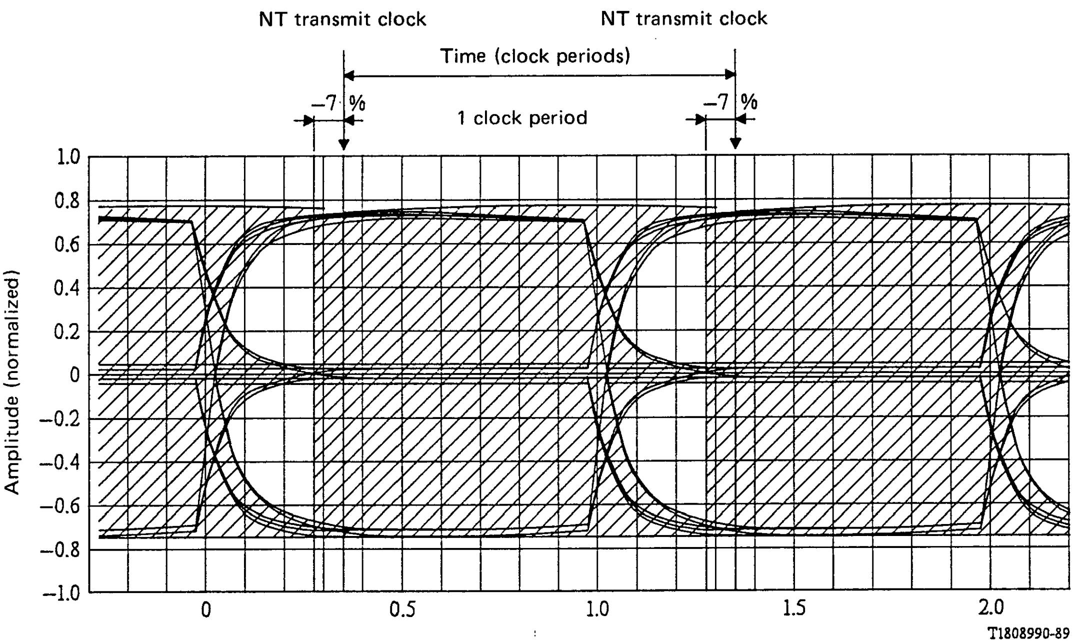
8.6.2.1 *TEs*

TEs shall operate with the input signals conforming to the waveforms specified in § 8.2.1. For the waveforms in Figures 7/I.430 to 9/I.430, TEs shall operate with the input signals having any amplitude in the range of +1.5 dB to −3.5 dB relative to the nominal amplitude of the transmitted signal as specified in § 8.5.3.2. For signals conforming to the waveform in Figure 6/I.430, operation shall be accomplished for signals having any amplitude in the range of +1.5 to −7.5 dB relative to the nominal amplitude of the transmitted signal as specified in § 8.5.3.2. In addition, TEs shall operate with signals conforming to each waveform with jitter up to the maximum permiteed (see § 8.3) in the output signal of NTs superimposed on the input signals.

Additionally, for input signals having the waveform shown in Figure 6/I.430, the TEs shall operate with sinusoidal signals having an amplitude of 100 mV (peak-to-peak value) at frequencies of 200 kHz and 2 MHz superimposed individually on the input signals along with jitter.

8.6.2.2 *NTs for short passive bus (fixed timing)*

NTs designed to operate with only short passive bus wiring configurations shall operate when receiving input signals indicated by the waveform mask shown in Figure 17/I.430. NTs shall operate, with the input signals having any amplitude in the range of +1.5 dB to −3.5 dB relative to the nominal amplitude of the transmitted signal as specified in § 8.5.3.2.



Note 1 — Shaded area is the region in which pulse transitions may occur.

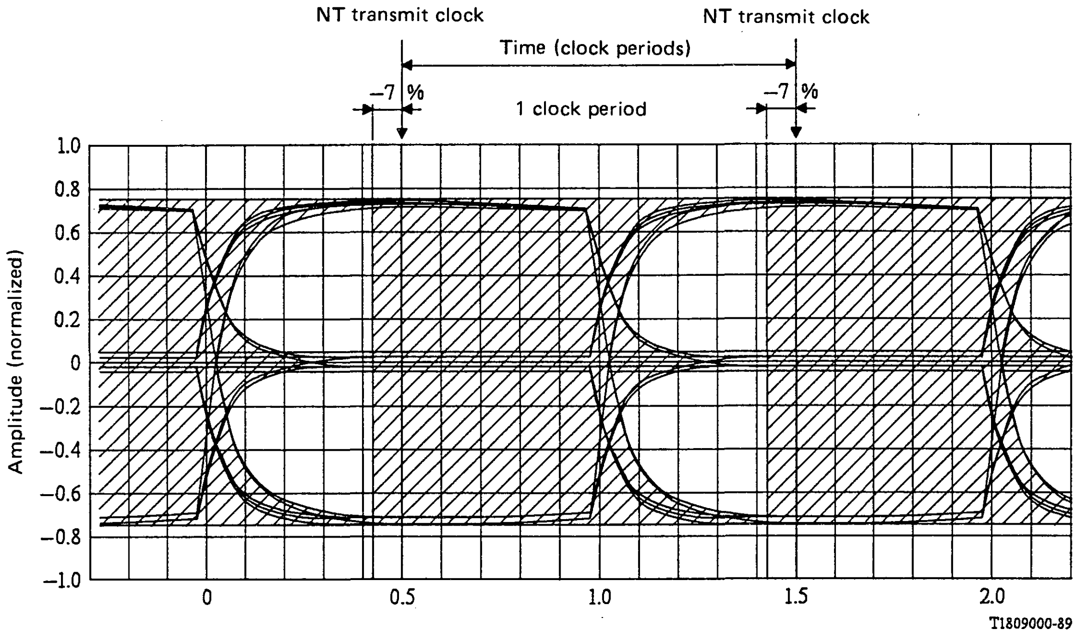
Note 2 — The waveform mask is based on the "worst case" configuration shown in Annex D, Figure D-1/I.430 and waveforms ii) and iii) in § 8.2.1. The shaded area of −7% of one clock period accounts for the situation of a single TE connected directly to the NT with a zero length passive bus. However, the waveform mask does not show the higher possible amplitude of framing and D-channel bit pulses and their associated balancing bits. It should be noted that the above waveform mask does not account for transient effects.

FIGURE 17/I.430

Short passive bus receive pulse waveform mask

8.6.2.3 *NTs for both point-to-point and short passive bus configurations (adaptive timing)*

NTs designed to operate with either point-to-point or short passive bus wiring configurations shall operate when receiving input signals indicated by the waveform mask shown in Figure 18/I.430. These NTs shall operate with the input signals having any amplitude in the range of +1.5 dB to −3.5 dB relative to the nominal amplitude of the transmitted signal as specified in § 8.5.3.2. These NTs shall also operate when receiving signals conforming to the waveform in Figure 6/I.430. For signals conforming to this waveform, operation shall be accomplished for signals having any amplitude in the range of +1.5 to −7.5 dB relative to the nominal amplitude of the transmitted signal as specified in § 8.5.3.2. Additionally, these NTs shall operate with the sinusoidal signals, as specified in § 8.6.2.1, and with jitter up to the maximum permitted in the output signal of TEs (see § 8.2.2), superimposed on the input signals having the waveform in Figure 6/I.430.



Note 1 – Shaded area is the region in which pulse transitions may occur.

Note 2 – The waveform mask is based on the same "worst case" passive bus configuration as the waveform mask in Figure 17/I.430 except that the permitted round trip delay of the cable is reduced. The shaded area of −7% of one clock period accounts for the situation of a single TE connected directly to the NT with a zero length passive bus. However, the waveform mask does not show the higher possible amplitude of framing and D-channel bit pulses and their associated balancing bits. It should be noted that the above waveform mask does not account for transient effects.

FIGURE 18/I.430

Passive bus receive pulse waveform mask
(NTs designed to operate with either point-to-point or short passive bus wiring configurations)

8.6.2.4 *NTs for extended passive bus wiring configurations*

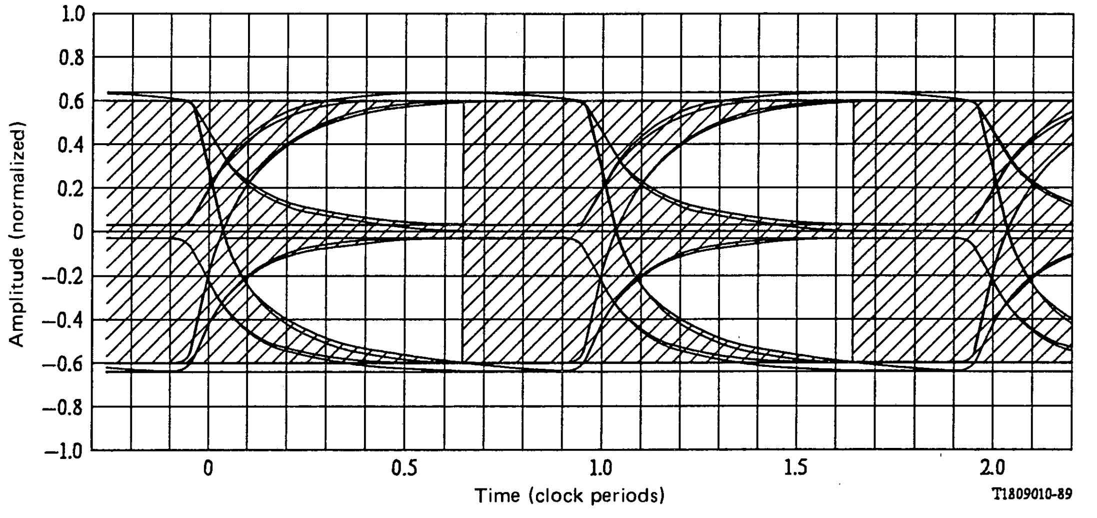
NTs designed to operate with extended passive bus wiring configurations shall operate when receiving input signals indicated by the waveform mask shown in Figure 19/I.430. These NTs shall operate with the input signals having any amplitude in the range of +1.5 dB to −5.5 dB relative to the nominal amplitude of the transmitted signal as specified in § 8.5.3.2. Additionally, these NTs shall operate with the sinusoidal signals, as specified in § 8.6.2.1, superimposed on the input signals having the waveform shown in Figure 19/I.430. (The above values assume a maximum cable loss of 3.8 dB. NTs may be implemented to accommodate higher cable loss).

8.6.2.5 *NTs for point-to-point configurations only*

NTs designed to operate with only point-to-point wiring configurations shall operate when receiving input signals having the waveform shown in Figure 6/I.430. These NTs shall operate with the input signals having any amplitude in the range of +1.5 to −7.5 dB relative to the nominal amplitude of the transmitted signal as specified in § 8.5.3.2. Additionally, these NTs shall operate with the sinusoidal signals, as specified in § 8.6.2.1, and with jitter up to the maximum permitted in the output signal of TEs (see § 8.2.2) superimposed on the input signals having the waveform shown in Figure 6/I.430.

8.6.3 *NT receiver input delay characteristics*

Note – Round trip delay is always measured between the zero-volt crossings of the framing pulse and its associated and balance bit pulse at the transmit and receive side of the NT (see also Annex A).



Note 1 – Shaded area is the region in which pulse transitions may occur.

Note 2 – The waveform mask is based on the worst case extended passive bus wiring configuration. It consists of a cable having a characteristic impedance of 75 ohms, a capacitance of 120 nF/km, a loss of 3.8 dB at 96 kHz, four TEs connected such that the differential delay is at the maximum permitted by § 8.6.3.3. The waveform mask does not show the higher possible amplitude of framing and D-channel bit pulses and their associated balancing bits. It should be noted that the above waveform mask does not account for transient effects.

FIGURE 19/I.430

Extended passive bus receive pulse waveform mask

8.6.3.1 *NT or short passive bus*

NTs shall accommodate round trip delays of the complete installation, including TEs, in the range 10 to 14 μs.

8.6.3.2 *NT for both point-to-point and passive bus*

NTs shall accommodate round trip delays (for passive bus configurations) in the range 10 to 13 μs.

NTs shall accommodate round trip delays (for point-to-point configurations) in the range 10 to 42 μs.

8.6.3.3 *NT for extended passive bus*

NTs shall accommodate round trip delays in the range 10 to 42 μs, provided that the differential delay of signals from different TEs is in the range 0 to 2 μs.

8.6.3.4 *NT for point-to-point only*

NTs shall accommodate round trip delays specified in § 8.6.3.2 for point-to-point configurations.

8.6.4 *Unbalance about earth*

Longitudinal conversion loss (LCL) of receiver inputs, measured in accordance with Recommendation G.117, § 4.1.3, by considering the power feeding and two 100-ohm terminations at each port, shall meet the following requirements (see Figure 15/I.430):

a) 10 kHz $\leq f \leq$ 300 kHz: $\geq$ 54 dB

b) 300 kHz $< f \leq$ 1 MHz: minimum value decreasing from 54 dB with 20 dB/decade.

8.7 *Isolation from external voltages*

IEC Publication 479-1, Second Issue 1984, specifies current limitation dealing with human safety. According to that publication, the value of a touchable leakage alternating current measured through a resistor of 2 kohms is limited. The application of this requirement to the user-network interface is not a subject of this Recommendation, but should be recognized that an apportionment of this limited current to each mains powered equipment connected to the passive bus is necessary.

8.8 *Interconnecting media characteristics*

Longitudinal conversion loss of pairs at 96 kHz shall be ⩾ 43 dB.

8.9 *Standard ISDN basic access TE cord*

A connecting cord for use with a TE designed for connection with a "standard ISDN basic access TE cord" shall have a maximum length of 10 metres and shall conform to the following:

a) Cords having a maximum length of 7 metres:
   - the maximum capacitance of pairs for transmit and receive functions shall be less than 300 pF;
   - the characteristic impedance of pairs used for transmit and receive functions shall be greater than 75 ohms at 96 kHz;
   - the crosstalk loss, at 96 kHz, between any pair and a pair to be used for transmit or receive functions shall be greater than 60 dB with terminations of 100 ohms;
   - the resistance of an individual conductor shall not exceed 3 ohms;
   - cords shall be terminated at both ends in plugs (individual conductors shall be connected to the same contact in the plug at each end);

b) Cords having a length greater than 7 metres:
   - cords shall conform to the above requirements except that a capacitance of 350 pF is permitted;
   - TEs may be designed that include a connecting cord which is part of the TE. In this case the requirements for a standard ISDN basic access TE cord do not apply.

9 **Power feeding**

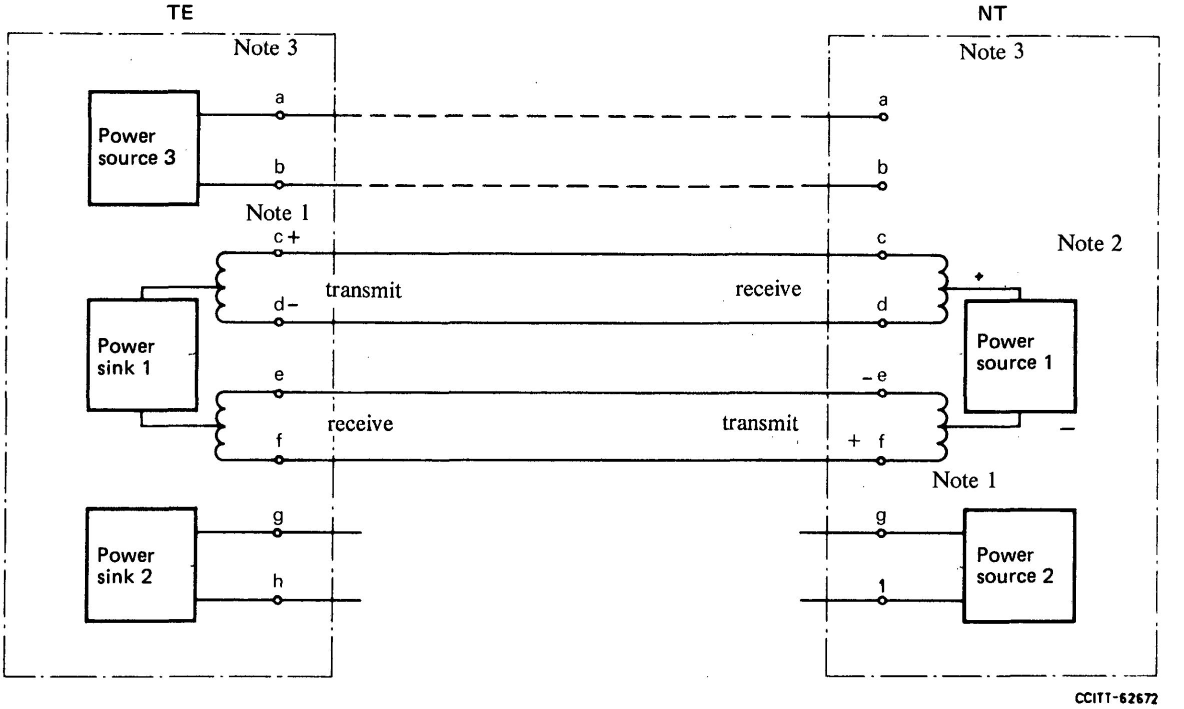
9.1 *Reference configuration*

The reference configuration for power feeding, which is based on an eight-pin interface connector, is described in Figure 20/I.430. The access lead designations, "a" through "h", are not intended to reflect particular pin assignments, which, as indicated in § 10, are to be specified in an ISO standard. The use of leads c, d, e and f is mandatory. The use of leads a, b, g and h is optional.

The reference configuration allows unique physical and electrical characteristics, for the interface at reference points S and T, which are independent of the choice of internal or external power source arrangements.

Power source 1 may derive its power from the network and/or locally (mains and/or batteries). While the source for restricted power is an integral part of the NT, the source for normal conditions may be physically separate and may be connected at any point in the interface wiring. Note that such a separate source should be considered functionally part of the NT. However, the provision of such a source is subject to the approval of the Administration/network provider. To avoid interworking problems, it is not permitted to connect such a separate source of phantom mode power in wiring associated with NTs having an internal source for normal conditions. Where a separate source of phantom mode power is provided, its compatibility with a source for restricted power that is part of the associated NT must be assured by the provider of the separate source. In particular, the resolution of power contention, which may result from the provision of the separate source, between the separate source and a restricted power condition source internal to an NT, is not specified in this Recommendation and must be taken into account. In addition, any effects on the transmission characteristics of interface cabling must also be accounted for, e.g., the impedance of a power source that bridges the interchange circuit pairs may require a reduction in the number of TEs that can be accommodated on a passive bus.

Power source 2 derives its power locally (mains and/or batteries). Power source 2 may be located in (or associated with) the NT as indicated, or it may be located separately.



Note 1 – This symbol refers to the polarity of framing pulses.

Note 2 – This symbol refers to the polarity of power during normal power conditions (reversed for restricted conditions).

Note 3 – The access lead assignments indicated in this figure are intended to provide for direct interface cable wiring, i.e. each interface pair is connected to a pair of access leads having the same two letters at TEs and NTs.

FIGURE 20/I.430

Reference configuration for signal transmission and power-feeding in normal operating mode

9.1.1 *Functions specified at the access leads*

The eight access leads for TE and NT shall be applied as follows:

i) Access lead pairs c-d and e-f are for the bidirectional transmission of the digital signal and may provide a phantom circuit for power transfer from NT to TE (power source 1).

ii) Access lead pair g-h may be used for additional power transfer from the NT to TE (power source 2).

iii) Access lead pair a-b may also be used for power transfer (power source 3) in TE-TE interconnection; this is not the subject of a CCITT Recommendation.

9.1.2 *Provision of power sources and sinks*

Power source 1 may not always be provided. Provision of power source 2 is subject to the decision of individual Administrations. Power source 3 is not subject to CCITT Recommendation. Power sink 1 is optional. Administrations may limit the use of power from power source 1 to those TEs capable of providing a minimum service. Power sink 2 is optional.

Note – It should be noted that a TE that is to be portable (for example from network to network, country to country) cannot rely exclusively on phantom power for its operation.

9.2 *Power available from NT*

It is desirable for power sources to include current limiting provisions to provide short-circuit protection.

9.2.1 *Power source 1 normal and restricted power conditions*

Power source 1 may provide either normal or restricted power conditions or both.

When power source 1 is provided, the power conditions are considered as follows:

i) Where power is provided under normal conditions, the power available from power source 1 is the responsibility of the individual Administration/network provider. However, power source 1 together with any separate source, as described in § 9.1, shall provide at least the power for the consumption of 1 watt (the maximum specified in § 9.3.1 that a TE may draw; see also note to § 9.3.1.1) at TE interfaces. The power required to be available from the NT may depend upon the possible provision of a separate source and the cable configuration.

ii) Under restricted power conditions, the minimum power available from power source 1 shall be 420 mW. When power source 1 enters a condition where it is able to supply only restricted power, it should indicate this condition by reversing its polarity. In this condition, only the unrestricted power functions of TEs are allowed to consume power from source 1.

iii) If power source 1 (and any separate source combination) can supply power in both normal and restricted power conditions, the change of condition of power source 1 from the normal to restricted power condition may occur when power source 1 (and any separate source combination) is unable to supply the "nominal" level of power. [The "nominal" level of power is defined as the minimum power that the power source 1 (or separate power source) is designed to supply.] In any case, the transition from normal to restricted condition shall occur when the power described in i) above is not available from power source 1 (as a result of a loss of its source of power).

9.2.2 *Minimum voltage at NT from power source 1*

9.2.2.1 *Normal power conditions*

Under normal power conditions, the nominal value of voltage of power source 1, if provided, at the output of the NT shall be 40 V and the tolerances shall be +5% and −15% when supplying up to the maximum available power.

9.2.2.2 *Restricted power conditions*

Under restricted power conditions, the nominal value of the voltage of power source 1, if provided, at the output of the NT shall be 40 V and the tolerances shall be +5% and −15% when supplying up to 420 mW.

9.2.3 *Minimum voltage of power source 2*

The nominal voltage of power source 2 (optional third pair) shall be 40 V. The maximum voltage shall be 40 V + 5% and the minimum voltage shall assure compliance with the requirements specified in § 9.3.2 concerning power available at a TE.

9.3 *Power available at a TE*

9.3.1 *Power source 1 – phantom mode*

9.3.1.1 *Normal power conditions*

Under normal power conditions, the maximum voltage at the interface of a TE shall be 40 V + 5% and the minimum voltage shall be 40 V − 40% (24 V) when drawing up to a maximum permitted power consumption of 1 watt.

Note – For a period until the end of 1988, TEs which cannot meet this requirement may consume up to 1.5 watts, subject to this power being available.

9.3.1.2 *Restricted power conditions*

In restricted power conditions, the nominal value of the voltages at the inputs of TEs (from power source 1) shall be 40 V and the tolerance shall be +5% abd −20% when drawing a power of up to 400 mW (380 mW for a designated TE and 20 mW for other TEs).

9.3.2 *Power source 2 – optional third pair*

9.3.2.1 *Normal power conditions*

Under normal power conditions, the voltage at the interface of a TE shall be a maximum of 40 V + 5% and a minimum voltage of 40 V − 20% when the TE is drawing a power of up to the minimum available power of 7 watts.

9.3.2.2 *Restricted power conditions*

When power source 2 is unable to provide 7 watts, it may go to a restricted power condition where it will provide a minimum power of 2 watts. The provision of this restricted power condition is subject to the power source 2 provider's assumed responsibility. The nominal value of the voltages at the inputs of the TEs shall be 40 V and the tolerance shall be +5% and −20%. The mechanism to indicate this condition to the TEs is for further study.

9.4 *Current transient*

The rate of change of current drawn by a TE (for example, when connected or as a result of a change in polarity when a change from the normal condition to the restricted power condition occurs) shall not exceed 5 mA/μs.

9.5 *Power source 1 consumption*

The different values concerning the power source 1 consumption are summarized in Table 8/I.430.

9.5.1 *Normal power conditions*

Under normal power conditions and in the activated state, a TE which draws power from power source 1 shall draw no more than 1 watt (see Note of § 9.3.1.1). When a TE is not involved in a call, it is desirable that it minimize its power consumption (see Note below).

When in the deactivated state, a TE which draws power from power source 1 shall draw no more than 100 mW. However, if a local action has to be initiated in the TE when the interface is not activated, this TE shall not enter a "local action" state.

In this "local action" state the TE may consume up to 1 watt if the following conditions are assured:

– the corresponding power is provided by the NT (e.g., this service is supported by the NT);
– the "local action" state is not a permanent one. (A typical example of the use of this state is the modification of prestored dialing numbers in the TE.).

Note – The definition of "not involved in a call" mode may be based on the knowledge of the status of layer 2 (link established or not). When this limitation is applied in the design of a TE, a maximum value of 380 mW is recommended.

9.5.2 *Restricted power conditions*

9.5.2.1 *Power available to the TE "designated" for restricted power operation*

A TE which is permitted to draw power from power source 1 under restricted power conditions shall consume no more than 380 mW.

In restricted power conditions, a designated TE which is powered down may consume power from power source 1 only to maintain a line activity detector and to retain its Terminal Endpoint Identifier (TEI) value. The value of the power down mode consumption shall be ⩽ 25 mW (see Note below).

Note – For a period until the end of 1988, TEs may consume up to 100 mW subject to this power being available.

TABLE 8/I.430

Summary of the different possible power source 1 consumptions

TE type and state	Maximum consumption
Normal conditions	
TE drawing power from PS1 Active state	1 W (Note 1)
TE drawing power from PS1 Deactivated state	100 mW
TE drawing power from PS1 Local action state	1 W (Note 2)
Restricted conditions	
TE drawing power from PS1 Designated TE; Active state	380 mW
TE drawing power from PS1 Designated; Deactivated state	25 mW (Note 3)
TE drawing power from PS1 Not designated	0 mW
TE drawing power from PS1 Designated; Local action state	380 mW (Note 2)
Locally powered TE using connected detector Any state	3 mW
Locally powered TE not using connected detector Any state	0 mW

PS1 Power source 1

Note 1 – See note to § 9.3.1.1.

Note 2 – Subject to the provision of the corresponding amount of power by power source 1.

Note 3 – See note to § 9.5.2.1.

9.5.2.2 *Power available to "non-designated" TEs*

Non-designated locally powered TEs which make use of a connected/disconnected detector may consume no more than 3 mW from power source 1 in restricted power conditions.

Non-designated locally powered TEs which do not make use of a connected/disconnected detector and non-designated TEs which are normally powered from power source 1 (normal conditions) shall not consume any power from power source 1 in restricted power conditions.

9.6 *Galvanic isolation*

TEs that provide power sinks 1 or 2 shall provide galvanic isolation between power sources 1 or 2 and the earths of additional sources of power and/or of other equipment. (This provision is intended to preclude earth loops or paths which could result in currents that would interfere with the satisfactory operation of the TE. It is independent of any requirement, for such isolation, related to safety which may result from the study under way in the IEC. It shall not be interpreted to require isolation which conflicts with necessary provisions for safety.) The way in which the galvanic isolation is to be implemented is left for further study.

10 Interface connector contact assignments

The interface connector and the contact assignments are the subject of an ISO standard. Table 9/I.430 is reproduced from the Draft International Standard, DIS 8877, dated November 1985. For the transmit and receive leads, pole numbers 3 through 6, the polarity indicated is for the polarity of the framing pulses. For the power leads, pole numbers 1, 2, 7 and 8, the polarity indicated is for the polarity of the d.c. voltages. See Figure 20/I.430 for the polarity of the power provided in the phantom mode. In that figure, the leads that are lettered a, b, c, d, e, f, g and h, correspond with pole numbers 1, 2, 3, 6, 5, 4, 7 and 8, respectively.

TABLE 9/I.430

Pole (contact) assignments for 8-pole connections (plugs and jacks)

Pole number	Function		Polarity
	TE	NT	
1	Power source 3	Power sink 3	+
2	Power source 3	Power sink 3	−
3	Transmit	Receive	+
4	Receive	Transmit	+
5	Receive	Transmit	−
6	Transmit	Receive	−
7	Power sink 2	Power source 2	−
8	Power sink 2	Power source 2	+

Note – This reference is only provisional.

ANNEX A

(to Recommendation I.430)

Wiring configurations and round trip delay considerations used as a basis for electrical characteristics

A.1 *Introduction*

A.1.1 In § 4, two major wiring arrangements are identified. These are point-to-point configuration and a point-to-multipoint configuration using a passive bus.

While these configurations may be considered to be the limiting cases for the definition of the interfaces and the design of the associated TE and NT equipments, other significant arrangements should be considered.

A.1.2 The values of overall length, in terms of cable loss and delay assumed for each of the possible arrangements, are indicated below.

A.1.3 Figure 2/I.430 is a composite of the individual configurations. These individual configurations are shown in this annex.

A.2 *Wiring configurations*

A.2.1 *Point-to-multipoint*

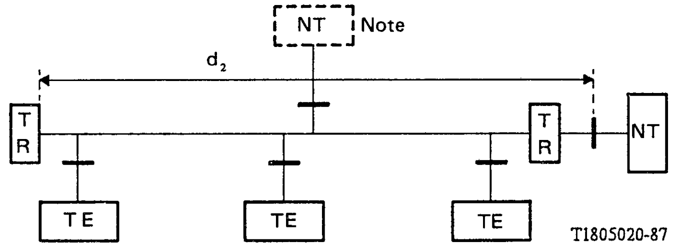
A.2.1.1 The point-to-multipoint wiring configuration identified in § 4.2 may be provided by the "short passive bus" or other configurations such as an "extended passive bus".

A.2.1.2 *Short passive bus* (Figure A-1/I.430)

An essential configuration to be considered is a passive bus in which the TE devices may be connected at random points along the full length of the cable. This means that the NT receiver must cater for pulses arriving with different delays from various terminals. For this reason, the length limit for this configuration is a function of the maximum round trip delay and not of the attenuation.

An NT receiver with fixed timing can be used if the round trip delay is between 10 to 14 μs. This relates to a maximum operational distance from the NT in the order of 100-200 metres (d_2 in Figure A-1/I.430) [200 m in the case of a high impedance cable (Z_c = 150 ohms) and 100 m in the case of a low impedance cable (Z_c = 75 ohms)]. It should be noted that the TE connections act as stubs on the cable thus reducing the NT receiver margin over that of a point-to-point configuration. A maximum number of 8 TEs with connections of 10 m in length are to be accommodated.

The range of 10 to 14 μs for the round trip delay is composed as follows. The lower value of 10 μs is composed of two bits offset delay (see Figure 3/I.430) and the negative phase deviation of −7% (see § 8.2.3). In this case the TE is located directly at the NT. The higher value of 14 μs is calculated assuming the TE is located at the far end of a passive bus. This value is composed of the offset delay between frames of two bits (10.4 μs), the round trip delay of the unloaded bus installation (2 μs), the additional delay due to the load of TEs (i.e. 0.7 μs) and the maximum delay of the TE transmitter according to § 8.2.3 (15% = 0.8 μs).



TR Terminating resistor

Note — In principle, the NT may be located at any point along the passive bus. The electrical characteristics in this Recommendation, however, are based on the NT located at one end. The conditions related to other locations require confirmation.

FIGURE A-1/I.430

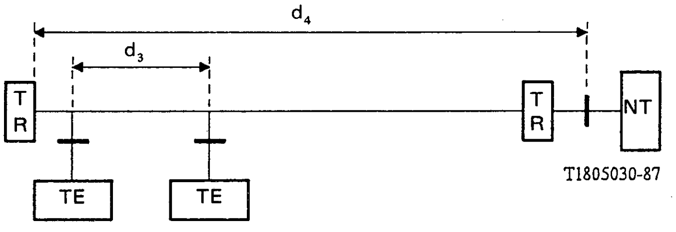
Short passive bus

A.2.1.3 *Extended passive bus* (Figure A-2/I.430)

A configuration which may be used at an intermediate distance in the order of 100 to 1000 metres is known as an extended passive bus. This configuration takes advantage of the fact that terminal connection points are restricted to a grouping at the far end of the cable from the NT. This places a restriction on the differential distance between TEs. The differential round trip delay is defined as that between zero-volt crossings of signals from different TEs and is restricted to 2 μs.

This differential round trip delay is composed of a TE differential delay of 22% or 1.15 μs according to § 8.2.3, the round trip delay of the unloaded bus installation of 0.5 μs (line length 25 to 50 metres) and an additional delay due to the load of 4 TEs (0.35 μs).

The objective from this extended passive bus configuration is a total length of at least 500 metres (d_4 in Figure A-2/I.430) and a differential distance between TE connection points of 25 to 50 metres (d_3 in Figure A-2/I.430). (d_3 depends on the characteristics of the cable to be used.) However, an appropriate combination of the total length, the differential distance between TE connection points and the number of TEs connected to the cable may be determined by individual Administrations.



TR Terminating resistor

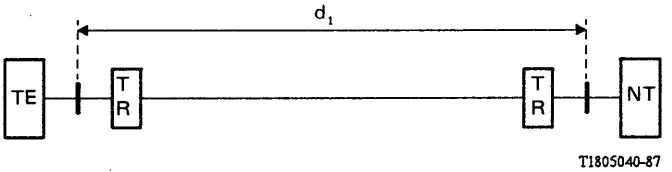
FIGURE A-2/I.430

Extended passive bus

A.2.2. *Point-to-point* (Figure A-3/I.430)

This configuration provides for one transmitter/receiver only at each end of the cable (see Figure A-3/I.430). It is, therefore, necessary to determine the maximum permissible attenuation between the ends of the cable to establish the transmitter output level and the range of receiver input levels. In addition, it is necessary to establish the maximum round trip delay for any signal which must be returned from one end to the other within a specified time period (limited by D-echo bits).

A general objective for the operational distance between TE and NT or NT1 and NT2 is 1000 meters (d_1 in Figure A-3/I.430). It is agreed to satisfy this general objective with a maximum cable attenuation of 6 dB at 96 kHz. The round trip delay is between 10 to 42 μs.



TR Terminating resistor

FIGURE A-3/I.430

Point-to-point

The lower value of 10 μs is derived in the same way as for the passive bus configuration. The upper value is composed of the following elements:

- 2 bits due to frame offset (2 × 5.2 μs = 10.4 μs, see § 5.4.2.3.);
- maximum 6 bits delay permitted due to the distance between NT and TE and the required processing time (6. × 5.2 ms = 31.2 ms);
- the fraction (+15%) of a bit period due to phase deviation between TE input and output (see § 8.2.3, 0.15 × 5.2 ms = 0.8 μs).

It should be noted that an adaptive timing device at the receiver is required at the NT to meet these limits.

For the NT used for both point-to-point and passive bus configurations (see § 8.6.3.2), the tolerable round trip delay in passive bus wiring configurations is reduced to 13 μs due to the extra tolerance required for the adaptive timing. Using this type of wiring configuration, it is also possible to provide point-to-multipoint mode of operation at layer 1.

Note – Point-to-multipoint operation can be accommodated using only point-to-point wiring. One suitable arrangement is an NT1 STAR illustrated in Figure A-4/I.430. In such an implementation, bit streams from TEs must be buffered to provide for operation of the D-echo channel(s) to provide for contention resolution, but only layer 1 functionality is required. It is also possible to support passive bus wiring configurations on the ports of NT1 STARs. Support of this configuration does not affect the provisions of Recommendations I.430, I.441 or I.451.

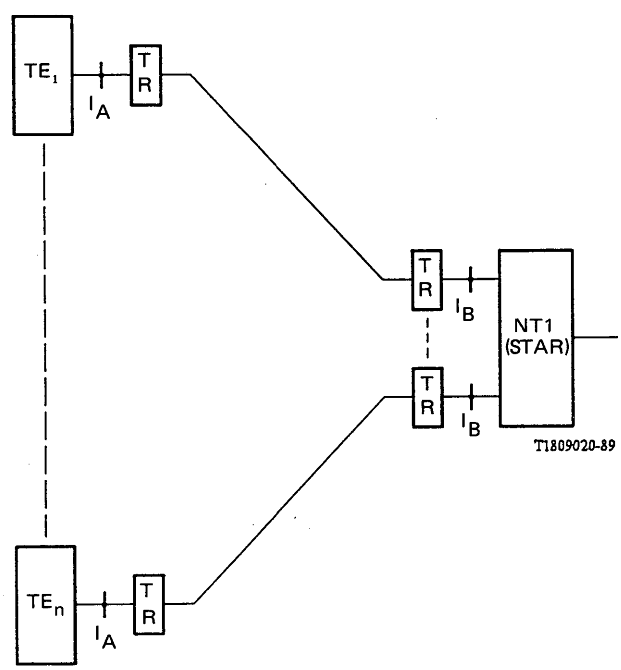


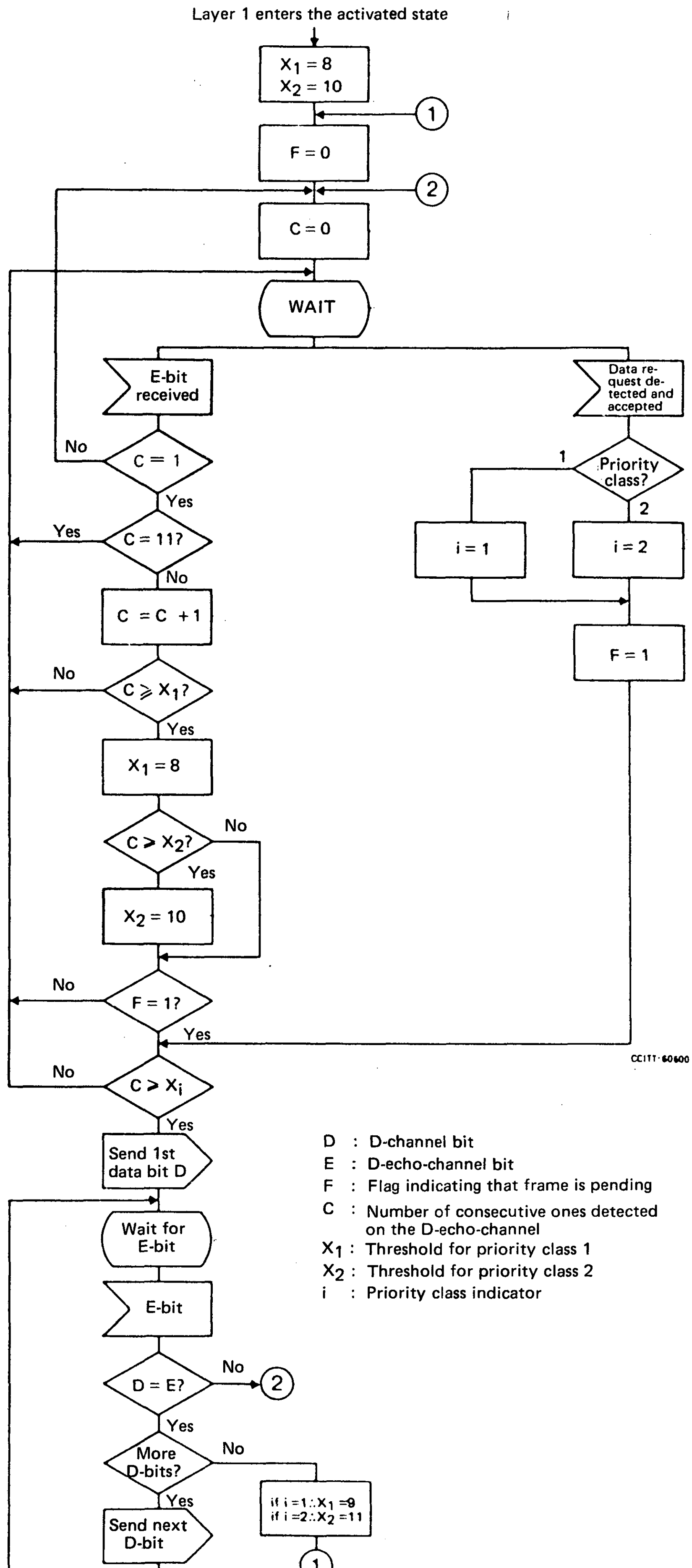
FIGURE A-4/I.430

NT1 STAR

ANNEX B

(to Recommendation I.430)

SDL representation of a possible implementation of the D-Channel access



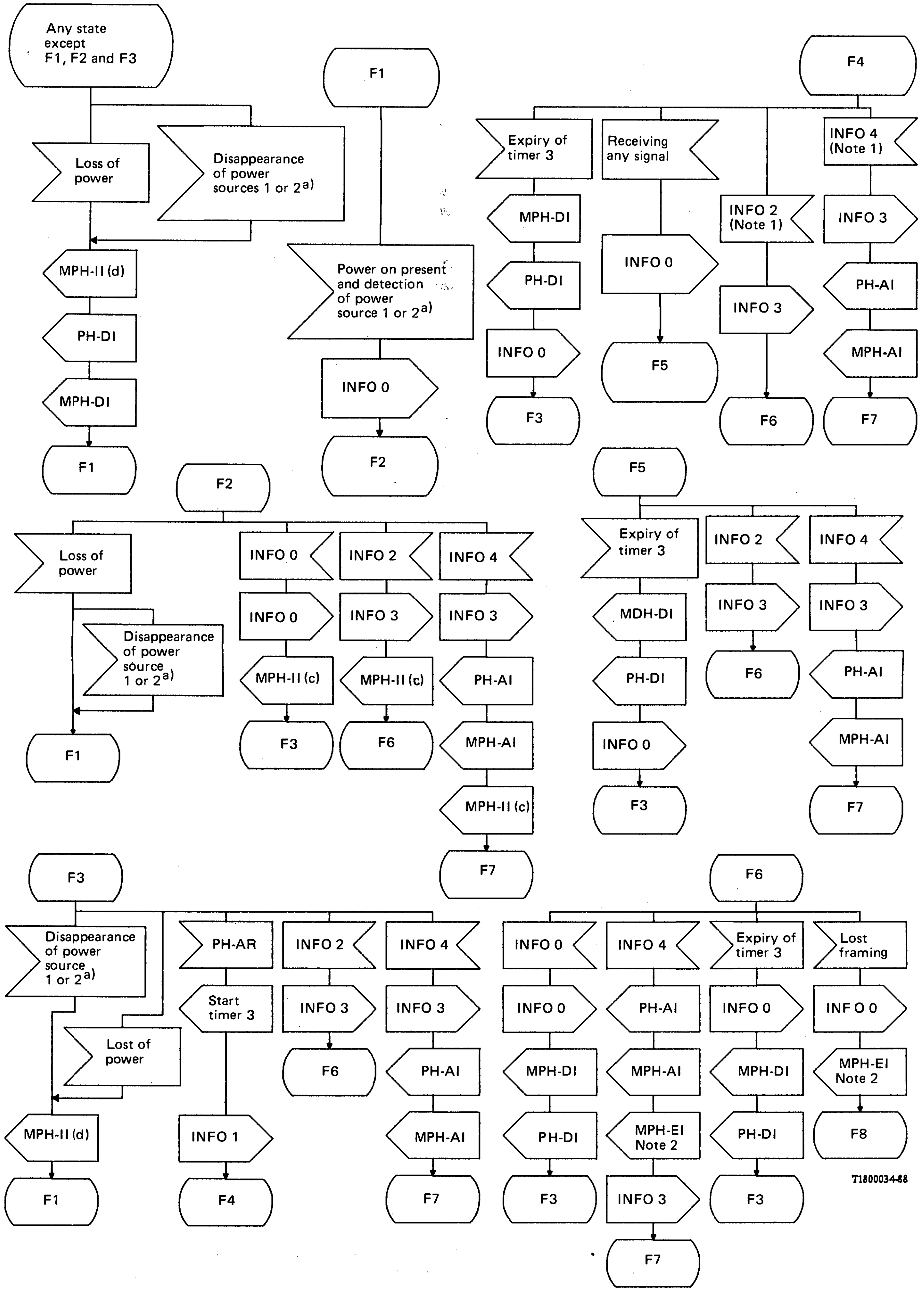
ANNEX C

(to Recommendation I.430)
(see Table 5/I.430)

C.1 *SDL representation of activation/deactivation procedures for TEs which can detect power source 1 or power source 2*

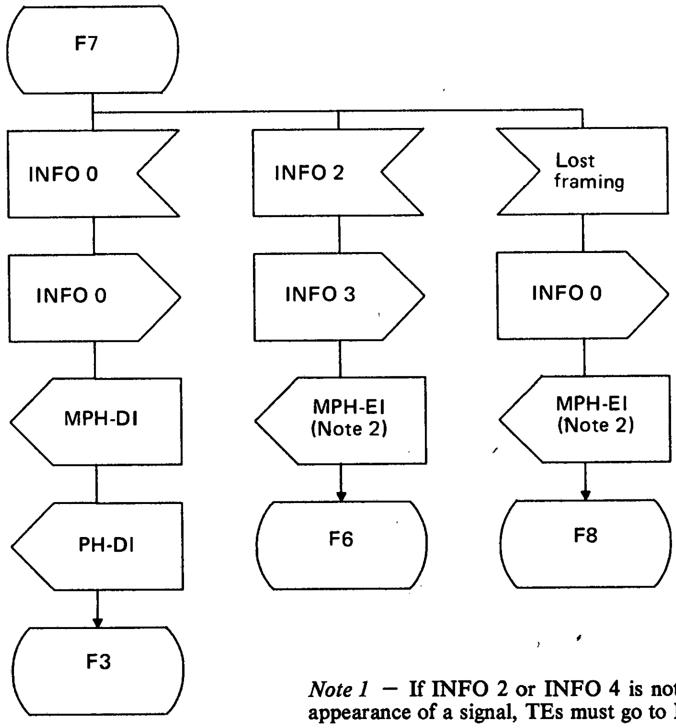
C.2 In § 6.2.3 the procedure at the terminal is specified in form of a finite state matrix given in Table 5/I.430. This Annex provides finite state matrices for two TE types in Tables C-1/I.430 and C-2/I.430.

C.3 *SDl representation of activation/deactivation procedures for NTs* (see Table 6/I.430)



a) Whichever power source is used for determining the connection status.

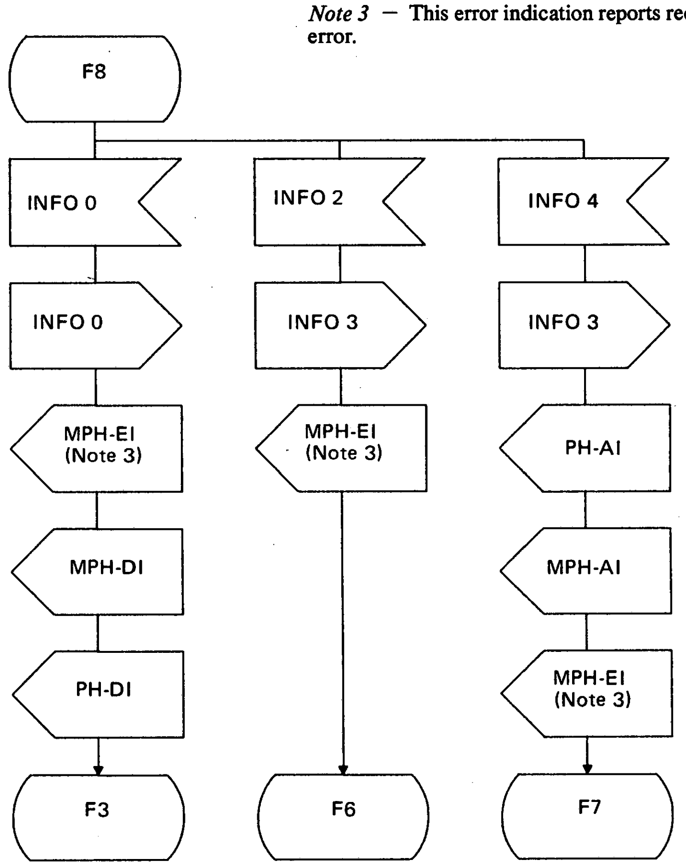
FIGURE C-1/I.430 (sheet 1 of 2)



Note 1 — If INFO 2 or INFO 4 is not recognized within 5 ms after the appearance of a signal, TEs must go to F5.

Note 2 — This error indication reports the detection of an error.

Note 3 — This error indication reports recovery from a previously reported error.



T1800022-86

PH-AI	Primitive PH-ACTIVATE INDICATION
MPH-AI	Primitive MPH-ACTIVATE INDICATION
MPH-DI	Primitive MPH-DEACTIVATE INDICATION
PH-DI	Primitive PH-DEACTIVATE INDICATION
MPH-EI	Primitive MPH-ERROR INDICATION including a parameter indicating the cause
MPH-II (c)	Primitive MPH-INFORMATION INDICATION (connected)
MPH-II (d)	Primitive MPH-INFORMATION INDICATION (disconnected)
PH	layer 1 ⟷ layer 2
MPH	layer 1 ⟷ management entity

FIGURE C-1/I.430 (sheet 2 of 2)

TABLE C-1/I.430

Activation/deactivation for TEs

TEs locally powered and unable to detect power source 1 or 2

<table>
<tr><td>State name</td><td>Inactive</td><td>Sensing</td><td>Deactivated</td><td>Awaiting signal</td><td>Identifying input</td><td>Synchro-nized</td><td>Activated</td><td>Lost framing</td></tr>
<tr><td>State number</td><td>F1</td><td>F2</td><td>F3</td><td>F4</td><td>F5</td><td>F6</td><td>F7</td><td>F8</td></tr>
<tr><td>Event / INFO sent</td><td>INFO 0</td><td>INFO 0</td><td>INFO 0</td><td>INFO 1</td><td>INFO 0</td><td>INFO 3</td><td>INFO 3</td><td>INFO 0</td></tr>
<tr><td>Loss of power (Note 2)</td><td>/</td><td>F1</td><td>MPH-II(d); F1</td><td>MPH-II(d), MPH-DI, PH-DI; F1</td><td>MPH-II(d), MPH-DI, PH-DI; F1</td><td>MPH-II(d), MPH-DI, PH-DI; F1</td><td>MPH-II(d), MPH-DI, PH-DI; F1</td><td>MPH-II(d), MPH-DI, PH-DI; F1</td></tr>
<tr><td>Application of power (Note 2)</td><td>F2</td><td>/</td><td>/</td><td>/</td><td>/</td><td>/</td><td>/</td><td>/</td></tr>
<tr><td>Detect power S</td><td colspan="8">Event not applicable to this type of terminal</td></tr>
<tr><td>Disappearance of power S</td><td colspan="8">Event not applicable to this type of terminal</td></tr>
<tr><td>PH-Activate Request</td><td>/</td><td>|</td><td>ST.T3 F4</td><td>|</td><td>|</td><td>–</td><td>|</td><td>–</td></tr>
<tr><td>Expiry T3</td><td>/</td><td>/</td><td>–</td><td>MPH-DI, PH-DI; F3</td><td>MPH-DI, PH-DI; F3</td><td>MPH-DI, PH-DI; F3</td><td>–</td><td>–</td></tr>
<tr><td>Receiving INFO 0</td><td>/</td><td>MPH-II(c); F3</td><td>–</td><td>–</td><td>–</td><td>MPH-DI, PH-DI; F3</td><td>MPH-DI, PH-DI; F3</td><td>MPH-DI, PH-DI, MPH-EI2; F3</td></tr>
</table>

TABLE C-1/I.430 *(cont.)*

State name / State number / INFO sent / Event	Inactive	Sensing	Deactivated	Awaiting signal	Identifying input	Synchro-nized	Activated	Lost framing
State number	F1	F2	F3	F4	F5	F6	F7	F8
INFO sent	INFO 0	INFO 0	INFO 0	INFO 1	INFO 0	INFO 3	INFO 3	INFO 0
Receiving any signal (Note 2)	/	–	–	F5	–	/	/	–
Receiving INFO 2	/	MPH-II(c); F6	F6	F6 (Note 3)	F6	–	MPH-EI1; F6	MPH-EI2; F6
Receiving INFO 4	/	MPH-II(c), PH-AI, MPH-AI; F7	PH-AI, MPH-AI; F7	PH-AI, MPH-AI; F7 (Note 3)	PH-AI, MPH-AI; F7	PH-AI, MPH-AI, MPH-EI2; F7	–	PH-AI, MPH-AI, MPH-EI2; F7
Lost framing	/	/	/	/	/	MPH-EI1; F8	MPH-EI1; F8	–

–	No change, no action
|	Impossible by the definition of the layer 1 service
/	Impossible situation
a, b; Fn	Issue primitives "a" and "b" and then go to state "Fn"
PH-AI	Primitive PH-ACTIVATE INDICATION
PH-DI	Primitive PH-DEACTIVATE INDICATION
MPH-AI	Primitive MPH-ACTIVATE INDICATION
MPH-DI	Primitive MPH-DEACTIVATE INDICATION
MPH-EI1	Primitive MPH-ERROR INDICATION reporting error
MPH-EI2	Primitive MPH-ERROR INDICATION reporting recovery from error
MPH-II(c)	Primitive MPH-INFORMATION INDICATION (connected)
MPH-II(d)	Primitive MPH-INFORMATION INDICATION (disconnected)
ST.T3	Start timer T3
Power S	Power source 1 or power source 2

Primitives are signals in a conceptual queue and will be cleared on recognition, while the INFO signals are continuous signals which are available all the time.

Note 1 – This event reflects the case where a signal is received and the TE has not (yet) determined whether it is INFO 2 or INFO 4.

Note 2 – The term "power" could be the full operational power or backup power. Backup power is defined such that it is enough to hold the TEI values in memory and maintain the capability of receiving and transmitting layer 2 frames associated with the TEI procedures.

Note 3 – If INFO 2 or INFO 4 is not recognized within 5 ms after the appearance of a signal, TEs must go to F5.

TABLE C-2/I.430

Activation/deactivation for TEs

TEs locally powered and able to detect power source 1 or 2. Use confined to NTs which provide power source 1 or 2

State name	Inactive		Sensing	Deactivated	Awaiting signal	Identifying input	Synchro-nized	Activated	Lost framing
	Power off	Power on							
State number	F1.0	F1.1	F2	F3	F4	F5	F6	F7	F8
Event / INFO sent	INFO 0	INFO 0	INFO 0	INFO 0	INFO 1	INFO 0	INFO 3	INFO 3	INFO 0
Loss of power (Note 2)	/	F1.0	F1.0	MPH-II(d); F1.0	MPH-II(d), MPH-DI, PH-DI; F1.0	MPH-II(d), MPH-DI, PH-DI; F1.0	MPH-II(d), MPH-DI, PH-DI; F1.0	MPH-II(d), MPH-DI, PH-DI; F1.0	MPH-II(d), MPH-DI, PH-DI; F1.0
Application of power (Note 2)	F1.1	/	/	/	/	/	/	/	/
Detect power S	/	F2	/	/	/	/	/	/	/
Disappearence of power S	/	/	F1.1	MPH-II(d); F1.1	MPH-II(d), MPH-DI, PH-DI; F1.1	MPH-II(d), MPH-DI, PH-DI; F1.1	MPH-II(d), MPH-DI, PH-DI; F1.1	MPH-II(d), MPH-DI, PH-DI; F1.1	MPH-II(d), MPH-DI, PH-DI; F1.1
PH-ACR REQ	/	|	|	ST.T3 F4	|	|	–	|	–
Expiry T3	/	–	–	–	MPH-DI, PH-DI; F3	MPH-DI, PH-DI; F3	MPH-DI, PH-DI; F3	–	–

TABLE C-2/I.430 *(cont.)*

State name	Inactive		Sensing	Deactivated	Awaiting signal	Identifying input	Synchro-nized	Activated	Lost framing
	Power off	Power on							
State number	F1.0	F1.1	F2	F3	F4	F5	F6	F7	F8
Event / INFO sent	INFO 0	INFO 0	INFO 0	INFO 0	INFO 1	INFO 0	INFO 3	INFO 3	INFO 0
Receiving INFO 0	/	/	MPH-II(c); F3	–	–	–	MPH-DI, PH-DI; F3	MPH-DI, PH-DI; F3	MPH-DI, PH-DI, MPH-EI2; F3
Receiving signal (Note 1)	/	/	–	–	F5	–	/	/	–
Receiving INFO 2	/	/	MPH-II(c); F6	F6	F6 (Note 3)	F6	–	MPH-EI1; F6	MPH-EI2; F6
Receiving INFO 4	/	/	MPH-II(c), PH-AI, MPH-AI; F7	PH-AI, MPH-AI; F7	PH-AI, MPH-AI; F7 (Note 3)	PH-AI, MPH-AI; F7	PH-AI, MPH-AI, MPH-EI2; F7	–	PH-AI, MPH-AI, MPH-EI2; F7
Lost framing	/	/	/	/	/	/	MPH-EI1; F8	MPH-EI1; F8	–

For notation and notes, see Table C-1/I.430.

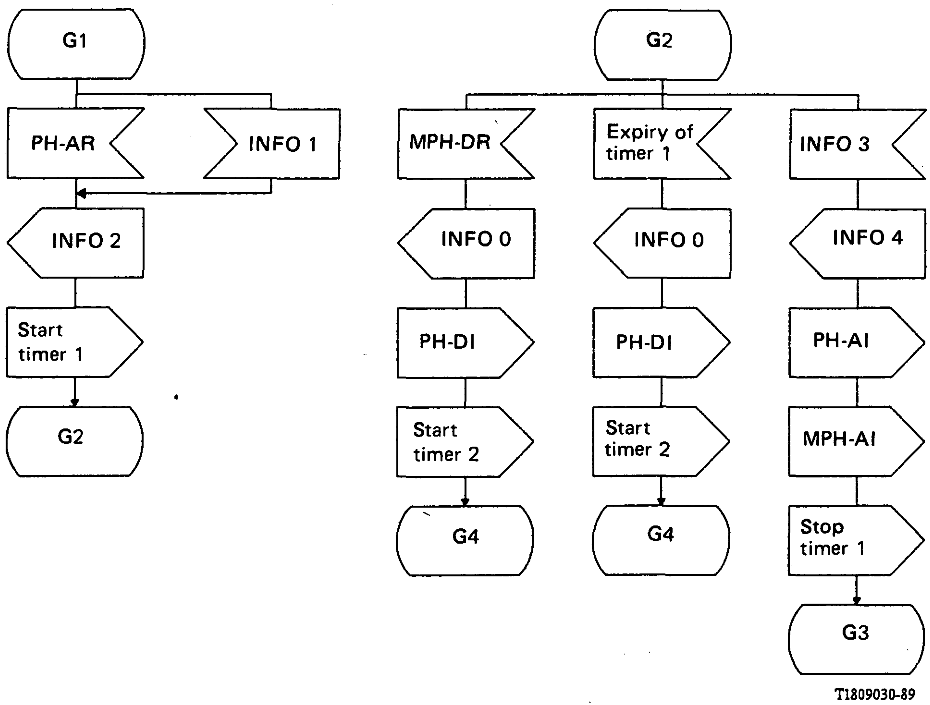
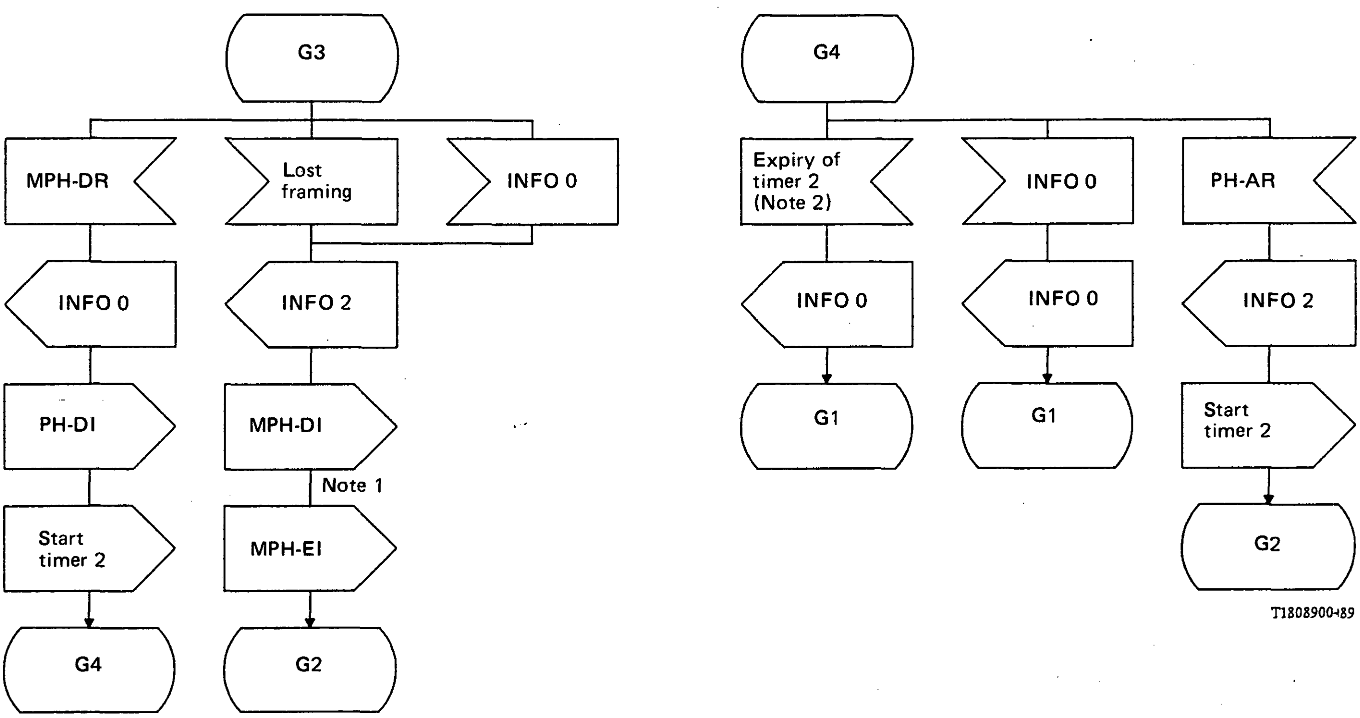


FIGURE C-2/I.430 (sheet 1 of 2)



Note 1 – The notification MPH-DI and MPH-EI need not be transferred to the management entity at the NT.

Note 2 – The duration of timer 2 is network dependent (25 to 100 ms). This implies that a TE has to recognize INFO 0 and to react on it within 25 ms. If the NT is able to unambiguously recognize INFO 1, then the value of timer 2 may be 0.

FIGURE C-2/I.430 (sheet 2 of 2)

ANNEX D

(to Recommendation I.430)

Test configuration

In § 8, waveforms are shown for testing NT and TE equipment. This Annex describes configurations, for testing TE equipment, which can be used to generate these waveforms (see Figure D-1/I.430). Similar configurations can be used to test NT equipment.

Table D-1/I.430 gives the parameters for the artificial lines reproduced in Figure D-1/I.430. The artificial lines are used to derive the waveforms. For test configurations ii) and iii), the cable length used corresponds to a signal delay of 1 μs.

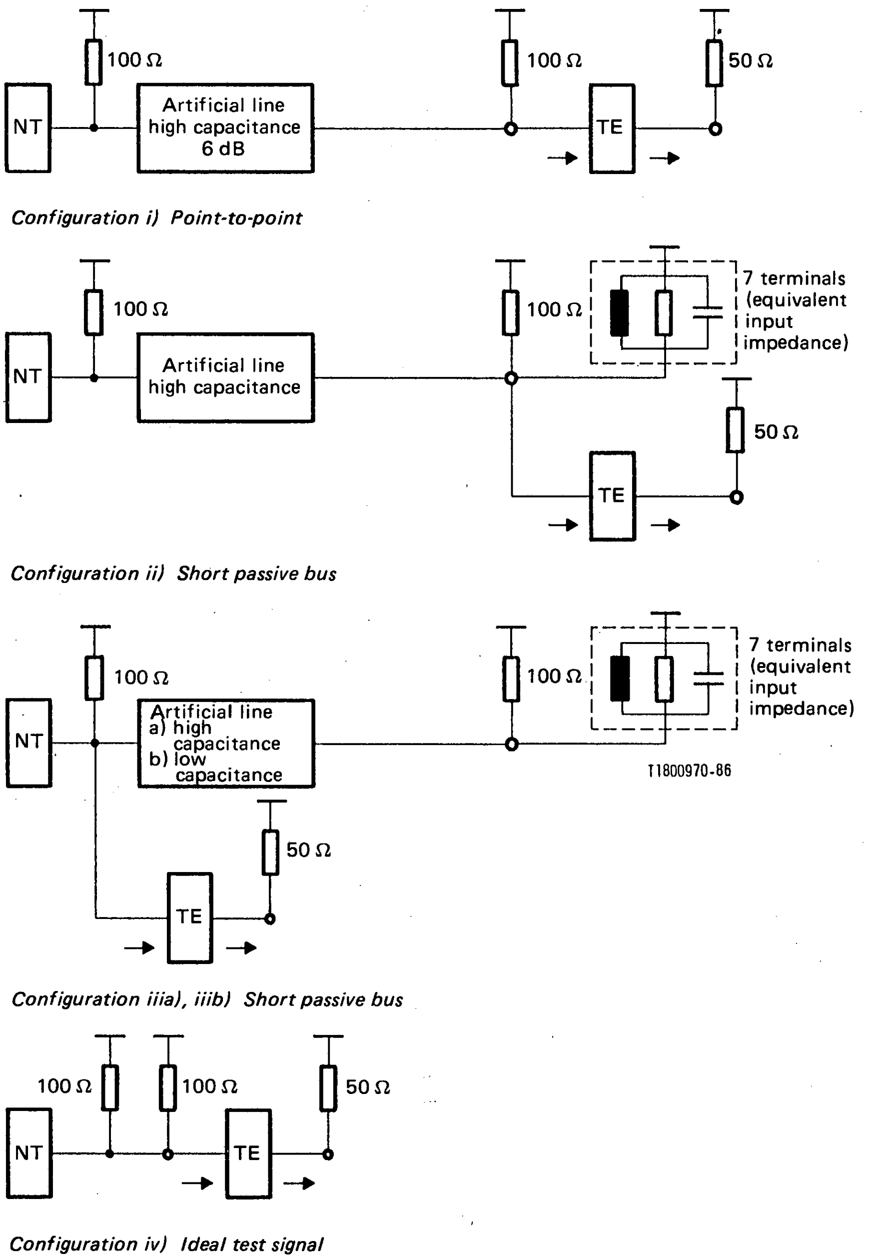


FIGURE D-1/I.430

Test configurations

TABLE D-1/I.430

Parameters for the artificial lines

Parameters	High capacitance cable	Low capacitance cable
R (96 kHz)	160 ohms/km	160 ohms/km
C (1 kHz)	120 nF/km	30 nF/km
Zo (96 kHz)	75 ohms	150 ohms
Wire diameter	0.6 mm	0.6 mm

ANNEX E

(to Recommendation I.430)

Vocabulary of terms used in connection with Recommendations I.430, I.431, G.960 and G.961

Introduction

This Annex provides a vocabulary of terms and definitions that are appropriate to layer 1 aspects of the ISDN customer access for basic access and primary rate access.

It should be considered in relation to Recommendations I.430, I.431, G.960 and G.961 since its scope is limited to these Recommendations. It is provided for a clear understanding of these Recommendations and will be reviewed during the next Study Period for alignment with Recommendations produced by other bodies.

A small number of terms in this Annex are duplicated in other Recommendations (e.g. Recommendation I.112 and/or Recommendation G.701). References to these are given in parenthesis as an aid to ensuring consistency between the Recommendations in the event of future amendments (e.g. "complete loopback {M.125}"). Where the term is defined differently, but the spirit is maintained, the reference is shown as in the following example: "functional group [{I.112 419}]".

According to the conventions applied in this Annex any term in common usage, but whose use is deprecated in the sense defined, is shown after the recommended term as in the following example: "line [loop]".

Where a truncated term is widely used in an understood context the complete term is quoted following the colloquial form, for example: "multiplex, digital multiplex equipment".

§ E.7 contains an alphabetical list of all of the terms contained in this Recommendation.

§ E.8 illustrates the general aspects of the terminology.

§ E.9 explains the V reference point, V interface, and interface point concept.

E.1 *General*

101 **basic access, basic rate access**

A user-network access arrangement that corresponds to the interface structure composed of two B-channels and one D-channel. The bit rate of the D-channel for this type of access is 16 kbit/s.

102 **primary rate access**

A user-network access arrangement that corresponds to the primary rates of 1544 kbit/s and 2048 kbit/s. The bit rate of the D-channel for this type of access is 64 kbit/s. The typical primary rate interface structures are as given in Recommendations I.412 and I.431.

103 **local exchange, ISDN local exchange**

The exchange which, in addition to the switching function, contains the exchange termination for the ISDN customer accesses.

104 **line termination (LT)**

The functional group containing at least the transmit and receive functions terminating one end of a digital transmission system.

105 **exchange termination (ET)**

The functional group containing at least the layer 2 and layer 3 network side functions of the I.420 interface at the T reference point.

Note 1 – This may not be true if concentrators or other intelligent equipment are located in the local line distribution network.

Note 2 – The ET is not the switching function. The extent to which the ET supports call control processing and management is not defined.

106 **network termination (NT)**

The functional group on the network side of a user-network interface.

Note – In Recommendations I.430 and I.431, "NT" is used to indicate network terminating layer 1 aspects of NT1 and NT2 functional groups.

107 **terminal equipment (TE)**

The functional group on the user side of a user network interface.

Note – In Recommendations I.430 and I.431, "TE" is used to indicate terminal terminating layer 1 aspects of TE1, TA and NT2 functional groups.

108 **functional group** [{I.112 419}]

A set of functions that may be performed by a single equipment.

Note 1 – The transmission medium is not part of any functional group.

Note 2 – Regenerators, multiplexers and concentrators are functional groups which are outside the scope of Recommendation I.411.

109 **access connection element [subscriber access]** [{I.324}]

The equipment providing the concatenation of functional groups between and including the exchange termination and the NT1. The term should be qualified by the type of access supported. That is:

– basic access connection element
– primary rate access connection element.

110 **customer equipment [subscriber installation]** [{I.324}]

The concatenation of equipment on the user side of the T reference point (i.e. TAs, TE2s, TE1s NT2 and associated transmission media). In the case of multiple access, the customer equipment includes all the equipment on the user side of all those accesses comprising the multiple access.

Note 1 – This term should not imply or restrict ownership or responsibility for providing equipment.

Note 2 – The terms "user equipment" and "subscriber equipment" are deprecated.

111 **ISDN customer access [ISDN subscriber access]**

The equipment providing the concatenation of all functional groups relevant to an individual or group of related access connection elements (i.e. customer equipment and access connection element).

Note – This term should not imply or restrict ownership or responsibility for providing equipment.

112 **direct access, direct access connection element**

A specific access connection element in which the basic access digital section or primary rate access digital section is directly connected to the exchange termination at a V_1 or V_3 reference point respectively.

113 **remote access, remote access connection element**

A specific access connection element in which the digital section is not directly connected to the exchange termination but is connected through a multiplexer or concentrator.

114 **reference point** {I.412 420}

A conceptual point at the conjunction of two non-overlapping functional groups.

Note – Each reference point is assigned a prefix letter, for example: T reference point.

115 **interface, physical interface** {I.112 408; G.701 1008}

The common boundary between physical equipment.

116 **user network interface [customer network interface]** {I.112 409}

An interface, at which the access protocols apply, and which is located at the S or T reference point.

117 **V interface**

A digital interface which usually coincides with the V reference point.

Note – A specific V interface is denoted by a suffix number.

Note – The V interfaces are internal network interfaces.

118 **V_1 reference point**

A V reference point at the network side of a basic access digital section for the provision of a single basic access.

Note – The V_1 interface is a functional boundary between the exchange termination and the line termination and may or may not exist as a physical interface. The V_1 interface structure is comprised of two B-channels, one D-channel, and a C_{v1}-channel.

119 **V_2 reference point**

A V reference point at the network side of a concentrator for the provision of a number of basic and/or primary rate accesses.

120 **V_3 reference point**

A V reference point at the network side of a primary rate access digital section for the provision of a single primary rate access.

121 **V_4 reference point**

A V reference point at the network side of a multiplexer supporting several basic access digital sections.

E.2 *Digital transmission*

201 **Digital link, digital transmission link** [{I.112 302; G.701 3005}]

The whole of the means of digital transmission of a digital signal of specified rate between specified reference points.

Note – A digital link comprises one or more digital sections and may include either a multiplexer or concentrator, but not switching.

202 **digital access link**

A digital link between the T reference point and the V reference point in the case of remote access only.

203 **digital section [section]** [{G.701 3007}]

The whole of the means of digital transmission of a digital signal of specified rate between two consecutive reference points. The term should be qualified by the type of access supported, or by a prefix denoting the V interface at the digital section boundaries. For example:

- basic access digital section;
- primary rate access digital section;
- V_x digital section.

204 **digital section boundaries**

The reference points at the near and far ends of the digital section.

205 **digital system, digital transmission system [system]** [{G.701 3014}]

A specific means of providing a digital section.

Note – For a specific type of system this term may be qualified by the insertion of the name of the transmission medium employed by that specific system. Some examples are:

- digital line transmission system;
- digital radio system;
- digital optical transmission system.

206 **transmission method**

The technique by which the transmission system transmits and receives signals via the transmission medium.

207 **echo cancellation**

A transmission method used in digital transmission systems in which bi-directional transmission occurs simultaneously on the same line and in the same frequency band. An echo canceller is required to attenuate the echo of the near-end transmission.

208 **time compression multiplex burst mode]**

A transmission method used in digital transmission systems in which bi-directional transmission occurs in non-overlapping uni-directional bursts.

209 **multiplex, digital multiplex equipment** [{G.701 4017}]

The combination of a digital multiplexer and a digital demultiplexer at the same location, operating in opposite directions of transmission.

210 **static multiplex [fixed multiplex]**

A multiplex where each tributary channel is assigned to one or more main-stream time-slots and the assignment is fixed.

211 **dynamic multiplex [statistical multiplex]**

A multiplex where signalling information of some or all tributary D-channels is assigned to a lesser number of main-stream time-slots on a statistical basis, but the assignment of other channels is fixed.

212 **concentrator, digital concentrator**

Equipment containing the means to combine, in one direction, a number of basic accesses, and/or primary rate accesses into a lesser number of time-slots by omitting the idle channels and/or redundancy, and to perform the corresponding separation in the contra-direction.

E.3 *Signalling*

301 **INFO**

A defined layer 1 signal with specified meaning and coding at a basic access user-network interface.

302 **SIG**

A signal representing an exchange of layer 1 information between line terminations of a digital transmission system for basic access.

303 **function elements (FEs)**

A signal representing a functional exchange of layer 1 information at the V_1 interface.

304 **control channel; C-channel [service channel]**

Additional dedicated transmission capability provided at a reference point or interface, or transported by a digital transmission system, to support the execution of management functions.

Note – The control channel at a specific reference point, interface or type of transmission system is denoted by an appropriate suffix. For example:

– C_{v1} channel: the control channel at the V_1 interface
– C_L-channel: the control channel at the line.

E.4 *Activation/deactivation*

401 **deactivation**

A function which places a system, or part of a system, into a non-operating or partially operating mode where the power consumption of the system may be decreased (low power consumption mode).

402 **activation**

A function which places a system, or part of a system, which may have been in a low power consumption mode during deactivation, into its fully operating mode.

403 **permanent activation**

Activation of a system, or part of a system, that will not be deactivated even when it is not required to be fully operating.

404 **line activation**

The function which requires the digital line transmission system to be activated but which may also activate the user-network interface.

405 **line-only activation**

The function which requires the activation of only the digital line transmission system and does not activate the user-network interface.

406 **one-step activation**

A type of activation which invokes a sequence of actions to activate the digital line transmission system and user-network interface from a single command.

407 **two-step activation**

A type of activation which is initiated by one command to invoke a sequence of actions to activate the digital line transmission system and continued by a second command to invoke a sequence of actions to activate the user-network interface.

408 **one-step deactivation**

Deactivation of the digital line transmission system and user-network interface invoked by a single command.

409 **user-network interface only deactivation**

Deactivation of the user-network interface which does not deactivate the digital line transmission system.

E.5 *Loopbacks*

501 **loopback, digital loopback** {M.125} **[test loop]** [{I.112 G}]

A mechanism incorporated into a piece of equipment whereby a bi-directional communication path may be connected back on itself so that some or all of the information contained in the bit sream sent on the transmit path is returned on the receive path.

502 **loopback type**

The characteristic of a loopback which specifies the relationship between information entering the loopback and the information leaving the loopback in the contra-direction.

503 **complete loopback** {M.125}

A physical layer 1 mechanism which operates on the full bit stream. At the loopback point, the receive bit stream shall be transmitted back towards the transmitting station without modification.

Note – The use of the term "complete loopback" is not related to implementation since such a loopback may be provided by means of active logic elements or controlled unbalance of a hybrid transformer, etc. At the control point only the information channels may be available.

504 **partial loopback** {M.125} **[echoing loopback]**

A physical layer 1 mechanism which operates on one or more specified channels multiplexed within the full bit stream. At the loopback point, the received bit stream associated with the specified channel(s) shall be transmitted back towards the transmitting station without modification.

505 **logical loopback** {M.125}

A loopback which acts selectively on certain information within a specified channel or channels and may result in some specified modification of the looped information. Logical loopbacks may be defined to apply at any layer, depending on the detailed maintenance procedures specified.

506 **loopback point** [{M.125}]

The precise location of the loopback.

507 **loopback control mechanism [control mechanism]** {M.125}

The means by which the loopback is operated and released from the loopback control point.

508 **loopback control point [control point]** {M.125}

The point which has the ability to directly control loopbacks. The loopback control point may receive requests for loopback operation from several loopback requesting points.

509 **loopback requesting point** [{M.125}]

The point which requests the loopback control point to operate loopbacks.

510 **loopback application** {M.125}

The maintenance phase for which the loopback operation is used.

511 **forward signal**

The signal transmitted beyond the loopback point.

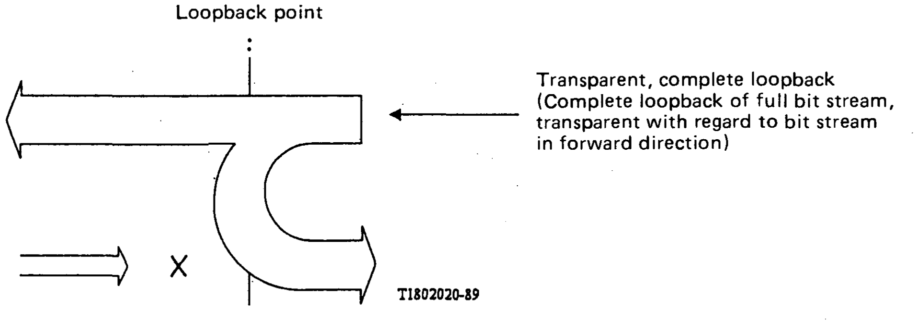
Note – The forward signal may be a defined signal or unspecified.

512 **loopback test pattern** [{M.125}]

The information transmitted during the operation of the loopback in the channel or channels which are to be redirected by the loopback.

513 **transparent loopback** {M.125}

A transparent loopback is one in which the signal transmitted beyond the loopback point (the forward signal) when the loopback is activated, is the same as the received signal at the loopback point. See Figure E-1/I.430.

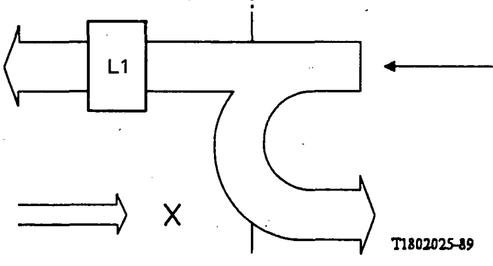


X Signal inhibited in order to avoid interference with looped signal

FIGURE E-1/I.430

514 **non-transparent loopback** {M.125}

A non-transparent loopback is one in which the signal transmitted beyond the loopback point (the forward signal) when the loopback is activated is not the same as the received signal at the loopback point. The forward signal may be a defined signal or unspecified. See Figure E-2/I.430.



X Signal inhibited in order to avoid interference with looped signal

L1 Device which changes or inhibits the transferred signal

FIGURE E-2/I.430

E.6 *local line distribution network*

601 **local line distribution network**

A network of cables and wires which are currently installed between a local exchange and customer premises.

602 **twisted pair**

A line or part of a line which has each (insulated) conductor twisted around the other to reduce the effect of induction from stray electromagnetic and/or electrostatic fields.

Note – This definition also applies to twisted quad except that two pairs are twisted together.

603 **exchange cable**

A cable forming part of the local line distribution network, used in the local exchange between the line termination and main distribution frame.

604 **main cable**

A cable used in the local line distribution network between the main distribution frame and a cross connection point.

605 **distribution cable**

A cable used in the local line distribution network between the cross connection point and a distribution point.

606 **installation cable [subscriber cable]**

A cable or single pair of metallic wires used in the local line distribution point and the customer premises.

607 **bridged tap**

A length of unused open circuit line that is "T"ed to the customer line to provide flexibility in the local line distribution network.

Note – Bridged taps are not used in all local line distribution networks.

608 **open wire**

A pair of suspended and often uninsulated metallic wires which run parallel to each other.

Note – Overhead installation cables in common use between distribution poles and customer premises are not open wires.

609 **loading coil**

A device used to modify the electric characteristics of a line to give relatively constant attenuation over the voice-frequency range, but which gives relatively high attenuation beyond that range.

610 **crosstalk**

A phenomenon by which an unwanted signal is introduced into a line through coupling to one or more other lines.

611 **intrasystem crosstalk**

Crosstalk between lines sharing the same cable on which the same type of transmission system is used on each line.

612 **intersystem crosstalk**

Crosstalk between lines sharing the same cable and on which different types of transmission systems are used on each line.

613 **near-end crosstalk (NEXT)**

Crosstalk where the coupling is occurring at or near to the transmitter.

614 **far-end crosstalk (FEXT)**

Crosstalk where the coupling is occurring at or near to the end of the line furthest from the transmitter.

615 **line [loop]**

The transmission medium between line terminations. The term may be qualified by the type of medium used, for example:

- metallic line: a pair of metallic (usually copper) wires,
- optical line: one optical fibre (bi-directional transmission), or one pair of fibres (uni-directional transmission).

616 **local line [subscriber line]**

An individual line which is continuous between the line termination (LT) and the customer premises, passing through the exchange, main, distribution and installation cables.

617 **digital local line**

A local line which is used by a digital transmission system.

Note – Regenerators are not part of the line but may be inserted between two line lengths.

E.7 *Alphabetical list of terms contained in this Annex*

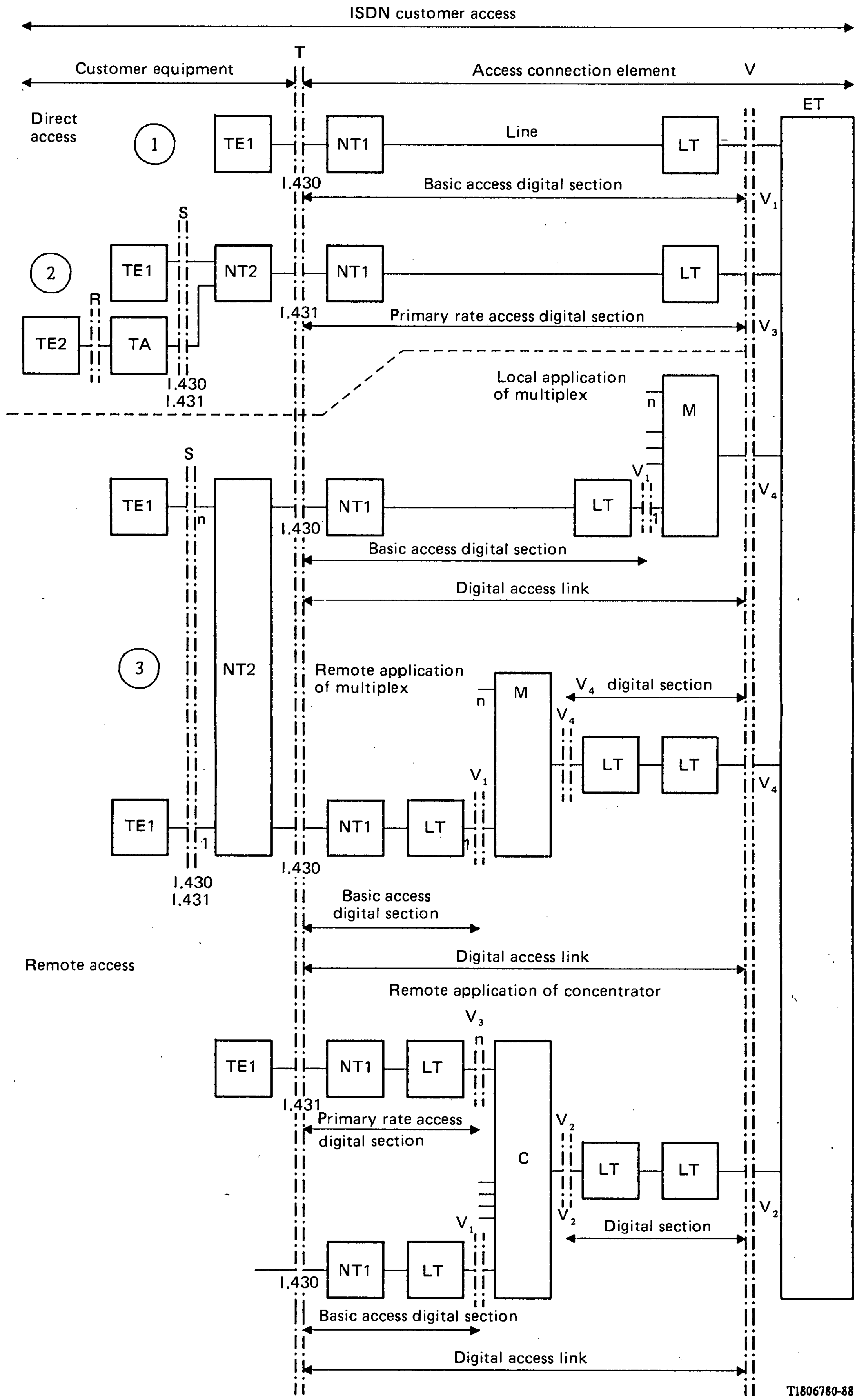


FIGURE E-3/I.430

E.9 *Clarification of the V reference point, V interface, and reference point concept*

E.9.1 The V_1 reference point and the V_3 reference point are always on the network side of the line termination and are applicable to individual (low order) accesses.

A reference point, when physically realized by an interface, requires the specification of at least two interface points. See Figure E-4/I.430.

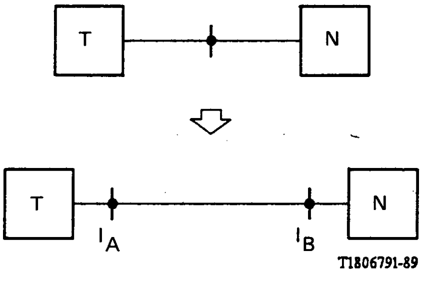
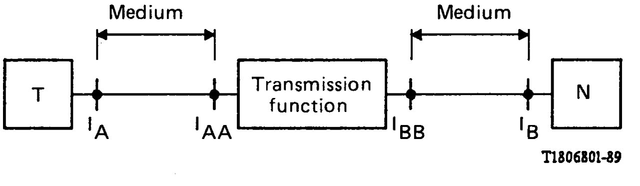


FIGURE E-4/I.430

E.9.2 *Interface point*

One of at least two physical locations associated with an interface. The interface points mark the end of the transmission medium which supports the interface and may be the location of connectors (if used).

The reach of any interface may be extended by the use of a transmission system, providing that the transmission system is transparent with regard to the functions transported by the interface. In such a case, two further interface points would be required. See Figure E-5/I.430.



Note – The insertion of a transmission system to a specific interface may be limited by performance related requirements.

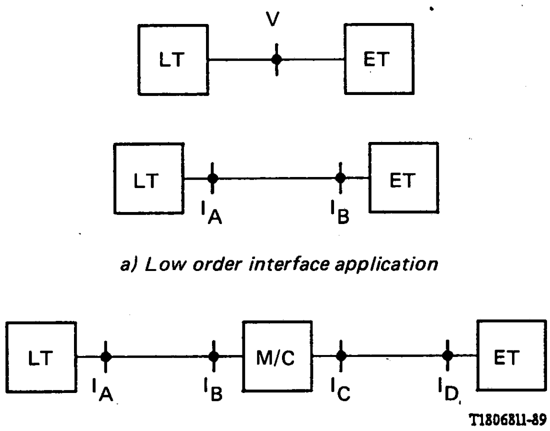
FIGURE E-5/I.430

E.9.3 A group of individual accesses may be multiplexed or concentrated together to comprise a higher order access (i.e. V_2 or V_6 for basic access higher order interfaces).

There is only one V reference point at which the V interfaces may be implemented (between LT and ET). See Figure E-6/I.430.

This approach aligns with the use of I_B and I_A interface points in Recommendations I.430 and I.431.

- with the modelling technique used so far;
- with the terminology used so far;
- with the fact that an S or T reference point may support a range of interfaces (I.430/I.431);
- does not contradict Recommendation Q.512.



a) Low order interface application

b) High order interface application

M/C Multiplexer or concentrator

Note – I_B and I_A are the interface points supporting V_1 or V_3 interfaces. I_C and I_D are the interface points supporting V_2 or V_4 interfaces.

FIGURE E-6/I.430

APPENDIX I

(to Recommendation I.430)

Test loopbacks defined for the basic user-network interface

I.1 *Introduction*

Recommendations in the I.600-Series specify an overall approach to be employed in maintaining the ISDN basic access. An integral part of that approach is the use of looping mechanisms in the failure confirmation and failure localization phases of network maintenance.

Detailed specifications of how such loopbacks are to be used may be found in the I.600-Series Recommendations. However, since the required loopbacks may impact the design of terminating pieces of equipment, a brief description of the loopbacks and their characteristics is presented in this Appendix.

I.2 *Loopback mechanism definitions*

This section defines the terminology used in specifying the characteristics of loopbacks.

The loopback point is the location of the loopback.

The control point is the location from which activation/deactivation of the loopback is controlled.

Note – The generation of the test pattern used over the loopback may not be located at the control point.

The following three types of loopback mechanisms are defined:

a) Complete loopback – a complete loopback is a layer 1 mechanism which operates on the full bit stream. At the loopback point, the received bit stream shall be transmitted back towards the transmitting station without modification.

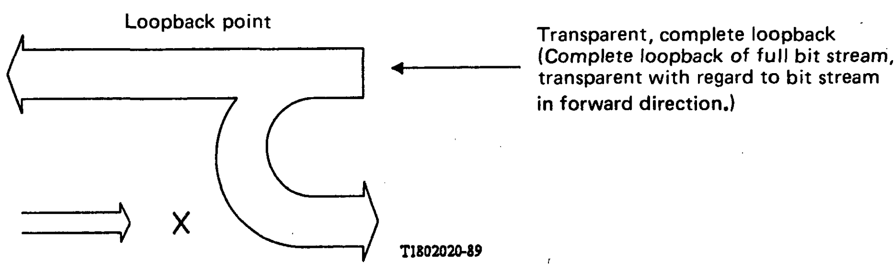
Note – The use of the term "complete loopback" is not related to implementation since such a loopback may be provided by means of active logic elements or controlled unbalance of a hybrid transformer, etc. At the control access point only the information channels may be available.

b) Partial loopback – a partial loopback is a layer 1 mechanism which operates on one or more specified channels multiplexed within the full bit stream. At the loopback point, the received bit stream associated with the specified channel(s) shall be transmitted back towards the transmitting station without modification.

c) Logical loopback – a logical loopback acts selectively on certain information within a channel or channels and may result in some specified modification of the looped information. Logical loopbacks may be defined at any layer of the OSI model and depend on the detailed maintenance procedures specified.

For each of the above three types of loopback mechanisms, the loopback may be further categorized as either transparent or non-transparent.

i) A transparent loopback is one in which the signal transmitted beyond the loopback point (the forward signal) when the loopback is activated, is the same as the received signal at the loopback point. See Figure I-1/I.430.

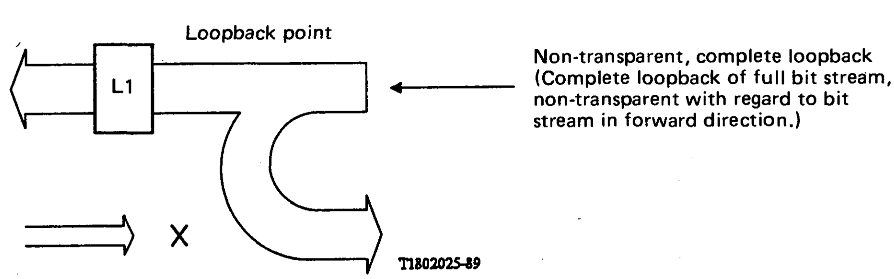


X = Signal inhibited in order to avoid interference with looped signal

FIGURE I-1/I.430

Transparent loopback

ii) A non-transparent loopback is one in which the signal transmitted beyond the loopback point (the forward signal) when the loopback is activated is not the same as the received signal at the loopback point. The forward signal may be a defined signal or unspecified. See Figure I-2/I.430.



X = Signal inhibited in order to avoid interference with looped signal

L1 = Device which changes or inhibits the transferred signal.

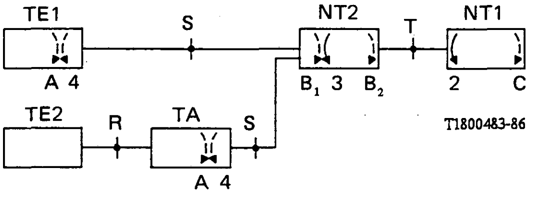
FIGURE I-2/I.430

Non-transparent loopback

Note – Whether or not a transparent loopback is used, the loopback should not be affected by facilities connected beyond the point at which the loop is provided, e.g. by the presence of short circuits, open circuits or foreign voltages.

I.3 *Test loopback reference configuration*

Figure I-3/I.430 shows the possible locations of test loopbacks pertaining to the maintenance of the ISDN basic user-network interface. Recommended and desirable loopbacks are drawn in solid lines. Optional loopbacks are drawn with dashed lines. These optional loopbacks may not be provided by all equipments. The characteristics of each of these loopbacks are given in Tables I-1/I.430 and I-2/I.430, respectively.



Note – Loopbacks B_1 and 3 are applicable to each individual interface at reference point S.

FIGURE I-3/I.430

Location of loopbacks

I.4 *Test loopback characteristics*

Tables I-1/I.430 and I-2/I.430 present the characteristics applicable to each recommended, desirable and optional loopback. In particular, the control point, control mechanism, loopback type, and loopback location are identified.

The loopback type indicates whether a complete, partial or logical loopback is required and whether the loopback should be transparent or non-transparent.

The loopback location is specified in a somewhat approximate manner, since the precise location may be implementation dependent.

The choice of loopback mechanism is dictated by the protocol layers available at the looping point and the addressing requirements. Thus, for instance, loopback 3 is controlled via layer 3 since selection of a particular S interface may be required.

Table I-3/I.430 lists characteristics of those loopbacks whose use and parameters are for further study.

TABLE I-1/I.430

Characteristics of recommended loopbacks

Loopback (see Figure I-3/I.430)	Location	Channel(s) looped	Loopback type	Control point	Control mechanism	Implementation
2	In NT1, as near as possible to T reference point, towards the ET (Note 1)	2B + D channels	Complete, transparent or non-transparent (see Note to § I.2) (Note 4)	Under control of local exchange	Layer 1 signals in transmission system	Recommended
3	In NT2, as near as possible to S reference point, towards the ET	2B + D channels	Complete, transparent or non-transparent (see Note to § I.2)	NT2	Local maintenance	Desirable (Note 3)
				NT2	Layer 3 messages in D-channel or in band signalling in B-channel (Note 2)	

Note 1 – In the case of a combined NT1 and NT2 (i.e., an NT12), loopback 2 is located at the position within the NT12 which equates to the T reference point.

Note 2 – Activation/deactivation of loopback 3 may be initiated by request from a remote maintenance server by layer 3 messages in the D channel or other signalling in the B channel. However, the generation of the test pattern over the loopback would be by the NT2.

Note 3 – From a technical viewpoint, it is desirable (although not mandatory) that loopback 3 can always be implemented, therefore the design of protocols for loopback control should include the operation of loopback 3.

Note 4 – In case a transparent loopback 2 is applied, the NT1 should send INFO 4 frames toward the user with the D-echo channel bits set to binary ZERO.

TABLE I-2/I.430

Characteristics of optional loopbacks

<table>
<tr><th>Loopbacks (see Figure I-3/I.430)</th><th>Location</th><th>Channel(s) looped</th><th>Loopback type</th><th>Control point</th><th>Control mechanism</th><th>Implementation</th></tr>
<tr><td rowspan="2">C</td><td rowspan="2">Inside NT1</td><td rowspan="2">B_1, B_2 (Note 4)</td><td rowspan="2">Partial, transparent or non-transparent</td><td>TE, NT2</td><td>Layer 1 (Note 1)</td><td rowspan="2">Optional</td></tr>
<tr><td>Under control of local exchange</td><td>(Note 2)</td></tr>
<tr><td>B_1</td><td>Inside the NT2, at subscriber side (Note 3)</td><td>B_1, B_2 (Note 4)</td><td>Partial, transparent or non-transparent</td><td>TE, NT2</td><td>Layer 1 or Layer 3</td><td>Optional</td></tr>
<tr><td>B_2</td><td>Inside the NT2, at the network side</td><td rowspan="2" colspan="5">These loopbacks are optional in the TE/NT2. When used, e.g. as part of an internal test, no information should be sent towards the network interface, (i.e. INFO 0 is transmitted to the interface).</td></tr>
<tr><td>A</td><td>Inside the TE</td></tr>
<tr><td>4</td><td>Inside the TA or TE</td><td>B_1, B_2 (Note 4)</td><td>Partial, transparent or non-transparent</td><td>NT2 local exchange, remote maintenance server or remote user</td><td>Layer 3</td><td>Optional</td></tr>
</table>

Note 1 – An exchange of layer 3 service messages may take place between TE (or NT2) and the exchange prior to the use of the layer 1 control mechanism. However, there are situations where the TE (or NT2) may not receive a reply:

a) the message may not be transmitted when the interface is in a failure situation;

b) a network that does not support the layer 3 signalling option, need not respond.

The definition of layer 1 control signal from TE (or NT2) towards NT1 (based on the use of the optional multi-frame) is for further study.

Note 2 – The control mechanism in this case could be the same as in Note 1 except that the network controls the loopback by spare capacity in the transmission system.

Note 3 – Loopback B_1 is applicable to each individual interface at reference point S.

Note 4 – The B_1- and B_2-channel loopbacks are controlled by separate control signals. However, both loopbacks may be applied at the same time.

TABLE I-3/I.430

Characteristics of loopbacks whose need and parameters are for further study

Loopbacks (see Figure I-3/I.430)	Location	Channel(s) looped	Loopback type	Control point	Control mechanism	Implementation
2_1	Within the NT1, not impacting the network interface	B_1, B_2 (Note)	Partial, transparent or non-transparent	Under control of the local exchange	Layer 1 signals in the transmission system	Optional

Note – The B_1- and B_2-channel loopbacks are controlled by separate control signals; however, both loopbacks may be applied at the same time.

PRIMARY RATE USER-NETWORK INTERFACE – LAYER 1 SPECIFICATION

(Malaga-Torremolinos, 1984; amended at Melbourne, 1988)

1 Introduction

This Recommendation is concerned with the layer 1 electrical, format and channel usage characteristics of the primary rate user-network interface at the S and T reference points. In this Recommendation, the term "NT" is used to indicate network terminating layer 1 aspects of NT1 and NT2 functional groups, and the term "TE" is used to indicate terminal terminating layer 1 aspects of TE1, TA and NT2 functional groups, unless otherwise indicated. The terminology used in this Recommendation is very specific and not contained in the relevant terminology Recommendations. Therefore, Annex E to Recommendation I.430 provides terms and definitions used in this Recommendation. Interfaces for the 1544 kbit/s primary rate and for the 2048 kbit/s primary rate are described. It has been an objective that differences between the interface specifications for the two rates be kept to a minimum.

1.1 *Scope and field of application*

This specification is applicable to user-network interfaces at 1544 kbit/s and 2048 kbit/s primary rates for ISDN channel arrangements as defined in Recommendation I.412.

2 Type of configuration

The type of configuration applies only to the layer 1 characteristics of the interface and does not imply any constraints on modes of operation at higher layers.

2.1 *Point-to-point*

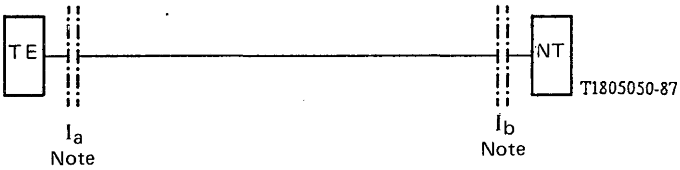
The primary rate access will support only the point-to-point configuration.

Point-to-point configuration at layer 1 implies that for each direction only one source (transmitter) and one sink (receiver) are connected to the interface. The maximum reach of the interface in the point-to-point configuration is limited by the specification for the electrical characteristics of transmitted and received pulses and the type of interconnecting cable. Some of these characteristics are defined in Recommendation G.703.

2.2 *Location of interfaces*

The electrical characteristics for both the 1544 kbit/s case (§ 4.1) and the 2048 kbit/s case (§ 5.1) apply at the interfaces I_a and I_b defined in Figure 1/I.431.

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



Note – I_a and I_b are located at the input/output port of the TE or NT.

FIGURE 1/I.431

Location of interfaces

3 Functional characteristics

3.1 *Summary of functions (Layer 1)* (see Figure 2/I.431)

TE		NT
B-, H_0- or H_1-channels	←→	B-, H_0- or H_1-channels
1 D-channel 64 kbit/s	←→	1 D-channel 64 kbit/s
Bit timing	←→	Bit timing
Octet timing	←→	Octet timing
Frame alignment	←→	Frame alignment
Power feeding (see Note)	→	Power feeding (see Note)
Maintenance	←→	Maintenance
CRC procedure	←→	CRC procedure

CRC Cyclic redundancy check

Note – This power-feeding function is optional and, if implemented, uses a separate pair of wires in the interface cable.

FIGURE 2/I.431

Functional characteristics

B-channel

This function provides for the bidirectional transmission of independent B-channel signals each having a bit rate of 64 kbit/s as defined in Recommendation I.412.

H_0-channel

This function provides for the bidirectional transmission of independent H_0-channel signals each having a bit rate of 384 kbit/s as defined in Recommendation I.412.

H_1-channels

This function provides for the bidirectional transmission of an H_1-channel signal having a bit rate of 1536 (H_{11}) or 1920 (H_{12}) kbit/s as defined in Recommendation I.412.

D-channel

This function provides for the bidirectional transmission of one D-channel signal at a bit rate of 64 kbit/s as defined in Recommendation I.412.

Bit timing

This function provides bit (signal element) timing to enable the TE or NT to recover information from the aggregate bit stream.

Octet timing

This function provides 8 kHz timing towards TE or NT for the purpose of supporting an octet structure for voice coders and for other timing purposes as required.

Frame alignment

This function provides information to enable the TE or NT to recover the time-division multiplexed channels.

Power feeding

This function provides for the capability to transfer power across the interface towards the NT1.

Maintenance

This function provides information concerning operational or failure conditions of the interface. The network reference configuration for maintenance activities on primary rate subscriber access is given in Recommendation I.604.

CRC procedure

This function provides for the protection against false framing and may provide for error performance monitoring of the interface.

3.2 *Interchange circuits*

Two interchange circuits, one for each direction, are used for the transmission of digital signals. All the functions listed above, with the exception of power feeding and possibly maintenance, are combined into two composite digital signals, one for each direction of transmission.

If power feeding via the interface is provided, an additional interchange circuit is used for power feeding.

The two wires of the pairs carrying the digital signal may be reversed if symmetrical wiring is provided.

3.3 *Activation/deactivation*

The interfaces for the primary rate user-network interface will be active at all times. No activation/deactivation procedures will be applied at the interface. However, to indicate the layer 1 transport capability to layer 2, the same primitive set is used as defined in Recommendation I.430. This provides for a unique application of the layer 1/layer 2 interface The primitives PH-AR, MPH-DR, MPH-DI and MPH-II are not required for this application and, therefore, they are not used in this Recommendation.

3.4 *Operational functions*

In this section the term network is used to indicate either:

- NT1, LT and ET functional groups in case of an interface at the T reference point; or
- relevant parts of the NT2 functional group in case of an interface at the S reference point.

The term TE (or "user side") is used to indicate terminal terminating layer 1 aspects of TE1, TA and NT2 functional groups.

3.4.1 *Definition of signals at the interface*

Signals exchanged between the network and user sides under normal and fault conditions are listed in Table 1/I.431. Further information on these signals is given in § 4.7.3 and § 5.9.1.

TABLE 1/I.431

Signals between the network and user sides under normal and fault conditions

Name	List of the signals
Normal operational frame	Operational frame with: – active associated CRC bits – CRC error information (see Recommendation G.704) – no defect indication
RAI	Operational frame with: – active associated CRC bits – CRC error information (Note) – with remote alarm indication, see Table 4a/G.704 (2048 kbit/s systems only)
LOS	No received incoming signal (Loss of signal)
AIS	Continuous stream of ONEs (Recommendation M.20)
CRC error information	E bit according to Recommendation G.704, Table 4b, set to "ZERO" if CRC block is received with error (2048 kbit/s systems only)

AIS Alarm indication signal

CRC Cyclic redundancy check

LOS Loss of signal

RAI Remote alarm indication

Note – The 1544 kbit/s systems RAI and CRC-derived error performance information cannot be sent simultaneously. Failure conditions may be sectionalized across the interface by obtaining additional information by means that are for further study.

3.4.2 *Definitions of state tables at network and user sides*

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

For that purpose, two state tables are defined, one at the user side and one at the network side. States at the user side (F states) are defined in § 3.4.3 and states at the network side (G states) are defined in § 3.4.4. The state tables are defined in § 3.4.6.

Fault conditions FC1 to FC4 that could occur at the network side or between the network side and user side are defined in Figure 3/I.431. These fault conditions directly affect the F and G states. Information on these fault conditions are exchanged between the user and network sides in the form of signals defined in Table 1/I.431.

Note 1 – Only stable states needed for operation and maintenance of 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 CRC error information are not taken into account.

Note 2 – The user does not need to know where a failure is located in the network. The user must be informed on the availability and the continuity of the layer 1 service.

Note 3 – The user has all information relative to the CRC associated with each direction of its adjacent CRC section. The supervision of the quality of this section is the user's responsibility.

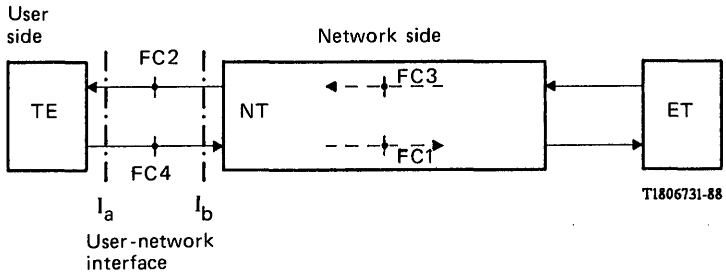


FIGURE 3/I.431

Location of fault conditions (FC) relative to interface

3.4.3 *Layer 1 states on the user side of the interface*

F0 state : Loss of power on the user side

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

F1 state : Operational state

– Network timing and layer 1 service is available.

– The user side transmits and receives operational frames with associated CRC bits and with temporary CRC error information (Note 1).

– The user side checks the received frames and the associated CRC bits, and transmits to the network side operational frames containing the CRC error information, if a CRC error is detected.

F2 state : Fault condition No. 1

– This fault state corresponds to the fault condition FC1.

– Network timing is available at the user side.

– The user side receives operational frames with associated CRC bits and with temporary CRC error information (Note 1).

– The received frames contain RAI.

– The user side transmits operational frames with associated CRC bits.

– The user side checks the received frames and the associated CRC bits and transmits to the network side operational frames containing the CRC error information, if a CRC error is detected.

F3 state : Fault condition No. 2

– This fault state corresponds to the fault condition FC2.

– Network timing is not available at the user side.

– The user side detects loss of incoming signal (this will involve loss of frame alignment).

– The user side transmits operational frames with associated CRC bits and RAI (Note 2).

F4 state : Fault condition No. 3

– This fault state corresponds to fault condition FC3.

– Network timing is not available at the user side.

– The user side detects AIS.

– The user side transmits to the network side operational frames with associated CRC bits and RAI (Note 2).

F5 state : Fault condition No. 4

- This fault state corresponds to the fault condition FC4.
- Network timing is available at the user side.
- The user side receives operational frames with continuous CRC error information (optional) (Note 3).
- The received frames contain RAI.
- The user side transmits operational frames with associated CRC bits.
- The user side checks the received frames and the associated CRC bits. It may transmit to the network side operational frames containing the CRC error information, if a CRC error is detected.

F6 state : Power on state

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

Note 1 – The interpretation of the CRC error information depends on the option used in the network (see § 5.9.2 and Recommendation I.604).

Note 2 – In 1544 kbit/s systems, RAI and CRC-derived error performance information cannot be sent simultaneously. Failure conditions may be sectionalized across the interface by obtaining additional information by means that are for further study.

Note 3 – Only in options 2 and 3 of Recommendation I.604, Annex A. The condition of "continuous CRC error information" corresponds to loss of incoming signal or loss of frame alignment on the network side.

3.4.4 *Layer 1 states at the network side of the interface*

G0 state : Loss of power in the NT1

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

G1 state : Operational state

- The network timing and layer 1 service is available.
- The network side transmits and receives operational frames with associated CRC bits and temporary CRC error information.
- The network side checks the received frames and the associated CRC bits and transmits to the user side the CRC error information if a CRC error is detected.

G2 state : Fault condition No. 1

- This fault state corresponds to the fault condition FC1.
- Network timing is provided to the user side.
- The network side receives operational frames with associated CRC bits.
- The network side transmits to the user side operational frames with associated CRC bits and RAI. The operational frames may contain CRC error information (Note 1).

G3 state : Fault condition No. 2

- This fault state corresponds to the fault condition FC2.
- Network timing is not provided to the user side.
- The network side transmits to the user side operational frames with associated CRC bits.
- The network side receives operational frames with associated CRC bits and RAI (Note 2).

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 network side transmits AIS.
- The network side receives operational frames with associated CRC bits and RAI (Note 2).

G5 state : Fault condition No. 4

- This fault states corresponds to the fault condition FC4.
- Network timing is provided to the user side.
- The network side detects loss of incoming signal or loss of frame alignment.
- The network side transmits to the user side operational frames with associated CRC bits and RAI and continuous CRC error information (Notes 2 and 3).

G6 state : Power on state

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

Note 1 – The interpretation of the CRC error information depends on the option used in the network (see § 5.9.2 and Recommendation I.604).

Note 2 – In 1544 kbit/s systems, RAI and CRC-derived error performance information cannot be sent simultaneously. Failure conditions may be sectionalized across the interface by obtaining additional information by means that are for further study.

Note 3 – Only in options 2 and 3 of Recommendation I.604, Annex A.

3.4.5 *Definition of primitive*

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

PH-AI	PH ACTIVATE INDICATION
PH-DI	PH DEACTIVATE INDICATION
MPH-AI	MPH ACTIVATE INDICATION (is used as error recovery and initialization information)
MPH-EIn	MPH ERROR INDICATION with parameter
n	Parameter which defines the failure condition relevant to the reported error

3.4.6 *State tables*

Operational functions are defined in Table 2/I.431 for the layer 1 states at the user side of the interface and in Table 3/I.431 for the network side. The exact reaction in case of double faults may depend on the type of double fault condition and the sequence in which they occur.

4 Interface at 1544 kbit/s

4.1 *Electrical characteristics*

4.1.1 *Bit rate*

The signal shall have a bit rate of 1544 kbit/s ± 50 parts per million (ppm).

4.1.2 *Interchange circuit support*

One symmetric metallic pair shall be used for each direction of transmission.

4.1.3 *Code*

The B8ZS code is recommended (see Note 1 under Table 4/I.431 for definition of B8ZS code).

4.1.4 *Specifications at the output ports*

4.1.4.1 *Test load*

Test load impedance shall be 100 ohms, resistive.

4.1.4.2 *Pulse mask*

An isolated pulse measured at interfaces I_a or I_b defined in Figure 1/I.431 shall have an amplitude between 2.4 and 3.6 volts measured at the centre of the pulse.

A possible normalized pulse mask is shown in Figure I-1/I.431. This pulse mask is for further study.

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

TABLE 2/I.431

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

	Initial state	F0	F1	F2 [b]	F3	F4	F5 [b]	F6
Definition of the states	Operational condition or failure condition	Power off at user side	Operational	FC1	FC2	FC3	FC4	Power on at user side
	Signal transmitted towards interface	No signal	Normal operational frames	Normal operational frames	Frames with RAI	Frames with RAI	Normal operational frames	No signal
New event, detected at the receiving side	Loss of TE power	/	PH-DI MPH-EI0 F0	MPH-EI0 F0	MPH-EI0 F0	MPH-EI0 F0	MPH-EI0 F0	MPH-EI0 F0
	Return of TE power	F6	/	/	/	/	/	/
	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	/
	Reception of RAI [a]	/	PH-DI MPH-EI1 F2	–	MPH-EI1 F2	MPH-EI1 F2	MPH-EI1 F2	MPH-EI1 F2
	Loss of signal or frame alignment	/	PH-DI MPH-EI2 F3	MPH-EI2 F3	–	MPH-EI2 F3	MPH-EI2 F3	MPH-EI2 F3
	Reception of AIS	/	PH-DI MPH-EI3 F4	MPH-EI3 F4	MPH-EI3 F4	–	MPH-EI3 F4	MPH-EI3 F4
	Reception of RAI and continuous CRC error report [a]	/	PH-DI MPH-EI4 F5	MPH-EI4 F5	MPH-EI4 F5	MPH-EI4 F5	–	MPH-EI4 F5

Single fault conditions

–	No state change
/	Impossible situation
PH-x MPH-y Fz	Issue primitive x Issue management primitive y Go to state Fz

PH-AI = PH ACTIVATE INDICATION

PH-DI = PH DEACTIVATE INDICATION

MPH-EIn = MPH ERROR INDICATION with parameter n (n = 0 to 4)

[a] This event covers different network options. The network options 2 and 3 (see Recommendation I.604) of the 2048 kbit/s system (which include CRC processing in the digital transmission link) provide CRC error information which allows the user-side equipment to localize a fault, indicated by means of RAI, to either:

i) the network side (FC1), if frames without continuous CRC error reports are received; or

ii) the user side (FC4), if frames with continuous CRC error reports are received.

If network options other than 2 and 3 of the 2048 kbit/s system apply, the faults FC1 and FC4 are indicated identically at the interface, therefore, the signal "RAI with continuous CRC error report" does not occur.

[b] This state covers two user options:

i) if a TE adopting the option to distinguish between F2 and F5 (given by options 2 and 3 of 2048 kbit/s interfaces only) is used, but the network does not provide the distinction (see Note 1), then signal "RAI with continuous CRC error report" will not occur and the TE always enters state F2 on receipt of RAI;

ii) the user option of not processing CRC error information when accompanied with RAI, even if provided, merges states F2 and F5.

TABLE 3/I.431

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

	Initial state	G0	G1	G2	G3	G4	G5 [a]	G6
Definition of the states	Operational condition or failure condition as seen from the interface	Power off at NT	Operational	FC1	FC2	FC3	FC4	Power on at NT
	Signal transmitted towards interface	No signal	Normal operational frames	RAI [b]	Normal operational frames	AIS	[b]	No signal
New event detected at the receiving side	Loss of NT power	/	MPH-EI0 PH-DI G0	MPH-EI0 G0	MPH-EI0 G0	MPH-EI0 G0	MPH-EI0 G0	MPH-EI0 G0
	Return NT power	G6	/	/	/	/	/	/
	Normal operational frames, no internal network failure	/	–	PH-AI MPH-AI G1	PH-AI MPH-AI G1	PH-AI MPH-AI G1	PH-AI MPH-AI G1	/
	Internal network failure FC1	/	PH-DI MPH-EI1 G2	–	MPH-EI1 [c] G2	MPH-EI1 [c] – G2	MPH-EI1 [c] – G2	MPH-EI1 G2
	Reception of RAI FC2	/	PH-DI MPH-EI2 G3	MPH-EI2 [c] – G3	–	MPH-EI2 [c] – G3	MPH-EI2 [c] – G3	MPH-EI2 G3
	Internal network failure FC3	/	PH-DI MPH-EI3 G4	MPH-EI3 [c] G4	MPH-EI3 [c] G4	–	MPH-EI3 [c] G4	MPH-EI3 G4
	Loss of operational frames FC4	/	PH-DI MPH-EI4 G5	MPH-EI4 [c] G5	MPH-EI4 [c] G5	MPH-EI4 [c] G5 G5	–	MPH-EI4 G5

Single fault conditions

–	No state change
/	Impossible situation
PH-x MPH-y Gz	Issue primitive x Issue management primitive y Go to state Gz

Double fault conditions

MPH-y [c] Gz	Second fault is dominant. Action to be taken when second fault occurs.
	The disappearance of the first fault is not visible at the interface since the second fault is dominant and the state has changed already to Gz.
MPH-y [c] –	First fault is dominant, therefore the state will not change when the second fault occurs but the error indication may be given to the management if possible.
Gz	Action to be taken when first (dominant) fault disappears.

PH-AI PH ACTIVATE INDICATION

PH-DI PH DEACTIVATE INDICATION

MPH-EIn MPH ERROR INDICATION with parameter n (n = 0 to 4)

[a] In the case of no CRC processing in the digital link, the state G5 is identical to state G2.

[b] In options 2 and 3 of the 2048 kbit/s systems, the RAI signal must contain CRC error information of the section between TE and NT which can be used by the user to localize faults FC1 and FC4. In option 1, the faults FC1 and FC4 are indicated identically at the interface (see § 5.9).

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

TABLE 4/I.431

Digital interface at 1544 kbit/s

Bit rate		1544 kbit/s
Pair(s) in each direction of transmission		One symmetric pair
Code		B8ZS (Note 1)
Test load impedance		100 ohms resistive
Nominal pulse shape		See pulse mask
Signal level (Note 2)	Power at 772 kHz	+12 dBm to +19 dBm
	Power at 1544 kHz	At least 25 dB below the power at 772 kHz

Note 1 – B8ZS is modified AMI code in which eight consecutive zeros are replaced with 000 + – 0 – + if the preceding pulse was positive (+) and with 000 – + 0 + – if the preceding pulse was negative (–).

Note 2 – The signal level is the power level measured in a 3 kHz bandwidth at the output port for an all 1s pattern transmitted.

4.1.4.3 *Voltage of zero*

The voltage within a time slot containing a zero (space) shall be no greater than either the value produced in that time slot by other pulses (marks) within the mask of Figure I-1/I.431 or ± 5% of the zero-to-peak pulse (mark) amplitude, whichever is greater in magnitude.

4.1.5 *Specifications at the input ports*

The digital signal presented at the input port shall be as defined above but modified by the characteristic of the interconnecting pair. The attenuation of this pair shall be assumed to follow $\sqrt{f}$ law and the loss at a frequency of 772 kHz shall be in the range 0 to 6 dB.

4.2 *Frame structure*

4.2.1 The frame structure is based on Recommendation G.704, §§ 3.1.1 and 3.1.2 and is shown in Figure 4/I.431.

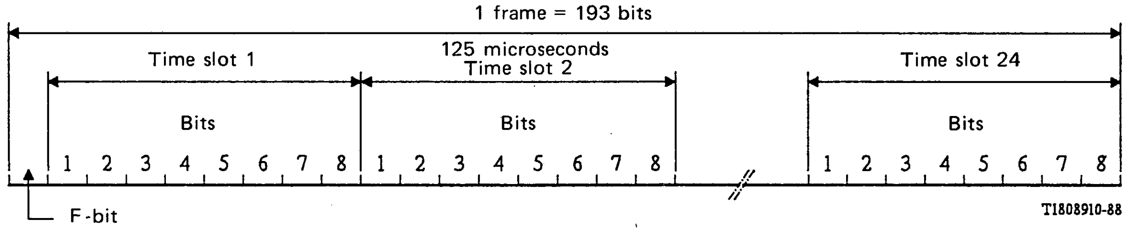


FIGURE 4/I.431

Frame structure of 1544 kbit/s interface

4.2.2 Each frame is 193 bits long and consists of an F-bit followed by 24 consecutive time slots, numbered 1 to 24.

4.2.3 Each time slot consists of eight consecutive bits, numbered 1 to 8.

4.2.4 The frame repetition rate is 8000 frame/s.

4.2.5 The multi-frame structure is shown in Table 5/I.431. Each multi-frame is 24 frames long and is defined by the multi-frame alignment signal (FAS) which is formed by every fourth F-bit and has the binary pattern (.... 001011...).

4.2.6 The bits e_1 to e_6 in Table 5/I.431 are used for error checking, as described in § 2.1.3.1.2 of Recommendation G.704. A valid error check by the receiver is an indication of transmission quality and of the absence of false frame alignment (see § 4.6.3 of this Recommendation).

TABLE 5/I.431

Multi-frame structure

Multi-frame frame number	F-Bits			
	Multi-frame bit number	Assignments		
		FAS	See Note	See § 4.2.6
1	1	–	m	n
2	194	–	–	e_1
3	387	–	m	–
4	580	0	–	–
5	773	–	m	–
6	966	–	–	e_2
7	1159	–	m	–
8	1352	0	–	–
9	1545	–	m	–
10	1738	–	–	e_3
11	1931	–	m	–
12	2124	1	–	–
13	2317	–	m	–
14	2510	–	–	e_4
15	2703	–	m	–
16	2896	0	–	–
17	3089	–	m	–
18	3282	–	–	e_5
19	3475	–	m	–
20	3668	1	–	–
21	3861	–	m	–
22	4054	–	–	e_6
23	4247	–	m	–
24	4440	1	–	–

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

4.3 *Timing considerations*

This section describes the hierarchical synchronization method selected for synchronizing ISDNs. It is based upon consideration of satisfactory customer service, ease of maintenance, administration and minimizing cost.

The NT derives its timing from the network clock. The TE synchronizes its timing (bit, octet, framing) from the signal received from the NT and synchronizes accordingly its transmitted signal.

4.4 *Time slot assignment*

4.4.1 *D-channel*

Time slot 24 is assigned to the D-channel when this channel is present.

4.4.2 *B- channel and H-channels*

A channel occupies an integer number of time slots and the same time slot positions in every frame. A B-channel may be assigned any time slot in the frame, an H_0-channel may be assigned any six slots in the frame, in numerical order (not necessarily consecutive), and an H_{11}-channel may be assigned slots 1 to 24 in a frame. The assignment may vary on a call by call basis (see Note). Mechanisms for the assignment of these slots for a call are specified in Recommendation I.451.

Note – For an interim period, a fixed time slot allocation to form channels may be required. An example of a fixed assignment of slots for the case where only H_0-channels are present at the interface is given in Annex A.

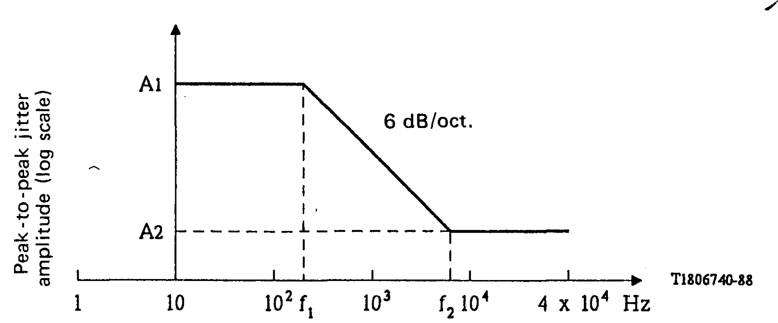
4.5 *Jitter*

4.5.1 *Timing jitter*

Timing jitter is specified as follows:

4.5.1.1 *Tolerable jitter at TE input*

A TE shall tolerate a sinusoidal input jitter according to the amplitude-frequency characteristic of Figure 5/I.431 without producing bit errors or losing frame alignment.



A_1 = 5.0 UI
A_2 = 0.1 UI
f_1 = 120 Hz
f_2 = 6 kHz
UI = Unit interval (648 ns)

FIGURE 5/I.431

Tolerable TE input jitter characteristic

4.5.1.2 *TE output jitter*

With no jitter on the TE input signal that provides timing, jitter at the TE output shall not exceed the following two limitations simultaneously:

i) Band 1 (10 Hz-40 kHz) : 0.5 UI (Unit Interval) peak-to-peak

ii) Band 2 (8 kHz-40 kHz) : 0.07 UI peak-to-peak.

4.5.2 *Wander*

Wander is specified for frequencies below 10 Hz.

4.5.2.1 *Signal from the network side*

Wander shall not exceed 5 UI peak-to-peak in any 15 minute interval and shall not exceed 28 UI peak-to-peak within a period of 24 hours.

4.5.2.2 *Signal from the user side*

Wander shall not exceed 5 UI peak-to-peak in any 15 minute interval and shall not exceed 28 UI peak-to-peak within a period of 24 hours.

4.6 *Interface procedures*

4.6.1 *Codes for idle channels and idle slots*

A pattern including at least three binary ONEs in an octet must be transmitted in every time slot that is not assigned to a channel (e.g. time slots awaiting channel assignment on a per-call basis, residual slots on an interface that is not fully provisioned, etc.), and in every time slot of a channel that is not allocated to a call in both directions.

4.6.2 *Interframe (layer 2) time fill*

Contiguous HDLC flags shall be transmitted on the D-channel when its layer 2 has no frames to send.

4.6.3 *Frame alignment and CRC-6 procedure*

The frame alignment and CRC-6 procedures shall be in accordance with Recommendation G.706, § 2.

4.7 *Maintenance*

4.7.1 *General introduction*

Recommendation I.604 specifies an overall approach to be employed in maintaining ISDN primary rate access. However, since the required maintenance functions may influence the design of terminating pieces of equipment, a brief description of primary rate access maintenance is presented in this Recommendation.

4.7.2 *Maintenance functions*

The interface divides maintenance responsibility between network and user sides.

Specified maintenance functions are as follows:

a) Supervision of layer 1 capability and reporting across the interface, which includes, on the user side, reporting loss of incoming signal or loss of frame alignment from the network side.

   On the network side, reporting loss of layer 1 capability and the incoming signal or frame alignment from the user side, are included.

b) CRC performance monitoring and reporting across the interface (this function is specified in § 4.7.4.).

c) Other maintenance functions are for further study.

4.7.3 *Definition of maintenance signals at the interface*

The RAI (Remote Alarm Indication) signal indicates loss of layer 1 capability at the user-network interface. RAI propagates towards the network if layer 1 capability is lost in the direction of the user, and RAI propagates toward the user if layer 1 capability is lost in the direction of the network. RAI is coded as continuously repeated 16-bit sequences of eight binary ONEs and eight binary ZEROs (1111111100000000) in the m bit. [*Note* – HDLC flag patterns (01111110) are transmitted in the m bits when no information signal is to be sent.]

The AIS (Alarm Indication Signal) is used to indicate loss of layer 1 capability in the ET-to-TE direction on the network side of the user-network interface. A characteristic of AIS is that its presence indicates that the timing provided to the TE may not be the network clock. AIS is coded as a binary all ONEs, 1544 kbit/s bit stream.

In leased line circuit applications with no D-channel, some channel-associated layer maintenance messages may need to be transferred across the interface. These maintenance messages would be transported in the m bit. Further characteristics of these messages are for further study.

4.7.4 *CRC-6 in-service performance monitoring and reporting*

Messages in the m bit that exercise CRC-6 performance monitoring capabilities can be used to sectionalize troubles in the primary rate access. This sectionalization could be accomplished from either the NT or the TE. Characteristics of these maintenance messages are for further study.

5 Interface at 2048 kbit/s

5.1 *Electrical characteristics*

This interface should conform to Recommendation G.703, § 6, which recommends the basic electrical characteristics.

Note – The use of the unbalanced 75 ohm (coaxial) interface is required by some Administrations in the short-term. However, the balanced 120 ohm (symmetric pair) interface is preferred for the ISDN primary rate application.

5.2 *Frame structure*

5.2.1 *Number of bits per time slot*

Eight, numbered from 1 to 8.

5.2.2 *Number of time slots per frame*

Thirty-two, numbered from 0 to 31. The number of bits per frame is 256 and the frame repetition rate is 8000 frame/s.

5.2.3 *Assignment of bits in time slot 0*

The bits of time slot 0 are in accordance with Recommendation G.704, § 2.3.2. The E bits are assigned to the CRC error information procedures.

S_a bits with bit position 4 and 8 are reserved for international standardization and shall be ignored by the TE for the time being. S_a bits with position 5, 6, 7: are reserved for national use. The terminals not making use of these bits shall ignore any received pattern.

5.2.4 *Time slot assignment*

5.2.4.1 *Frame alignment signal*

Time slot 0 provides for frame alignment in accordance with § 5.2.3.

5.2.4.2 *D-channel*

Time slot 16 is assigned to the D-channel when this channel is present. The assignment of time slot 16 when not used for a D-channel is for further study.

5.2.4.3 *B-channel and H-channels*

A channel occupies an integer number of time slots and the same time slot positions in every frame.

A B-channel may be assigned any time slot in the frame and an H_0-channel may be assigned any six slots, in numerical order, not necessarily consecutive (Note 1).

The assignment may vary on a call-by-call basis (Note 2). Mechanisms for the assignment of these slots for a call are specified in Recommendation I.451.

An H_{12}-channel shall be assigned time slots 1 to 15 and 17 to 31 in a frame and an H_{11}-channel may be assigned time slots as in the example given in Annex B.

Note 1 – In any case, time slot 16 should be kept free for D-channel utilization.

Note 2 – For an interim period, a fixed time slot allocation to form channels may be required. Examples of a fixed assignment of slots for the case where only H_0-channels are present at the interface are given in Annex A.

5.2.4.4 *Bit sequence independence*

Time slots 1 to 31 provide bit sequence independent transmission.

5.3 *Timing considerations*

The NT derives its timing from the network clock. The TE synchronizes its timing (bit, octet, framing) from the signal received from the NT and synchronizes accordingly the transmitted signal.

In an unsynchronized condition (e.g. when the access that normally provides network timing is unavailable) the frequency deviation of the free-running clock shall not exceed ± 50 ppm.

5.4 *Jitter*

5.4.1 *General considerations*

The jitter specifications take into account subscriber configurations with only one access and configurations with multiple accesses.

In the case of one access only, this may be to a network with transmission systems of either high Q or low Q clock recovery circuits.

In the case of multiple accesses, all access transmission systems may be of the same kind (either low Q or high Q clock recovery circuits) or they may be of different kinds (some with high Q and some with low Q clock recovery circuit).

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

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

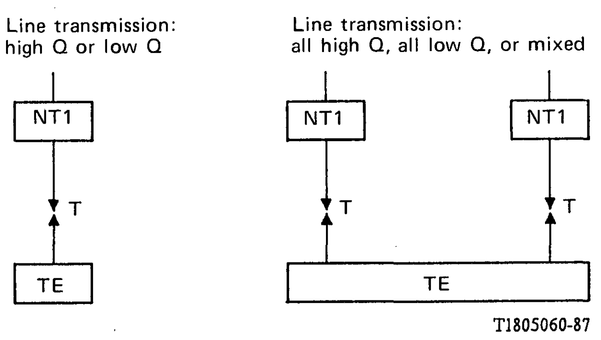
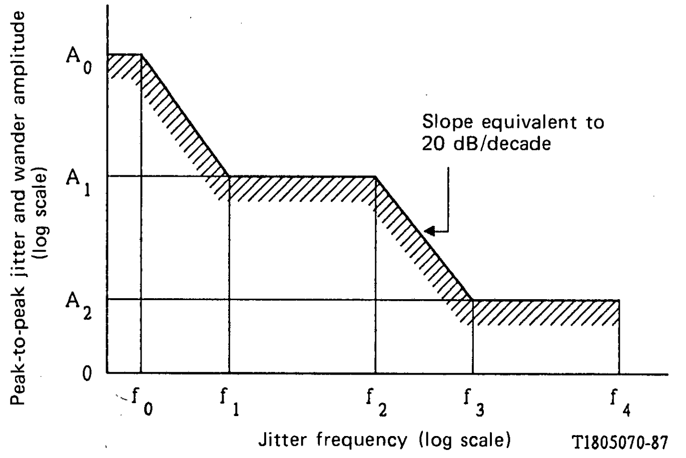


FIGURE 6/I.431

Examples of single and multiple accesses

5.4.2 *Minimum tolerance to jitter and wander at TE inputs*

The 2048 kbit/s inputs of a TE shall tolerate sinusoidal input jitter/wander in accordance with Figure 7/I.431 without producing bit errors or losing frame alignment.



A_0	A_1	A_2	f_0	f_1	f_2	f_3	f_4
20.5 UI (Note 1)	1.0 UI (Note 2)	0.2 UI	12×10^{-6} Hz	20 Hz	3.6 kHz	18 kHz	100 kHz

Note 1 – A_0 represents Maximum Relative Time Interval Error (MRTIE) as defined in Recommendation G.812, i.e. a phase difference between the synchronizing input and the input being considered.

Note 2 – With TEs for multiple access (e.g. when an access is connected to a long leased circuit leading to a distant PABX), a jitter tolerance of 1.5 UI (with a corresponding f_2 at 2.4 kHz) may be required.

FIGURE 7/I.431

Minimum tolerable jitter and wander at the TE input

5.4.3 *TE and NT2 output jitter*

Two cases must be considered:

5.4.3.1 *TE and NT2 with only one user-network interface*

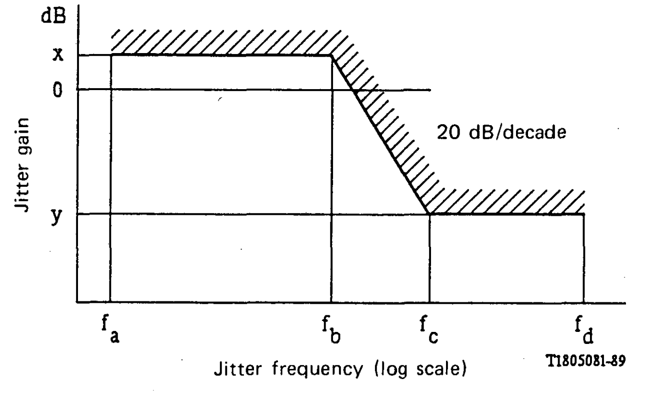
a) With no jitter at the input supplying timing or in the free-running mode, the TE output jitter shall be in accordance with Table 6/I.431.

b) With jitter present at the input supplying timing, the output jitter is the sum of the intrinsic jitter of the TE plus the input jitter multiplied by the jitter transfer characteristics.

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

TABLE 6/I.431

Measurement filter bandwidth		Output jitter: (UI peak-to-peak)
Lower cutoff	Upper cutoff	
20 Hz	100 kHz	⩽ 0.125
700 Hz	100 Hz	⩽ 0.12



Y	X	f_a	f_b	f_c	f_d
−19.5 dB	0.5 dB	10 Hz	40 Hz	400 Hz	100 kHz

FIGURE 8/I.431

Jitter transfer characteristics

5.4.3.2 *TE with more than one user-network interface to the same network*

a) With no jitter at the input (or inputs) supplying timing or in the free running mode see § 5.4.3.1 a).

b) In the multiple access case the output jitter depends on:

- the input jitter of each access;
- the transfer characteristic;
- the timing extraction and distribution concept;

– the future growth of the TE. Since the timing extraction and distribution concept of the TE is outside of the scope of this Recommendation, the output jitter at each individual individual access can be controlled only by the definition of the appropriate jitter transfer characteristic in the TE.

In order to restrict the output jitter to tolerable values and to simplify testing, the jitter transfer characteristic between any receiver and its associated transmitter shall be tested to the transfer characteristic given in Figure 8/I.431 and the following parameters:

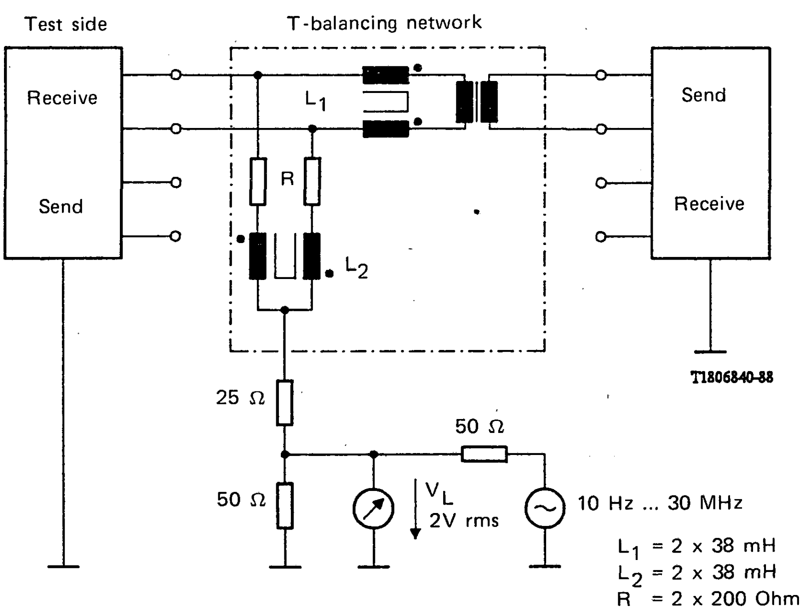
Y	X	f_a	f_b	f_c	f_d
– 19.8 dB	0.2 dB	not to be defined	0.1 Hz	1 Hz	100 Hz

5.5 *Tolerable longitudinal voltage*

For minimum tolerance to longitudinal voltage at input ports, the receiver shall operate without errors with any valid input signal in the presence of a longitudinal voltage V_L.

V_L = 2 Vrms over the frequency range 10 Hz to 30 MHz.

The test configuration is given in Figure 9/I.431.



Note – The inherent longitudinal conversion loss of the T-balancing network should be 20 dB better than required at the interface under test (see Recommendation O.121).

FIGURE 9/I.431

Test of tolerance to longitudinal voltage

5.6 *Output signal balance*

Output signal balance, which is measured in accordance with Recommendation O.9, § 2.7, shall meet the following requirements:

a) $f = 1$ MHz: $\geqslant 40$ dB

b) 1 MHz $< f \leqslant 30$ MHz: minimum value decreasing from 40 dB at 20 dB/decade.

5.7 *Impedance towards ground*

The impedance towards ground of both the receiver input and the transmitter output shall meet the following requirements:

$$10 \text{ Hz} < f \leqslant 1 \text{ MHz}: > 1000 \text{ ohm}$$

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

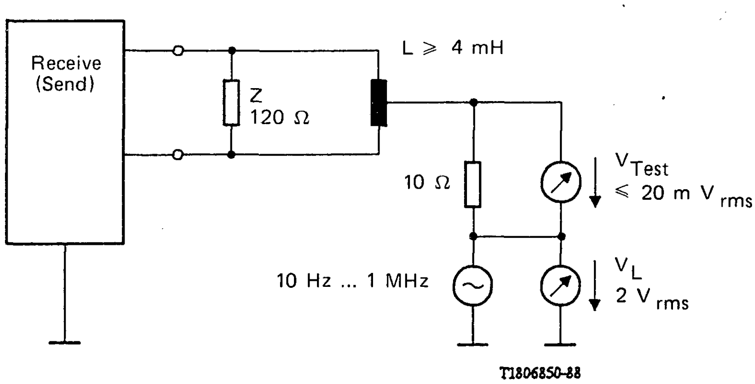


FIGURE 10/I.431

Test of minimum impedance towards ground

5.8 *Interface procedures*

5.8.1 *Codes for idle channels and idle slots*

A pattern including at least three binary ONEs in an octet must be transmitted in every time slot that is not assigned to a channel (e.g. time slots awaiting channel assignment on a per-call basis, residual slots on an interface that is not fully provisioned, etc.), and in every time slot of a channel that is not allocated to a call in both directions.

5.8.2 *Interframe (layer 2) time fill*

Contiguous HDLC flags will be transmitted on the D-channel when its layer 2 has no frames to send.

5.8.3 *Frame alignment and CRC-4 procedures*

The frame alignment and CRC procedures shall be in accordance with Recommendation G.706, § 4.

5.9 *Maintenance at the interface*

The network reference configuration for the maintenance activities on primary rate subscriber access is given in Recommendation I.604.

The associated maintenance procedure, which is described there, needs a continuous supervision procedure on layer 1 for the automatic fault detection, automatic failure confirmation and information.

Note – The terms *anomaly, defect, fault* and *failure* are defined in Recommendation M.20.

5.9.1 *Definitions of maintenance signals*

The RAI (Remote Alarm Indication) signal indicates loss of layer 1 capability at the user-network interface. RAI propagates towards the network if layer 1 capability is lost in the direction of the user, and RAI propagates toward the user if layer 1 capability is lost in the direction of the network. RAI is coded in bit A, i.e. bit 3 of time slot 0 of the operational frame which does not contain the frame alignment signal (see Table 4b/G.704):

RAI present: A-bit set to 1

RAI not present: A-bit set to 0.

The AIS (Alarm Indication Signal) is used to indicate loss of layer 1 capability in the ET-to-TE direction on the network side of the user-network interface. A characteristic of AIS is that its presence indicates that the timing provided to the TE may not be the network clock. AIS is coded as a binary all ONEs, 2048 kbit/s bit stream.

CRC error report: E bit (see Table 4b/G.704) in operational frames.

5.9.2 *Use of CRC procedure*

5.9.2.1 *Introduction*

At the user-network interface the CRC procedure according to Recommendations G.704 and G.706 is applied to gain security in frame alignment and detect block errors. The CRC error information uses the E bits as defined in Table 4b/G.704. The coding is E = "0" for a block with failure and E = "1" for a block without failure. With respect to CRC error information to the other side of the interface and processing of this information, two different options exist, one has CRC processing in the transmission link and the other not.

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

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

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

iii) that the user side shall monitor the CRC bits associated with the received frames (CRC codes calculation and comparison with received CRC codes);

iv) that the user side shall detect the CRC blocks received with error;

v) that the user side shall generate the CRC error information according to the CRC procedure;

vi) that the network side shall monitor the CRC bits associated with the received frames;

vii) that the network side shall detect the CRC blocks received with error;

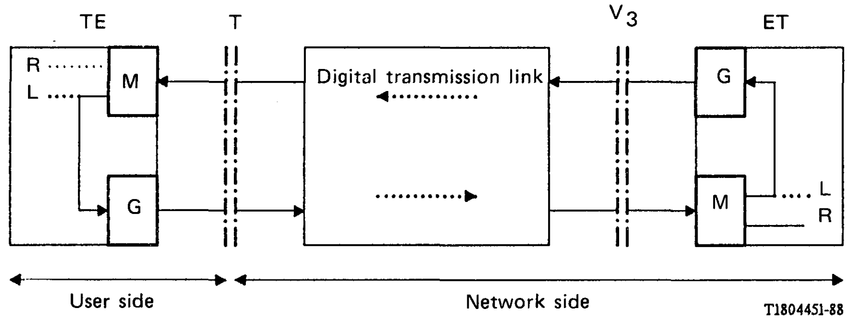
viii) that the network side shall generate the CRC error information according to the CRC procedure;

ix) that the network side shall detect the CRC error information and process all the received information in accordance with Recommendation I.604.

5.9.2.2 *Localization of the CRC functions in the subscriber access from the user point of view*

5.9.2.2.1 *No CRC processing in the transmission link*

Figure 11/I.431 gives the locations of the CRC function processes in a subscriber access when there is no CRC processing in the transmission link.



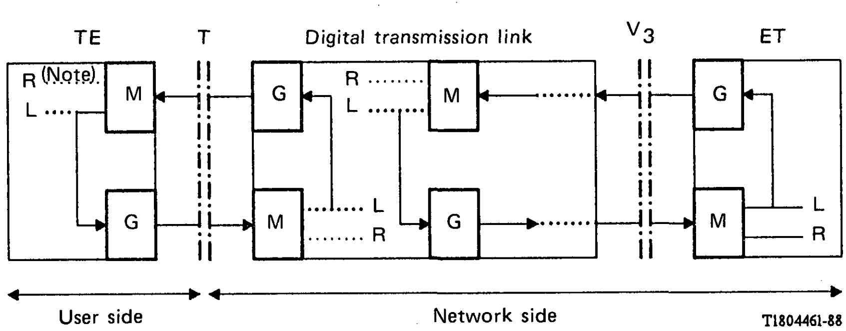
G = CRC generator
M = CRC monitor
— = Mandatory
... = Optional
L = Local "CRC error" information
R = Remote "CRC error" information

FIGURE 11/I.431

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

5.9.2.2.2 *CRC processing in the digital transmission link*

Figure 12/I.431 gives the locations of CRC function processes in a subscriber access, with CRC processing in the NT.



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

Note — The processing of remote CRC error information provides enhanced defect localization from the user point of view.

FIGURE 12/I.431

Localization of CRC processing function for a subscriber access with CRC processing in the digital transmission link

5.9.3 *Maintenance functions*

5.9.3.1 *General requirements*

The equipments located on the user side and on the network side of the interface shall:

- detect the anomalies;
- detect the defects;
- take actions for reporting the detected anomalies and defects (defect indication signals AIS, RAI);
- detect the received defect indication signals.

5.9.3.2 *Maintenance functions on the user side*

5.9.3.2.1 *Anomalies and defect detection*

The user side shall detect the following defects or anomalies:

- loss of power on the user side;
- loss of incoming signal at interface (see Note);
- loss of frame alignment (see Recommendation G.706);
- CRC error.

Note – The detection of this defect is required only when it has not the effect of a loss of frame alignment indication.

5.9.3.2.2 *Detection of defect indication signals*

The following defect indications received at interface shall be detected by the user side:

- remote alarm indication (RAI) (Note);
- alarm indication signal (AIS).

Note – The RAI signal is used to indicate loss of layer 1 capability. It may be used to indicate:

- loss of signal or loss of framing;
- excessive CRC errors (optional);
- loopbacks applied in the network.

The conditions of excessive CRC errors are outside the scope of this Recommendation.

5.9.3.2.3 *Consequent actions*

Table 7/I.431 gives the actions that the user side (TE function) has to take after the detection of a defect or of a defect indication signal.

Note 1 – When the defect conditions have disappeared or when the defect indication signals are no longer received, the defect indications AIS and RAI must disappear as soon as possible.

Note 2 – The following points are required to ensure that an equipment is not removed from service due to short breaks in transmission:

i) The persistence of an RAI or of an AIS shall be verified for at least 100 ms before action is taken;
ii) When an RAI or an AIS disappears, action shall be taken immediately.

5.9.3.3 *Maintenance functions on the network side*

5.9.3.3.1 *Defect detection*

All the following defect conditions shall be detected by the network side of the T interface (NT1, LT, ET functions) (see Note 2):

- loss of power on the network side;
- loss of incoming signal;
- loss of frame alignment (see Recommendation G.706);
- CRC error.

Note 1 – The equipment of the primary rate digital link (NT1, LT, etc.) have to detect loss of incoming signal and then to generate downstream towards the interface the fault indication signal AIS.

Note 2 – Some equipment in the network may detect only part of the defects or fault conditions listed above.

TABLE 7/I.431

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

Defect conditions and defect indication signals detected by the user side	Consequent actions	
	Defect indications at the interface	
	Generation of RAI	Generation of CRC error information (see Note 4)
Loss of power on user side	Not applicable	Not applicable
Loss of signal	Yes	Yes (Note 1)
Loss of frame alignment	Yes	No (Note 2)
Reception of RAI	No	No
Reception of AIS	Yes	No (Note 3)
Detection by NT2 of CRC errors	No	Yes

Note 1 – Only when loss of frame alignment has not yet occurred.

Note 2 – The loss of frame alignment inhibits the process associated with the CRC procedure.

Note 3 – The AIS signal is detected only after the fault "loss of frame alignment", thus the process associated with the CRC procedure is inhibited.

Note 4 – If CRC errors are detected in frames carrying the RAI signal, then CRC error reports should be generated.

5.9.3.3.2 *Detection of defect indication signals*

The following defect indications received at interface shall be detected by the network side:

– remote alarm indication (RAI);
– CRC error information.

5.9.3.3.3 *Consequent actions*

Table 8/I.431 gives the actions that the network side (NT1, ET functions) has to take after defect detection or defect indication detection.

Note 1 – When the defect conditions have disappeared or the defect indication signals are no longer received, the defect indication signals AIS and RAI should disappear as soon as possible.

Note 2 – The following points are required to ensure that an equipment is not removed from service due to short breaks in transmission:

i) the persistence of an RAI or of an AIS shall be verified for at least 100 ms before action is taken;

ii) when an RAI or an AIS disappears, action shall be taken immediately.

TABLE 8/I.431

Defect conditions and defect indication signals detected by the network side of interface, and consequent actions

Defect conditions and defect signal indications detected by network side	Consequent actions		
	Defect indications at interface		
	Generation of RAI	Generation of AIS	Generation of CRC error information
Loss of power on network side	Not applicable	Yes, if possible	Not applicable
Loss of signal	Yes	No	Yes (Note 1)
Loss of frame alignment	Yes	No	Option 1: No Option 2: Yes (Note 3)
Detection of defect in the network-to-user direction	No	Yes	No
Reception of RAI	No	No	No (Note 2)
Detection of defect in the user-to-network direction up to ET	Yes	No	No
Detection of CRC errors	No	No	Yes
Reception of CRC error information	No	No	No
Excessive CRC error ratio	Yes (Optional)	No	Not applicable

Note 1 – Only when loss of frame alignment has not yet occurred.

Note 2 – If CRC errors are detected in frames carrying the RAI signal, then CRC error reports shall be generated.

Note 3 – See CCITT Recommandation I.604.

6 Connector

Interface connectors and contact assignments are the subject of ISO and IEC standards. However, permanent wiring connections of TEs to NTs are also permitted.

7 Interface wiring

In case of symmetrical wiring, the magnitude of the characteristic impedance of the interface cables shall be 120 ohm ± 20% in a frequency range 200 kHz to 1 MHz and 120 ohm ± 10% at 1 MHz.

For coaxial interfaces, the magnitude of the characteristic impedance of the interface cables shall be 75 ohm (± 5% at 1024 kHz).

8 Power feeding

8.1 *Provision of power*

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

8.2 *Power available at the NT*

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

8.3 *Feeding voltage*

The feeding voltage for the NT shall be in the range of −32 to −57 volts.

The polarity of the voltage towards ground shall be negative.

8.4 *Safety requirements*

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

i) the voltage source and the feeding interface should be protected against short circuit or overload. The specific requirements are for further study;

ii) the power input of NT1 shall not be damaged by an interchange of wires.

With respect to the feeding interface of the power source, which is regarded as a touchable part in the sense of IEC Publication 950, the protection methods against electric shock specified in IEC Publication 950 may be applied.

ANNEX A

(to Recommendation I.431)

Time slot assignment for interfaces having only H_0-channels

The following are examples of fixed assignment of time slots when only H_0-channels are present at the interface.

A.1 *1544 kbit/s interface*

H_0-channel	a	b	c	d
Time slots used	1 to 6	7 to 12	13 to 18	19 to 24 [a)]

[a)] This fourth H_0-channel is available if time slot 24 is not used for a D-channel.

A.2 *2048 kbit/s interface*

Example 1

H_0-channel	a	b	c	d	e
Time slots used	1-2-3 17-18-19	4-5-6 20-21-22	7-8-9 23-24-25	10-11-12 26-27-28	13-14-15 29-30-31

Example 2

H_0-channel	a	b	c	d	e
Time slots used	1-2-3 4-5-6	7-8-9 10-11-12	13-14-15 17-18-19	20-21-22 23-24-25	26-27-28 29-30-31

Note – The time slot assignment in Example 2 is the one described in Recommendation G.704 for $n \times 64$ kbit/s interface with $n = 6$ and fixed first time slot allocation. It is therefore the preferred assignment.

ANNEX B

(to Recommendation I.431)

Time slot assignment for 2048 kbit/s interfaces having an H_{11}-channel

The following is an example of fixed assignment of times slots when an H_{11}-channel is present at the interface.

H_{11}-channel	1-15	16-24
Time slots used	1-15	17-25

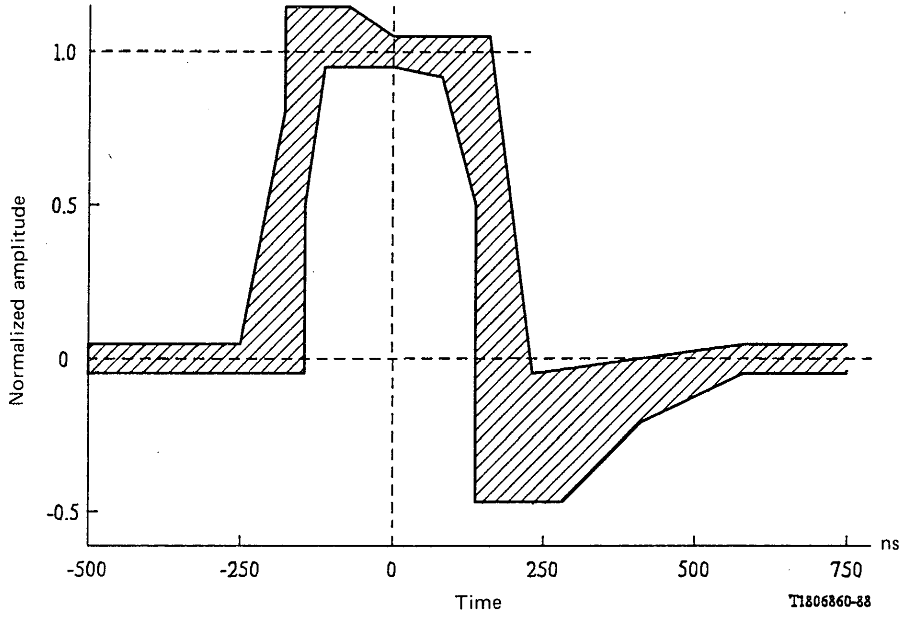
Note – Time slot 16 is to be assigned to the D-channel, when this channel is present. Time slots 26 to 31 may be used for an H_0-channel or six B-channels.

APPENDIX I

(to Recommendation I.431)

Pulse mask for interface at 1544 kbit/s

An isolated pulse, when scaled by a constant factor, shall fit the pulse mask shown in Figure I-1/I.431.



Corner points for upper curve

Time											
	ns	−500	−250	−175	−175	−75	0,0	175	225	600	750
	UI	−0.77	−0.39	−0.27	−0.27	−0.12	0.0	0.27	0.35	0.93	1.16
Amplitude		0.05	0.05	0.80	1.15	1.15	1.05	1.05	−0.07	0.05	0.05

Corner points for lower curve

Time													
	ns	−500	−150	−150	−100	0.0	0.15	150	150	300	425	600	750
	UI	−0.77	−0.23	−0.23	−0.15	0.0	100	0.23	0.23	0.46	0.66	0.93	1.16
Amplitude		−0.05	−0.05	0.50	0.95	0.95	0.90	0.50	−0.45	−0.45	−0.20	−0.05	−0.05

Note – UI = Unit Interval = 647.7 ns.

FIGURE I-1/I.431

Pulse mask for interface at 1544 kbit/s

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SECTION 4

ISDN USER-NETWORK INTERFACES: LAYER 2 RECOMMENDATIONS

Recommendation I.440

ISDN USER-NETWORK INTERFACE DATA LINK LAYER – GENERAL ASPECTS

(Malaga-Torremolinos, 1984; amended at Melbourne, 1988)

See Recommendation Q.920, Volume VI, Fascicle VI.10.

Recommendation I.441

ISDN USER-NETWORK INTERFACE, DATA LINK LAYER SPECIFICATION

(Malaga-Torremolinos, 1984; amended at Melbourne, 1988)

See Recommendation Q.921, Volume VI, Fascicle VI.10.

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SECTION 5

ISDN USER-NETWORK INTERFACES: LAYER 3 RECOMMENDATIONS

Recommendation I.450

ISDN USER-NETWORK INTERFACE LAYER 3 – GENERAL ASPECTS

(Malaga-Torremolinos, 1984; amended at Melbourne, 1988)

See Recommendation Q.930, Volume VI, Fascicle VI.11.

Recommendation I.451

ISDN USER-NETWORK INTERFACE LAYER 3 SPECIFICATION FOR BASIC CALL CONTROL

(Malaga-Torremolinos, 1984; amended at Melbourne, 1988)

See Recommendation Q.931, Volume VI, Fascicle VI.11.

Recommendation I.452

GENERIC PROCEDURES FOR THE CONTROL OF ISDN SUPPLEMENTARY SERVICES

(Melbourne, 1988)

See Recommendation Q.932, Volume VI, Fascicle VI.11.

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SECTION 6

MULTIPLEXING, RATE ADAPTION AND SUPPORT OF EXISTING INTERFACES

Recommendation I.460

MULTIPLEXING, RATE ADAPTION AND SUPPORT OF EXISTING INTERFACES

(Malaga-Torremolinos, 1984; amended at Melbourne, 1988)

This Recommendation describes procedures to be used to:

a) adapt the rate of one stream, of rate lower than 64 kbit/s, into a 64 kbit/s B-channel;

b) multiplex several streams, of rates lower than 64 kbit/s, into a 64 kbit/s B-channel.

The rates lower than 64 kbit/s are of two types:

1) binary rates of 8, 16 and 32 kbit/s; and

2) other rates including those associated with DTEs conforming to the X and V series Recommendations.

The detailed procedures for support of X-Series circuit mode DTEs, X-Series packet mode DTEs, and V-Series DTEs are given in Recommendations I.461 (X.30), I.462 (X.31), I.463 (V.110) and I.465 (V.120), respectively.

Rate adaption, multiplexing and support of existing interfaces for restricted 64 kbit/s transfer capability is covered in Recommendation I.464.

1 Rate adaption to a 64 kbit/s channel

1.1 *Rate adaption of 8, 16 and 32 kbit/s streams*

The procedure in this section will be used to adapt the rate of a *single* stream at 8, 16 or 32 kbit/s into a 64 kbit/s B-channel. In this Recommendation, bit positions in the B-channel octet are assumed to be numbered from 1 to 8 with bit position 1 being the first transmitted.

The procedure requires that:

i) the 8 kbit/s stream occupies bit position 1;
the 16 kbit/s stream occupies bit positions (1, 2);
the 32 kbit/s stream occupies bit positions (1, 2, 3, 4);

ii) the order of transmission of the bits of the subrate stream is identical before and after rate adaption; and

iii) all unused bit positions be set to binary "1".

1.2 *Rate adaption of streams other than 8, 16 and 32 kbit/s*

Information streams at bit rates less than 64 kbit/s need to be rate adapted to be carried on the B-channel. The approaches in this section are for adapting *single* information streams.

1.2.1 The rate adaption of bit rates up to 32 kbit/s uses a multi-stage approach. One stage is described in Recommendations I.461 (X.30), I.462 (X.31), I.463 (V.110). For example, user rates of 4.8 kbit/s and below are mapped to 8 kbit/s, 9.6 kbit/s is mapped to 16 kbit/s, and 19.2 kbit/s is mapped to 32 kbit/s.

Another stage of rate adaption is from 8 kbit/s, 16 kbit/s, or 32 kbit/s to 64 kbit/s and is described in § 1.1.

A third stage for asynchronous data is described in Recommendation I.463 (V.110).

1.2.2 Rate adaption of bit rates higher than 32 kbit/s uses a single stage approach as described in Recommendations I.461 (X.30) and I.463 (V.110). That is, 48 kbit/s and 56 kbit/s rates are adapted to 64 kbit/s in one stage.

1.2.3 Rate adaption for packet mode operation may be performed in two ways as described in Recommendation I.462 (X.31):

a) the preferred method: in using HDLC flag stuffing between HDLC frames; or

b) using the two stage approach.

1.2.4 Rate adaption of bit rates up to 48 kbit/s on a B-channel may be performed by insertion of HDLC frames as described in Recommendation I.465 (V.120).

2 Multiplexing into a 64 kbit/s channel

2.1 *Time division multiplexing of 8, 16 and 32 kbit/s*

Multiplexing of 8, 16 and 32 kbit/s streams is done by interleaving the subrate streams within each B-channel octet.

Using the procedures described in § 2.1.2, any number of 8, 16 and 32 kbit/s streams may be combined up to the limit of 64 kbit/s aggregate bit-rate in one B-channel.

Using the procedure described in § 2.1.1 can lead to situations where the full 64 kbit/s capacity cannot be utilized; however, this will not occur if the mixture of substreams is known in advance. The procedures in § 2.1.2 are recommended when the mixture will change during the duration of the 64 kbit/s connection.

2.1.1 *Fixed format multiplexing*

This procedure will multiplex any combination of 8, 16 and 32 kbit/s streams by allocating bit positions in each B channel octet to each subrate stream. The fixed format procedure requires that:

i) an 8 kbit/s stream be allowed to occupy any bit position; a 16 kbit/s stream occupies bit positions (1, 2) or (3, 4) or (5, 6) or (7, 8); a 32 kbit/s stream occupies bit positions (1, 2, 3, 4) or (5, 6, 7, 8);

ii) a subrate stream occupies the same bit position(s) in each successive B-channel octet;

iii) the order of transmission of the bits at each subrate stream is identical before and after multiplexing; and

iv) all unused bit positions be set to binary "1".

2.1.2 *Flexible format multiplexing*

This procedure will multiplex any combination of 8, 16 and 32 kbit/s streams by allocating bits in each B-channel octet to each subrate stream. This procedure always allows subrate streams to be multiplexed up to the 64 kbit/s limit of the B-channel. This procedure first attempts to accommodate the subrate streams by using the fixed format procedure of § 2.1.1. Although there may be a sufficient number of available bits in the B-channel octet, the attempt may fail because rule i) of § 2.1.1 cannot be satisfied. If this attempt does fail, then flexible format procedure requires that:

i) a subrate stream occupy the same bit position(s) in each successive B-channel octet;

ii) the new subrate stream be added to the existing multiplex by inserting each successive bit of the new subrate stream into the earliest (lowest numbered) available bit position in the B-channel octet; and

iii) all unused bit positions be set to binary "1".

2.2 *Multiplexing of rates other than 8, 16 and 32 kbit/s*

Two technical approaches for multiplexing lower bit rate information streams (e.g. Recommendation X.1 rates) can be used:

i) *Time division multiplexing*

In this case, the two stage approach (rate adaption up to 8, 16 or 32 kbit/s followed by multiplexing to 64 kbit/s) as defined in §§ 1.2 and 2.1 should be used.

Note – Multiplexing schemes according to X-Series Recommendations (e.g. X.50) may be used only in the context of 64 kbit/s access through the ISDN to existing dedicated networks.

ii) *Statistical multiplexing*

a) for supporting packet mode terminals using either the D-channel ro Recommendation X.25 protocols;

b) for circuit mode terminals or terminal adaptors on the B-channel, see Recommendation V.120.

Recommendation I.461

SUPPORT OF X.21, X.21 *bis* AND X.20 *bis* BASED DATA TERMINAL EQUIPMENTS (DTEs) BY AN INTEGRATED SERVICES DIGITAL NETWORK (ISDN)

(Malaga-Torremolinos, 1984)

See Recommendation X.30, Volume VIII, Fascicle VIII.2.

Recommendation I.462

SUPPORT OF PACKET MODE TERMINAL EQUIPMENT BY AN ISDN

(Malaga-Torremolinos, 1984; amended at Melbourne, 1988)

See Recommendation X.31, Volume VIII, Fascicle VIII.2.

Recommendation I.463

SUPPORT OF DATA TERMINAL EQUIPMENTS (DTEs) WITH V-SERIES TYPE INTERFACES BY AN INTEGRATED SERVICES DIGITAL NETWORK (ISDN)

(Malaga-Torremolinos, 1984; amended at Melbourne, 1988)

See Recommendation V.110, Volume VIII, Fascicle VIII.1.

Recommendation I.464

MULTIPLEXING, RATE ADAPTION AND SUPPORT OF EXISTING INTERFACES FOR RESTRICTED 64 kbit/s TRANSFER CAPABILITY

(Malaga-Torremolinos, 1984; amended at Melbourne, 1988)

Restricted 64 kbit/s transfer capability is defined as "64 kbit/s octet-structured capability with the restriction that an all-zero octet is not permitted".

The procedures given in Recommendations I.460, I.461 (X.30), I.462 (X.31), I.463 (V.110) and I.465 (V.120) for rate adaption, multiplexing and support of existing interfaces for 64 kbit/s, are fully compatible with the restricted 64 kbit/s transfer capability except for the following limitations:

i) For time division multiplexing, the 8th bit of each octet of the 64 kbit/s stream will be set to binary 1. This procedure is the same as that used for time division multiplexing into an unrestricted 64 kbit/s channel where the full 64 kbit/s is not utilized.

ii) Rate adapting an X.25 DTE, as contained in Recommendation I.462 (X.31) and rate adapting DTEs for circuit mode as described in Recommendation I.465 (V.120), for use with the restricted 64 kbit/s transfer capability, is a matter for urgent further study.

The procedures in Recommendation I.462 (X.31) apply only to synchronous terminals.

The procedures in Recommendations I.460, I.461 (X.30), I.463 (V.110) and I.465 (V.120) apply to both synchronous and asynchronous terminals.

Recommendation I.465

SUPPORT BY AN ISDN OF DATA TERMINAL EQUIPMENT WITH V-SERIES TYPE INTERFACES WITH PROVISION FOR STATISTICAL MULTIPLEXING

(Melbourne, 1988)

See Recommendation V.120, Volume VIII, Fascicle VIII.1.

SECTION 7

ASPECTS OF ISDN AFFECTING TERMINAL REQUIREMENTS

Recommendation I.470

RELATIONSHIP OF TERMINAL FUNCTIONS TO ISDN

(Melbourne, 1988)

1 General

1.1 An ISDN is intended to support a wide range of new and existing terminals (TE1, TE2 + TA, NT2) of various capabilities and designed for different access interfaces. This is necessary to permit a full application of the ISDN service potential.

1.2 The purpose of this Recommendation is to provide direction to the potential functional requirements which may be called upon for any specific terminal. The terminal functions used are more specific examples of the general functions described in Recommendation I.310. In this issue of the Recommendation, it is primarily directed at the TE1 and TA devices operating at the basic rate.

2 Relationship between terminals and services in the ISDN

2.1 A terminal device can be described by the list of its functional and physical characteristics. This Recommendation is concerned with only those functional characteristics which the terminal requires in order to be compatible with the network to which the terminal is to be connected, i.e. the ISDN.

2.2 Figure 1/I.470 displays the functional relationship between user, terminal and network. The terminal functions may be those necessary to interface with the user or the network and also those necessary to provide the required network dependent services.

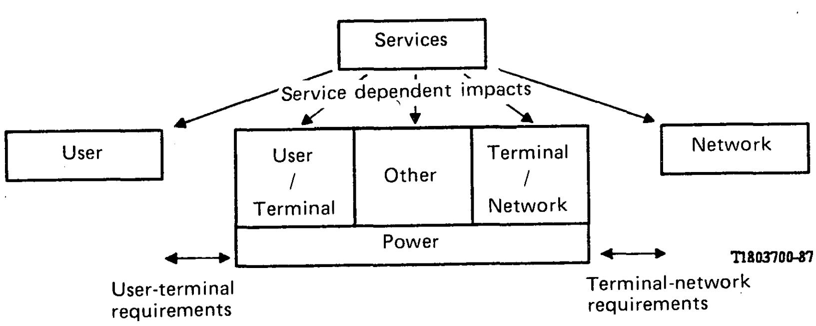

FIGURE 1/I.470

Terminal relationships

2.3 The terminal being considered may be an individual element (e.g. a TE1) or a composite element (e.g. a TE2 + TA or TE1 + NT2). Figure 2/I.470 shows these arrangements.

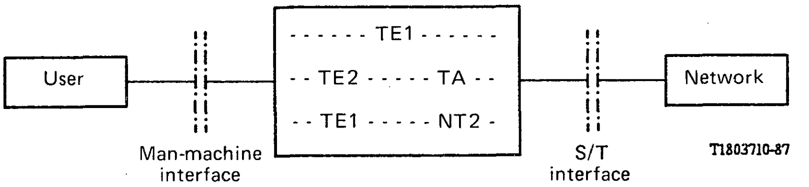

FIGURE 2/I.470

Terminal versions

A TE1 is generally considered as an ISDN interface compatible terminal, intended for use by an individual and connecting directly to the network at a T reference point or via an NT2 at a S reference point.

A TA provides the functions to adopt a non-ISDN compatible terminal to the network at either an S or T reference point. It normally provides the TE2 with compatibility to the network interface. The TE2 interconnects to the TA via a R reference point which may be real or virtual.

An NT2 is a multiple user device providing connection to a number of TE1s and/or TE2 + TAs (as for PBX). It provides S interfaces for these associated terminal devices and connects to the network via a T interface.

2.4 Certain common functions, in particular, concerning the signalling on the D-channel will be found in all terminals connecting to the same type of interface. These functions are essential for interworking with the network and may be therefore considered mandatory. Individual terminals will also have a selected set of service related functions necessary for the services to which they are to be applied.

2.5 Each terminal will have an interface to the user. These interfaces are not a function of the ISDN and are not discussed in this Recommendation.

2.6 A terminal may in addition supply other services to the user, which are independent of the network. The functions are not part of this Recommendation.

3 List of network related functions

3.1 The following list of functions represent an initial view. Additional functions may be required, both in the terminal and the network as new services are identified.

3.2 The mandatory functions for basic rate terminals are given below in the following three Tables 1/I.470, 2/I.470 and 3/I.470 for the physical, link and network layers respectively.

TABLE 1/I.470

Mandatory physical layer functions

Functions	Description	Reference, Rec. I.430
Wiring configuration	Interconnection of one TE with one NT	§ 4
Line code	Inverse of AMI	§ 5.5
Frame structure	Alignment of bit, octet and frame	§ 6.3
D-channel contention control	To control access to D-channel	§ 6.1
Channel identification	To identify B-, D-channels	Rec. I.412 (Definition)
Maintenance	Activities in support of maintaining network subscriber access and installations	§ 7
Electrical characteristics	Interfacing in passive bus interconnections	§ 8
Physical characteristics	Interface connector and contact assignments	§ 10

TABLE 2/I.470

Mandatory LAPD functions

Functions	Description	Reference, Rec. I.441 (Q921)
Zero suppression	Transparency transfer	§ 2.6
Frame identification	To recognize and validate all frames	§ 2, 3
Establish transfer mode	Terminal transmits message to network for initiation	§ 5.3
Sequential control	Sequence integrity of frame transfer/reception on one connection	§ 3.5.2
Error detection	Detection of errors in transfer; format errors and operation errors	§ 5.8
Recovery	Recovery from detected errors and information outputs to management entity for unrecoverable errors	§ 5.8
Flow control	Flow control by modulo and acknowledgement	§ 3.6
Broadcast capability	Provision of broadcast data links that are identifiable by global TEI	§ 3.3.4.1

TABLE 3/I.470

Mandatory network layer functions

Functions	Description	Reference, Rec. I.451 (Q.931)
Identify message and process message	To recognize and validate the message formats	§ 4
Call reference	To identify the call request at the local user-network interface	§ 4.3
Support messages	A set of mandatory messages for basic call control procedures	§ 3
Support information elements	Specification of the message types	§ 4.4

3.3 A list of service related functions is given below. Not all have yet been identified as related to a specific ISDN service.

a) *Other terminal functions*

Terminal equipment may include some of the following service dependent functions:

- analogue-digital conversion
- teleservice identification/selection
- supplementary service identification/selection
- stimulus to functional signalling conversion
- storage/memory
- code/rate translation
- encryption-decryption
- speech pattern recognition
- speech synthesis
- authorization checking
- charge data recording
- network maintenance data recording
- network control capability service/maintenance
- echo control
- dialled number identification
- bearer service identification/selection.

b) *Power*

- local power supply
- power feeding
- terminal energizing control
- activation/deactivation.

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