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DIGITAL SECTIONS AND DIGITAL LINE SYSTEMS

ACCESS DIGITAL SECTION FOR ISDN BASIC RATE ACCESS

ITU-T Recommendation G.960

(Previously "CCITT Recommendation")

FOREWORD

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

The World Telecommunication Standardization Conference (WTSC), which meets every four years, established the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

ITU-T Recommendation G.960 was revised by the ITU-T Study Group XVIII (1988-1993) and was approved by the WTSC (Helsinki, March 1-12, 1993).

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NOTES

1 As a consequence of a reform process within the International Telecommunication Union (ITU), the CCITT ceased to exist as of 28 February 1993. In its place, the ITU Telecommunication Standardization Sector (ITU-T) was created as of 1 March 1993. Similarly, in this reform process, the CCIR and the IFRB have been replaced by the Radiocommunication Sector.

In order not to delay publication of this Recommendation, no change has been made in the text to references containing the acronyms "CCITT, CCIR or IFRB" or their associated entities such as Plenary Assembly, Secretariat, etc. Future editions of this Recommendation will contain the proper terminology related to the new ITU structure.

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

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ACCESS DIGITAL SECTION FOR ISDN BASIC RATE ACCESS

(Melbourne, 1988; revised Helsinki, 1993)

1 General

1.1 Scope

This Recommendation describes the characteristics of an access digital section for the ISDN basic rate access between the user-network interface (at T reference point, defined in Recommendation I.411) and the local exchange (at V_1 reference point defined in Recommendation Q.512) supporting the recommended channel structure 2B + D and the required additional functions.

In this Recommendation and unless otherwise indicated, the term TE is used to indicate terminating layer 1 aspects of TE1, TA and NT2 functional groups.

When the term TE indicates terminating layer 1 aspects of TE1, then according to Figure 2/I.411, the S and T reference points coincide.

The terminology used in this Recommendation is contained in Recommendations I.112 and G.701.

1.2 Configuration

Figure 1 shows the boundaries of the access digital section in relation to the digital system definition.

The concept of the access digital section is used in order to allow a functional and procedural description and a definition of the network requirements.

Note that reference point T and V_1 are not identical and therefore the access digital section is not symmetric.

The concept of a digital transmission system is used in order to describe the characteristics of an implementation, using a specific medium, in support of the access digital section.

NOTE – The T and V reference points are defined in Recommendations I.411 and Q.512.

1.3 Application

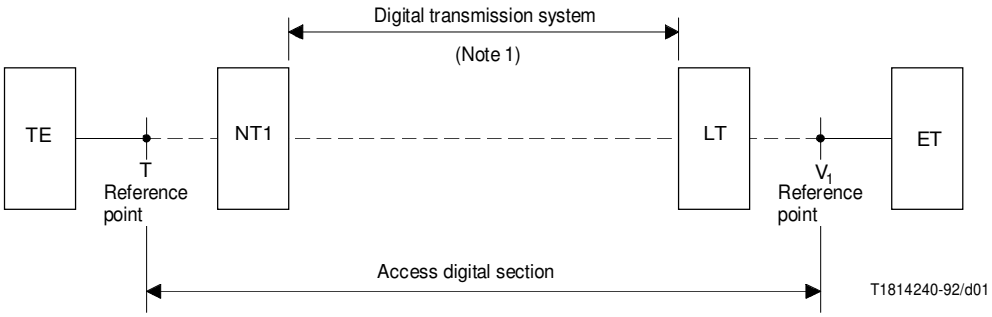
The basic access digital section may be applied as given in Figure 2 for:

- direct access to the local exchange (V_1-reference point);
- access via a basic access multiplex equipment (V_4-interface) to the local exchange;
- access via a basic access concentrator (V_2-interface) to the local exchange.

1.4 Abbreviations

A number of abbreviations are used in this Recommendation. Some of them are commonly used in the ISDN reference configuration while others are created only for this Recommendation. The latter are given below:

C_{V_1}	Control Channel at V_1 reference point
DS	Access digital section
FE	Function Element used between ET and LT
INFO	Information element defined at the user network interface
SIG	Signal between LT an NT1
DTS	Digital Transmission System



ET Exchange termination
LT Line termination
NT Network termination
TE Terminal equipment

NOTES

1 Digital transmission system refers to a line system using metallic pairs, optical fibres or radio systems.

2 The line transceivers in the NT1 and LT are part of the digital transmission system.

FIGURE 1/G.960

Access digital section and transmission system boundaries

2 Modelling and relationship between the access digital section and the ET

The general model shown in Figure 3 depicts the whole ISDN customer access layer 1 and adjacent entities and provides the basis to describe the functions performed by the access digital section and those performed by TE, ET and system management and how various functions are grouped. In particular, according to this model the activation/deactivation procedures and maintenance functions specified in this Recommendation are not confined to functions performed by the access digital section but include functions associated with ET layer 1.

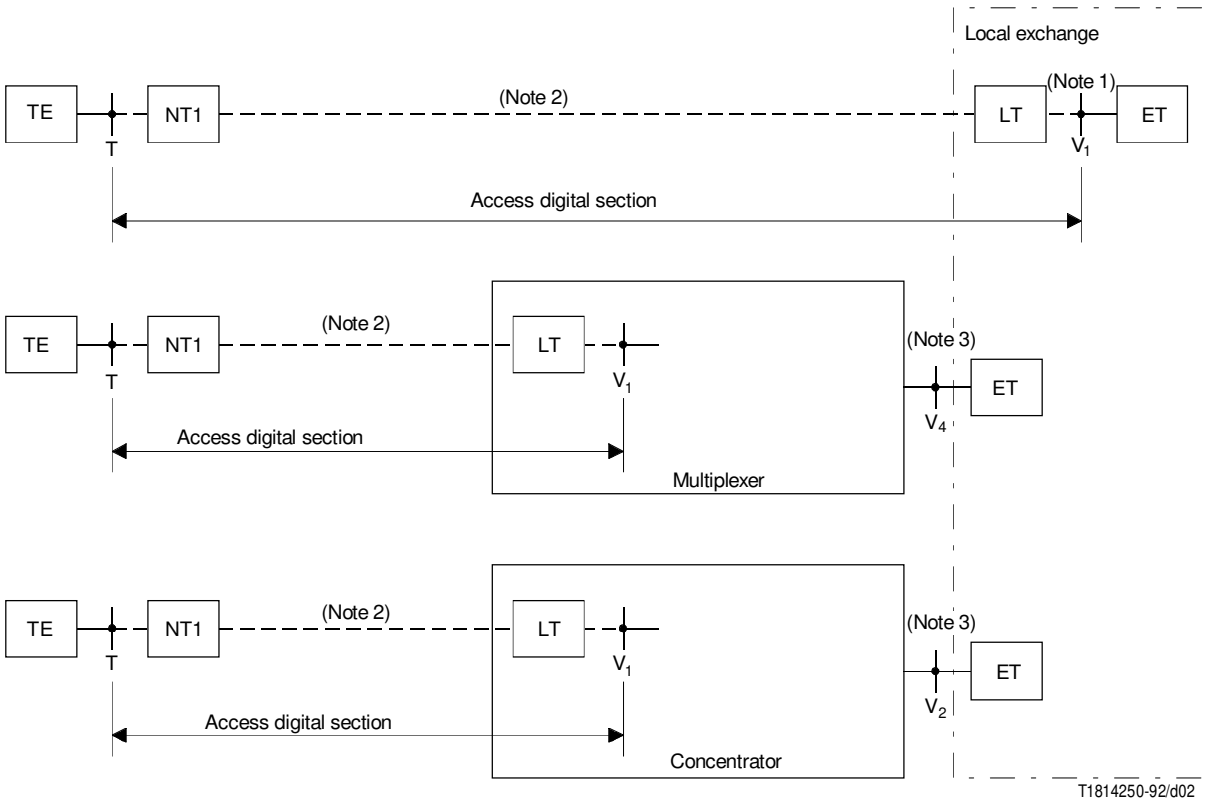
This model includes primitive procedures between ET layer 1, ET layer 2 and system management as follows:

i) Recommendations I.430 and Q.920/Q.921 interactions between ET layer 1 and ET layer 2, and ET layer 1 and system management based on PH and MPH primitives, respectively, as defined in Recommendation I.430. These interactions are for the support of functions specified in Recommendations Q.920 and Q.921;

ii) interactions between ET layer 1 and system management for the support of functions associated with the access digital section, based on MPH primitives.

The primitive procedures defined in this model do not conflict with those specified for the TE in Recommendation I.430.

This model does not constrain layer 1 arrangements between LT and NT1, (it is also applicable to remote access application as shown in Figure 2), or the digital transmission system technology.



NOTES

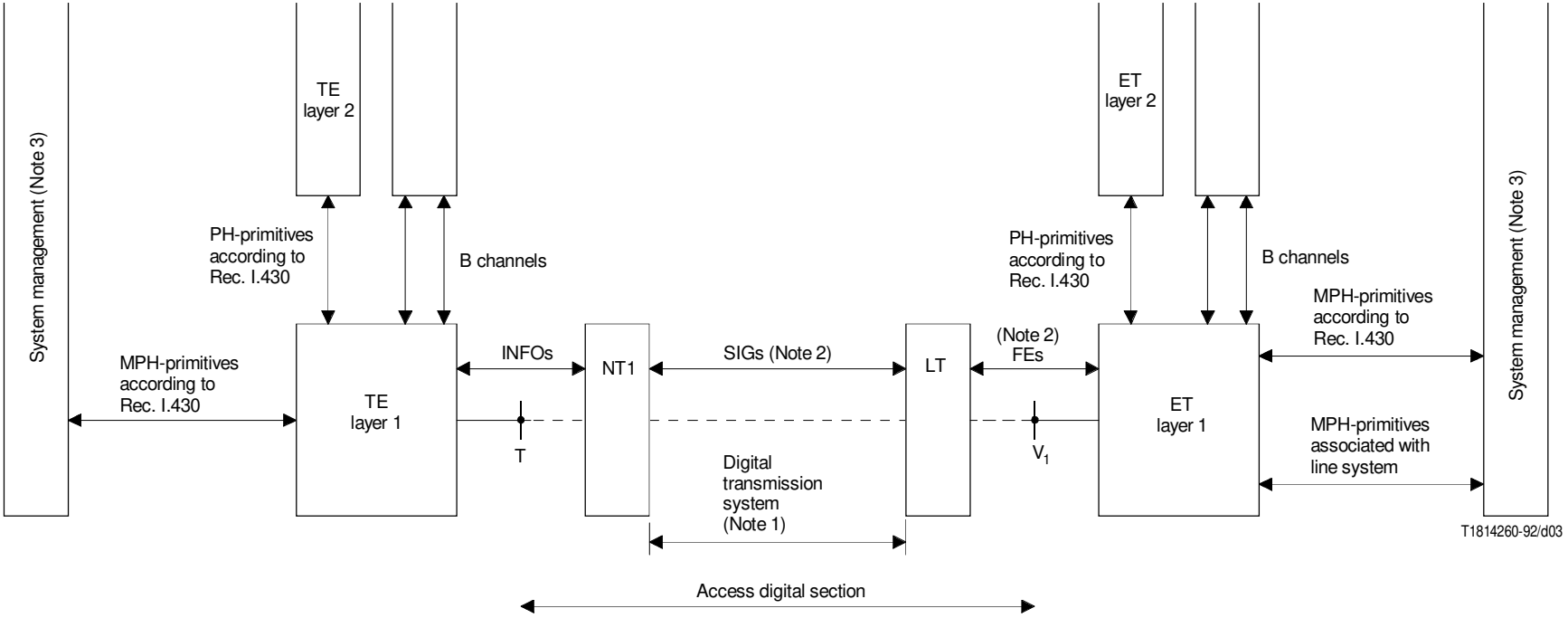
1 The LT may be integrated together with the ET or separate (as integral part or outside of the local exchange).

2 The application of one regenerator in an access digital section using a digital transmissions system for metallic pairs may be foreseen.

3 Local and remote application are envisaged. For the remote case a transparent link between the remote multiplexer or concentrator and the local exchange will be used.

FIGURE 2/G.960

Application of the access digital section



NOTES

1 The digital transmission system refers to a digital line transmission system using either a metallic pair of wires, optical fibre or radio system.

2 SIG, FE and primitives refer to an exchange of information. They do not imply any specific coding nor implementation. Some of these functions may be terminated in the LT and do not pass through the digital transmission system.

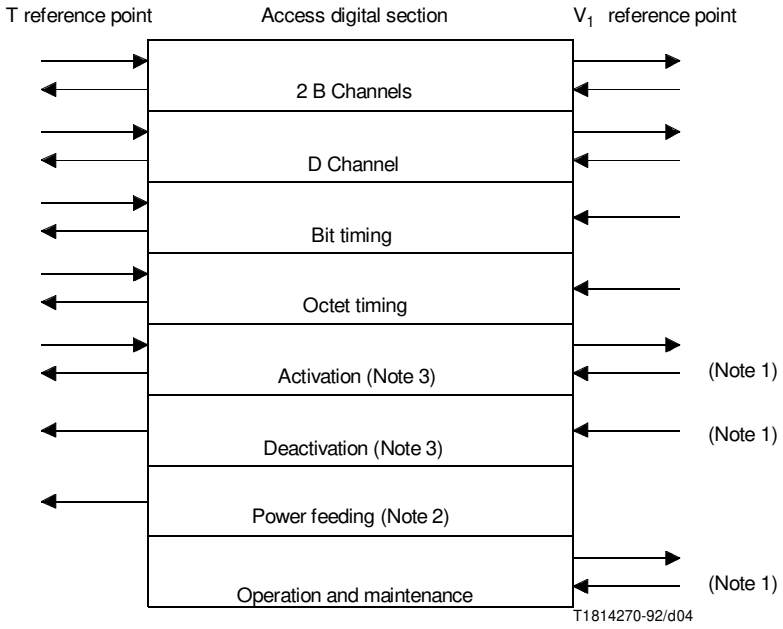
3 The term system management corresponds to both system management and layer management as defined in Recommendation Q.940.

FIGURE 3/G.960

General model of ISDN customer access layer 1 and adjacent entities

3 Functions

Figure 4 shows the functions which have to be supported by the basic access digital section.



NOTES

1 These functions are conveyed by the C_{V_1} channel across the V_1 reference point.

2 This function is optional.

3 The activation and deactivation functions are concerned with the operation of the access digital section and the user-network interface. However, for consistency with Recommendation I.430, they are described as separate functions.

FIGURE 4/G.960

Functions of the access digital section

3.1 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).

3.2 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).

3.3 Bit timing

This function provides bit (signal element) timing to enable the receiving equipment to recover information from the aggregate bit stream. At the V_1 reference point, the bit timing function is used for both transmit and receive data.

3.4 Octet timing

This function provides 8 kHz octet timing for the B-channels.

3.5 Activation

3.5.1 Activation from ET

This function places all the functions of the access digital section into a normal operating mode and supports the activation of the interface at the T reference point according to Recommendation I.430. This takes into account:

- power down mode;
- initial power up;
- a failure condition.

The procedures and exchange of information are described in 5.

An activation should be possible to a state which allows maintenance actions to be performed in the access digital section even when there is no customer equipment connected to the T reference point.

In case a basic access digital section uses a digital transmission system for a metallic line, an additional mode of operation may be applied for activation/deactivation, which is to activate/deactivate the access digital section only (partial activation of the DS, i.e. no signal shall be sent from the NT1 to the interface at the T reference point, but signals can be received for activation from the user side). This is optional.

3.5.2 Request for activation from TE

This function supports activation of the access digital section and of the interface at the T reference point according to Recommendation I.430.

These functions are conveyed by the C_{V_1}-channel (see 7).

3.6 Deactivation

This function permits the interface at the T reference point and the access digital section to be placed in a low power consumption mode. The procedures and exchange of information are described in 5.

Deactivation should be initiated only by the exchange (ET).

This function is conveyed by the C_{V_1}-channel (see 7).

3.7 Power feeding

This function provides for remote power feeding of NT1 and optionally the TE via the user-network interface in accordance with 9/I.430.

3.8 Operation and maintenance

This function supports required actions and information for operating and maintaining the access digital section controlled by the ET as defined in Recommendation I.603.

Four categories of functions have been identified:

- commands regarding LT, regenerator, or NT1;
- information from LT, regenerator, or NT1;
- indications of fault conditions;
- control of access digital section power feeding.

These functions are conveyed by the C_{V_1}-channel (see 7).

4 Network performance

4.1 Availability

The definition of availability is given in Annex A/G.821. The availability objective of the access digital section should be consistent with the availability requirement for the hypothetical reference access digital section as given in Recommendations G.801 and I.350.

4.2 Signal transfer delay

Signal transfer delay is specified for B- and D-channels and is defined as absolute signal delay between T and V_1 reference points for each direction of transmission. The value shall be less than 2 ms when a system for metallic pairs, optical fibre or a radio-relay system is used. The application of a satellite system in the access digital section is also possible, however, for speech services Recommendation G.114 may limit such an application until appropriate methods to control double satellite hops and switching of echo control devices are available. These methods are outside the scope of this Recommendation.

4.3 Error performance

Error performance must be consistent with the requirements given in Recommendation G.821.

4.4 Jitter

4.4.1 Output/input jitter at T reference point

The requirements are specified in 8/I.430.

4.4.2 Jitter at V_1 reference point

Jitter on timing signals provided at V_1 reference point to the LT shall be limited to values which do not require jitter reduction in the LT.

Jitter limits at V_1 reference point from LT are not required since the timing at V_1 reference point is defined as contradirectional.

Jitter requirements additional to those given here are system dependent and outside the scope of this Recommendation and may be defined in Recommendation G.961.

5 Activation/deactivation

5.1 Functional capabilities

The access digital section provides the layer 1 signalling capability and the necessary procedures to enable:

5.1.1 Customer equipment at the user side of reference point T

To activate the layer 1 of the user-network interface at reference point T and, if not already activated, the access digital section.

5.1.2 Equipment at the network side of V_1 reference point to:

a) *activate:*

1) the layer 1 of the user-network interface at reference point T and, if not already activated, the access digital section (this activation is related to call control); or

2) the access digital section partially (this activation is related to controlling the configuration of the access; it is a network option);

b) *deactivate:*

1) the layer 1 of the user-network interface at reference point T and the access digital section; or

2) the layer 1 of the user-network interface at reference point T only.

The functional capabilities defined in 5.1.2 a) 2) allow maintenance actions in the access digital section which do not affect the deactivated user-network interface at reference point T to be performed if required. In some applications they also permit the access digital section to be placed in a mode where the full information transfer capability is available while the user-network interface at reference point T remains deactivated.

The procedures for the activation or deactivation of the layer 1 of the user-network interface at reference point T comply with 6.2/I.430. These procedures are based on a repertoire of INFO signals as defined in Recommendation I.430 (see Table 4/I.430).

The procedures at V_1 reference point are based on a repertoire of function elements (FEs). These FEs have specific relationships to primitives between the ET layer 1 and ET layer 2, and ET layer 1 and system management for the activation or deactivation of the layer 1 of the user-network interface in accordance with 6.2/I.430 and Recommendations Q.920 and Q.921. The means for defining these interactions are the primitive procedures (see Figure 5/I.430) based on a repertoire of PH- and MPH-primitives.

5.2 Modelling

5.2.1 General

The model for activation/deactivation procedures is given in 2.

It is recognized that activation/deactivation is a process between the subscriber installation and local exchange requiring appropriate functionality at both ends. The model contained in 2 includes the functional blocks relevant to activation/deactivation and depicts the primitives related to the activation/deactivation procedures.

5.2.2 Partitioning of functions

Recommendation I.430 defines the network side of the user-network interface at reference point T as one functional block which supports the layer 1 activation/deactivation procedures across the T reference point and the primitive procedures at the ET layer 1/ET layer 2 boundary and ET layer 1/system management boundary. This block includes the functional groupings NT1, LT and ET layer 1.

This concept is described in terms of a state machine, called the G state machine in Recommendation I.430.

In order to describe the relationship between signals across the user-network interface at reference point T and function elements across reference point V_1, and the relationship between function elements across reference point V_1 and primitives, two state machines are defined. One in the access digital section (DS state machine), and one at the network side of the V_1 reference point (ET layer 1 state machine). Figure 5/ illustrates this approach.

In addition to primitives defined in Recommendations I.430 and Q.921 related to call control, Figure 5 also introduces a new set of primitives related to configuration control and the control of loopbacks. Partitioning of activation/deactivation procedures between two state machines is used for the convenience of easy and accurate description. The ET layer 1 state machine is to be viewed as conceptual and does not imply any particular implementation.

The model for activation/deactivation, given in 2, requires further partitioning of the DS state machine into the NT1 state machine (NT states) and the LT state machine (LT states). This is shown in Figure 6.

The NT1 state machine supports user-network interface procedures in accordance with Recommendation I.430 based on the INFOs, and interacts with the LT state machine by means of a signal repertoire (SIGs) which has to be supported by the digital transmission system. The LT state machine interacts with the ET layer 1 state machine by means of a set of function elements (FEs). The ET layer 1 state machine contains those states which represent the local exchange view of the status of the interface at reference point T and the access digital section. It supports the already specified primitive procedures to provide services to ET layer 2 and system management in accordance with Recommendation I.430, and additional primitive procedures for the support of functions associated with the access digital section.

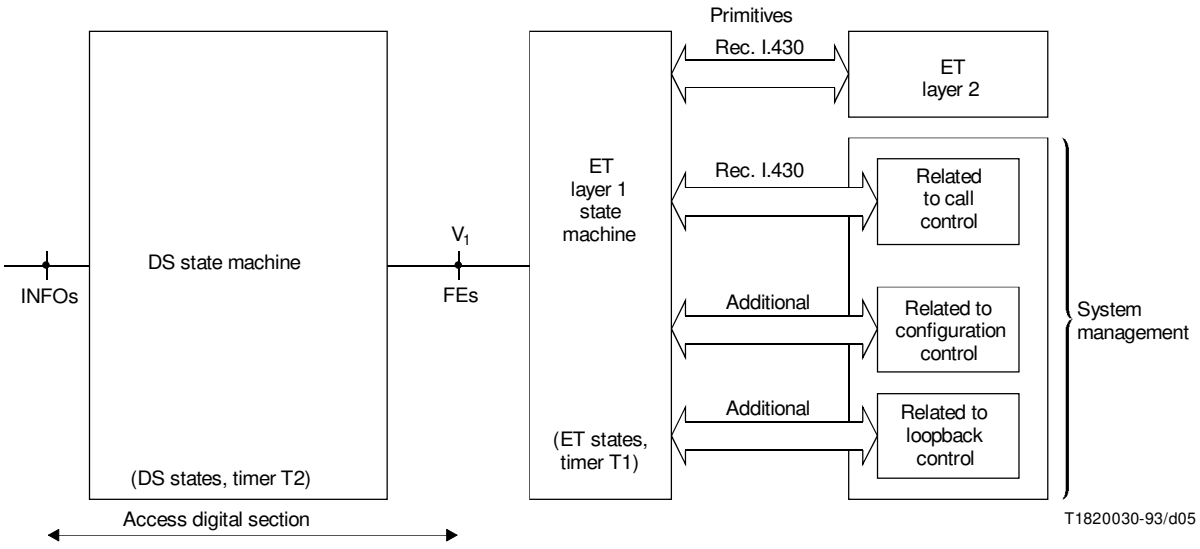


FIGURE 5/G.960

State machines

Figure 6 provides information for the description of the transmission system which is given in Recommendation G.961.

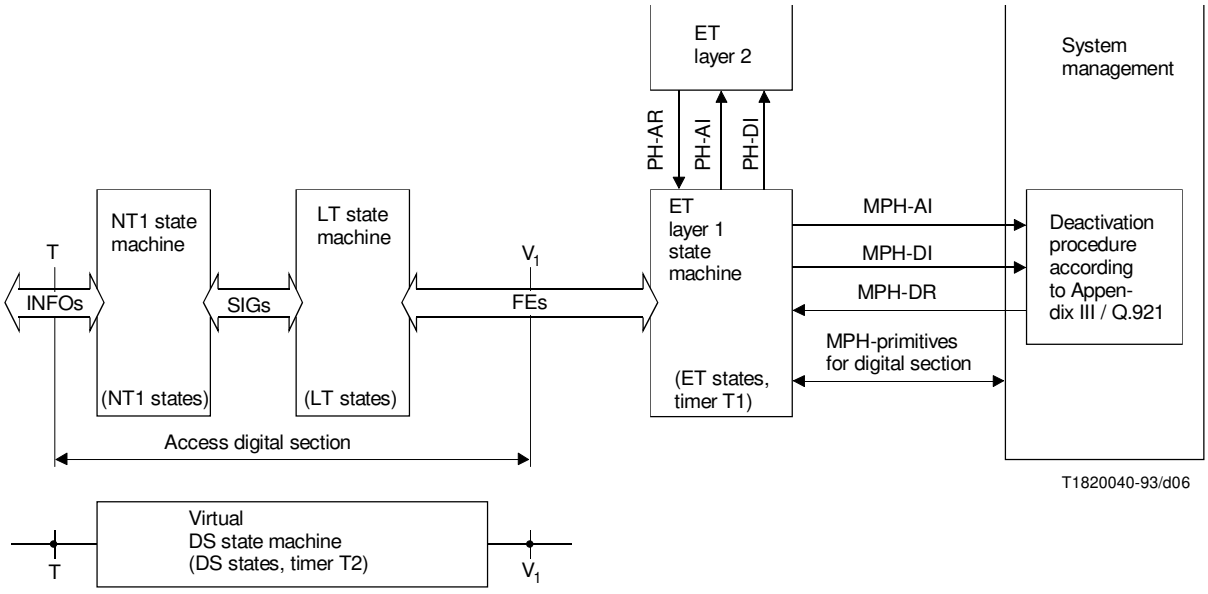


FIGURE 6/G.960

Partitioning of the DS state machine

5.2.3 Location of timers T1 and T2

In the following description of the DS and ET layer 1 state machines, timer T1 will be associated with ET layer 1 (ET layer 1 state machine) while timer T2 will be associated with the access digital section (DS state machine).

The association of timer T1 with layer 1 of the ET is applied for the convenience of easy description but may be implemented anywhere while being functionally part of the ET. The exact location of timer T2 within the access digital section does not affect the description of the DS state machine.

5.3 Activation/deactivation procedures

The procedures allow the activation/deactivation of the user-network interface at reference point T. The activation may be invoked by either side while deactivation is only invoked by the network. The overall activation/deactivation procedures can be divided into four classes:

a) basic procedures for call control used to activate the layer 1 of the user-network interface at the T reference point and if not already activated, the access digital section;

b) procedures to control loopbacks;

c) procedures to control the configuration;

d) optional procedures to activate/deactivate the digital section partially (see Annex B).

5.3.1 Basic characteristics of the procedures

5.3.1.1 Priority

Priority refers to contention resolution between activation/deactivation requests which have been invoked concurrently.

If contention between conflicting activation/deactivation requests from layer 2 and system management occurs it is resolved in the ET layer 1 state machine, which will then pass to the V_1 reference point a coordinated set of Function Elements (FEs). Table A.1 shows the ET layer 1 state machine priority order.

If contention between conflicting activation/deactivation requests from ET side and user side occurs it is resolved in the DS state machine. Table 1 shows the DS state machine priority order.

TABLE 1/G.960

Priority order of requests in the DS state machine

Type of request	Priority order
Call control activation request from ET side	2 (highest)
Call control activation request from user side	1
Access digital section partial activation/deactivation request from ET side	0 (lowest)

5.3.1.2 System management

Some assumptions related to the system management are described in Annex A.

5.3.1.3 Loopbacks

When a transparent loopback 2 is applied, the NT1 shall send INFO 4 frames toward the user with the D-echo-channel set to binary ZERO.

With a transparent loopback 1, the NT1 (when able to activate the user-network interface at the T reference point) shall send INFO 4 frames toward the user with the D-echo-channel set to binary ZERO or operating normally.

5.3.1.4 Protection of layer 2 frames

According to 6.2.6.1/I.430, a TE is allowed to take up to 100 ms to synchronize on INFO 2, no lower time limit is defined. The different time each TE may take to synchronize on INFO 2 affects the offering of an incoming call in layer 1 multiple terminal arrangements. The fastest TE notifies to the network that the access is activated and the message offering the incoming call (SETUP) may be transmitted (TE ready to receive the message) while other TEs are not yet ready to receive the message.

This could result in the slow TEs losing all or part of the incoming messages (layer 2 frames).

Reference is made to Table 2, Note 5, and to Table 6/I.430, Note 4, where some information concerning layer 1 methods to protect layer 2 frames can be found.

5.3.1.5 Structure of the tables

Both the DS state transition table and the ET layer 1 state transition table are structured such that three classes of the activation/deactivation procedures, as described at the beginning of 5.3 (with classes a) and c) combined), are clearly separated. This allows implementation of the basic procedure and the configuration control only.

5.3.1.6 Transmission of INFO 2

In the following procedures two different internal events of the access digital section are considered to start transmission of INFO 2:

a) the transmission system is synchronized in the direction LT to NT1;

b) the transmission system is synchronized in both directions of transmission (see Note 5, Table 2).

5.4 Description of the state transition tables

The ET state table dealing with procedures a), b) and c) (see 5.3) can be found in Annex A. The ET state table dealing with procedure d) is given in Annex B.

5.4.1 Access digital section states (DS states)

Defined below are the states that the access digital section may enter as a result of INFOs received from the user across the reference point T, function elements (FEs) received from the ET across the reference point V_1, or internal events. They are classified according to the functionality they support as follows:

i) DS 1.x states for the support of access activation according to Recommendation I.430 (i.e. “ISDN Customer Access” as defined in Figure 1/I.414);

ii) DS 2.x states for the support of functionality related to loopbacks;

iii) DS 3.x states for the optional support of functionality related to partial activation of the access digital section are defined in Annex B.

5.4.1.1 State DS 1.0 (Access deactivated)

The access is in its non-operational mode. INFO 0 is sent to the user and FE 6 is sent to the ET. Viewed from the user side of reference point T the network is in state G1 according to 6.2.1.2.1/I.430.

5.4.1.2 State DS 1.1 (Access activation initiated)

Activation of the access has been requested either by the receipt of FE 1 from the ET or by the receipt of INFO 1 from the user. The first stage of activation, namely, the activation of the DS, has been initiated. INFO 0 is sent to the user and FE 2 is sent to the ET. Viewed from the user side of reference point T the network is in state G1 according to 6.2.1.2.1/I.430.

5.4.1.3 State DS 1.2 (Access activation: DS synchronized LT -> NT)

In this second state of the access activation, the NT has been synchronised with the LT. INFO 2 is sent to the user and FE 2 is sent to the ET while the DS is synchronizing NT → LT. Viewed from the user side of reference point T the network is in state G2 according to 6.2.1.2.2/I.430 (see also Note 5 to Table 2).

5.4.1.4 State DS 1.3 (Access activation: DS activated)

In this third stage of the access activation, the DS has been synchronized in both directions. INFO 2 continuous to be sent to the user, but FE 3 is sent to the ET while the receipt of INFO 3 from the user is awaited. Viewed from the user side of reference point T the network is in state G2 according to 6.2.1.2.2/I.430.

5.4.1.5 State DS 1.4 (Access activated)

The access is in its stable active state, INFO 3 having been received from the user. FE 4 is sent to the ET and INFO 4 is sent to the user. (See Note 4 to DS state transition table). Viewed from the user side of reference point T the network is in state G3 according to 6.2.1.2.3/I.430.

5.4.1.6 State DS 1.5 (LOS/LFA at T)

The signal or frame alignment has been lost on the user side of the T reference point while the access is in its stable active state. This may have been caused, for example, by the temporary removal of the terminal (the terminal portability facility). INFO 2 is sent to the user to assist rapid re-synchronization of the terminal, and FE 12 is sent to the ET while awaiting either the receipt of INFO 3 from the user, or FE 5 from the ET (instruction to deactivate). Viewed from the user side of reference point T the network is in state G2 according to 6.2.1.2.2/I.430. Upon receipt of INFO 3 from the user, the DS state machine returns to state DS 1.4.

5.4.1.7 State DS 1.6 (Access deactivation initiated)

The access has been instructed by the ET to deactivate by the receipt of FE 5. FE 4 is returned to the ET and INFO 0 is sent to the user. Viewed from the user side of reference point T the network is in state G4 according to 6.2.1.2.4/I.430. Upon the receipt of INFO 0 from the user, the deactivation of the DS or the expiry of timer T2, the DS state machine changes to state DS 1.0.

5.4.1.8 State DS 1.7 (Defect condition)

LOS/LFA has occurred on the transmission system, or power has been lost at the NT. The defect condition is reported to the ET by sending FE 7. The INFO sent to the user, and the G state of the network according to 6.2.1.2/I.430, will depend on the NT state prior to the defect condition. Upon the receipt of FE 5 from the ET, the DS state machine changes to state DS 1.0.

NOTE – Two implementation alternatives exist when loss of frame alignment has occurred:

a) the implementation may not be able to recover from this condition and may initiate deactivation autonomously;

b) the implementation may be able to recover from this condition and may deactivate only on receipt of FE 5.

5.4.1.9 States DS 2.x (loopback states)

For further study.

5.4.2 Repertoire of signals sent across the T reference point

The INFO signals used in the activation/deactivation of the access are defined in 6.2.2/I.430.

5.4.3 Repertoire of function elements sent across the V_1 reference point

The function elements used in the activation/deactivation of the access are defined below:

–	FE 1	(LT ← ET)	Activate access
–	FE 2	(LT → ET)	Access activation initiated
–	FE 3	(LT → ET)	DS activated
–	FE 4	(LT → ET)	Access activated or loopback operated
–	FE 5	(LT ← ET)	Deactivate access
–	FE 6	(LT → ET)	Access deactivated
–	FE 7	(LT → ET)	LOS/LFA in DS or loss of power at NT
–	FE 8	(LT ← ET)	Activate loopback 2
–	FE 9	(LT ← ET)	Activate loopback 1
–	FE 10	(LT ← ET)	Activate loopback 1A
–	FE 11	(LT ← ET)	Partially activate DS; deactivate interface at T reference point (optional - see Annex B)
–	FE 12	(LT → ET)	LOS/LFA at T reference point

5.4.4 Specification of the procedures

5.4.4.1 Procedures across the user-network interface at reference point T

The access supports the procedures across the user-network interface at the reference point T, defined in 6.2/I.430.

5.4.4.2 Access digital section state transition table

The state transition table, see Table 2, specifies the procedures, showing the actions to be taken in response to various events while in a specific state. The procedures for loopback operation require further study.

5.4.4.3 Assumptions made in specifying the procedures in DS state transition table:

a) The response to events that should not normally occur in a current state shall be: no action, no state change.

b) The response to a request for an operation which is currently in progress shall be: no action, no state change.

c) The response to a request for an operation which has already been completed shall be to confirm the present status with no state change.

5.5 Activation time

For activation from the user side the activation time is measured at the T reference point between the initiation of the sending of INFO 1 to the interface at the T reference point and the receipt of INFO 4 from the access digital section.

For activation from the network side the activation time is defined between function element 1 and function element 4 at the V_1 reference point.

The values do not take into account the response time of TE for sending INFO 3 on receipt of INFO 2. Also see 6.2.6.1/I.430.

NOTE – Most of the activation of the TE takes place in parallel with the activation of the DS and in general does not extend the total activation time. For conformance testing both, activitation with loopback 2 or the time between FE1 and FE3 are appropriate.

The activation time is specified for an access digital section on which a bit error rate lower than the value x can be achieved when activated. The exact test conditions are for further study.

TABLE 2/G.960

State transition table of access digital section (DS state machine)

State number	DS 1.0	DS 1.1	DS 1.2 (Note 5)	DS 1.3	DS 1.4	DS 1.5	DS 1.6	DS 1.7
State name	Access deactivated	Access activation:			Access activated	Access activated	Access deactivation: initiated	Network defect
		Initiated	DS synch. LT → NT	DS activated		LOS/LFA at T		
FE sent	FE 6	FE 2 (Note 7)	FE 2	FE 3	FE4	FE 12 (Note 1)	FE 4	FE 7
INFO sent	INFO 0	INFO 0	INFO 2	INFO 2	INFO 4	INFO 2	INFO 0	(Note 2)
Event: Internal state	G1	G1	G2	G2	G3	G2	G4	(Note 2)
FE 1	DS 1.1	–	–	–	–	–	DS 1.1	–
FE 5	–	Start T2 DS 1.6	Start T2 DS 1.6	Start T2 DS 1.6	Start T2 DS 1.6	Start T2 DS 1.6	–	DS 1.0
Receiving INFO 0	–	–	–	–	DS 1.5	–	DS 1.0	–
Receiving INFO 1	DS 1.1	–	–	–	/	–	–	–
Receiving INFO 3	–	–	–	(Note 4) DS 1.4	–	DS 1.4 (Note 4)	–	–
LOS/LFA at T	/	–	–	–	DS 1.5	–	–	–
Expiry of Timer T 2 (Note 3)	–	–	–	–	–	–	DS 1.0	–
DS synchronized LT → NT	/	DS 1.2	–	–	–	–	–	–
DS activated	/	/	DS 1.3	–	–	–	–	(Note 6)
DS deactivated	–	–	–	/	/	/	DS 1.0	–
FE 8	DS 2.x	|	|	|	|	|	|	|
FE 9	DS 2.x	|	|	|	|	|	|	|
FE 10	DS 2.x	|	|	|	|	|	|	|
LOS/LFA at either NT or LT line side; or Loss of NT power	–	DS 1.7	DS 1.7	DS 1.7	DS 1.7	DS 1.7	DS 1.7	–

– No state change, no action when event occurs

/ Impossible event due to internal reasons or peer-to-peer procedures

| Impossible event due to definition of the layer 1 service

FE... Issue function element FE... across V_1 reference point

DS a.b Enter state DS a.b.

TABLE 2/G.960 *(end)*

State transition table of access digital section
(DS state machine)

NOTES

1 FE 12 may not be provided in some networks.

2 The INFO sent to the user and the corresponding G state depends on the NT1 state and also on the NT1 and LT state machine defined for the individual transmission system in Recommendation G.961.

3 A description of timer T2 can be found in Note 2 to Table 6/I.430.

4 As an implementation option, to avoid premature transmission of information (i.e. INFO 4), the DS state machine may introduce a delay before it changes state, i.e. see Note 4 to Table 6/I.430.

5 As an implementation option, INFO 2 shall be only sent when the DS is synchronized in both directions. Thus in the DS 1.2 state, INFO 0 is sent across the interface at the T reference point and the user perceives the DS to have the internal state G1.

6 A network unable to recover from a network defect shall take no action and make no state change when the event "DS activated" occurs. Networks able to recover from a network defect shall change to state DS 1.3.

7 FE 2 may not be sent in response to FE 1.

5.5.1 Maximum activation time (see Note 1) for activation occurring immediately after a deactivation (without any intervening loopback or powering action) (see Note 2):

Metallic pair cable transmission system

i) without regenerator: 300 ms,

ii) with regenerator: 600 ms.

5.5.2 Maximum activation time (see Note 1) for activation occurring after the first powering on of an access digital section:

i) without regenerator: 15 s,

ii) with regenerator: 20 s.

NOTES

1 The specified value for activation time is understood as a 95%-value. This means that for 95% of performed activations the activation time must be lower than the specified value.

2 Time T1 being a functional part of the ET it may be physically implemented in the ET. In this case, its value may be adjusted according to the characteristics of the transmission system between the ET and the access digital section when it exists (e.g. in case of a satellite transmission system a value of 1000 ms has to be taken into account).

6 Operation and maintenance

6.1 General

This subclause describes the operation and maintenance functions for the access digital section. For the time being only functions for a digital transmission system for a metallic line are defined.

Operational functions related to activation/deactivation procedure are specified in 5.

Further assumptions regarding the system management are given in Annex A.

The maintenance functions recommended in I.603 provide the capability to maintain the access digital section to the level of network performance given in 4.

It must be possible to test and maintain the access digital section in accordance with Recommendation I.603 regardless of the customer equipment.

6.2 Control facilities

6.2.1 Loopbacks

6.2.1.1 Loopback implementation

The location and characteristics of loopbacks are defined in Recommendation I.603.

6.2.1.2 Loopback procedure

The loopbacks are controlled by ET system management.

A normal call activation request cannot override a request for loopback 1, 1A or 2.

The procedure for loopback operation always starts from the deactivated state of the access digital section.

One possible sequence is:

a) ET generates an operation command for the required loopback;

b) ET receives MPH-AI;

c) ET performs the test;

d) ET generates a release command;

e) ET receives MPH-DI.

6.2.2 Auxiliary equipment line switchover

The function provides control of switchovers across the V_1 reference point:

a) to switch the line from the LT to a line measurement device;

b) to switch the line from the normal LT to a standby LT;

c) to switch the LT to test NT1 located in the local exchange.

This function is optional. The function definition, control options and procedures are for further study.

6.2.3 Control of functions in the NT1

This function allows control of specific functions within the NT1 and is for further study.

An example of such a function: control of switching between normal and restricted power at the user network interface.

6.2.4 Information request

This function allows the ET to request from the LT, regenerator and NT1 specific status reports.

6.2.5 Power switch on/off to the line

This function allows switching of the power to the line, and may be automatically applied upon reception of a power feed failure indication.

6.2.6 Continuity test

The continuity test is described in Recommendation I.603.

The continuity test is controlled by the ET and is initiated by MPH-AR. System management decides when the test is passed (i.e. on reception of MPH-DSAI or MPH-AI). When the system management receives MPH-EI (expiry T1) the test is considered to have failed. See also Annex A.

6.3 Monitoring

6.3.1 Functions

The following operational conditions are monitored throughout the access digital section:

a) the detect conditions;

b) the power feed arrangements;

c) transmission performance.

6.3.2 Implementation aspects

Monitoring capabilities must be provided in the access digital section (see Recommendation I.603). The handling and processing of the information is implementation-dependent. For example:

a) the use of registers/counters in functional groups, the use of explicit commands and responses to establish status reports;

b) the transfer of information to the exchange, either when a defect condition occurs or on a regular basis. This information is then processed by entities outside the access digital section.

6.3.3 Anomaly and defect conditions and consequent action

6.3.3.1 Defect conditions

The following defect conditions are examples:

i) loss of frame alignment (LFA), loss of incoming signal (LOS);

ii) loss of signal at T reference point;

iii) power overload condition at the DS;

iv) power feed failure at the DS;

v) power feed failure at the T reference point.

An example of an anomaly is a transmission error.

6.3.3.2 Consequent actions

Detection of defect conditions and consequent actions are relevant during activation or the active state. LOS/LFA at the regenerator side leads to the same FE7 as a LOS/LFA at the LT or INFO as a LOS/LFA at the NT1.

The consequent actions given in Table 3 are defined for stable defect conditions. Possible transient conditions of defects and actions are not considered.

6.3.4 Error performance monitoring

6.3.4.1 General

Provision has to be made in order to monitor the error performance of the access digital section and to report on such performance.

6.3.4.2 Error performance parameters

The access digital section must deliver to the ET the necessary information to allow it to evaluate the error performance parameters defined in Recommendation G.821.

TABLE 3/G.960

Anomalies, defect conditions and consequent actions

Equipment	Condition	Consequent actions	
		Signal at V_1	Signal at T
LT Line side	Transmission errors	(Note 2)	(Notes 2 et 3)
	LOS/LFA	FE 7	(Note 1)
NT1 Line side	Transmission errors	(Note 2)	(Note 3)
	LOS/LFA	FE 7	INFO 0
NT1 at T	LOS/LFA	FE 12 (Note 4)	INFO 0, state G2
NT1	Loss of power	FE 7	INFO 0

NOTES

1 The INFO sent depends on the NT1 state and the NT1 and LT state machine defined for the individual transmission system in Recommendation G.961.

2 The error report depends on the specification of the C_{V1}- and C_L-channel and may be system-dependent.

3 Transmission error reporting may be provided by an NT1 implementing the optional S-channel (see 7/I.430).

4 FE 12 may not be provided in some networks.

6.3.5 Status report functions

Status report functions cover information which relate to the overall operation and performance of the access digital section. The information may be transmitted either automatically or under request of ET.

Listed below are descriptions of the status report functions:

i) *Transmission errors*

This information, derived in the access digital section, allows the ET to evaluate the transmission error performance

ii) *Loopback 1 status*

This information, sent from the LT, gives the status of loopback 1.

iii) *Loopback 1A status*

This information, sent from the regenerator, gives the status of loopback 1A.

iv) *Loopback 2 status*

This information, sent from the NT1, gives the status of loopback 2.

v) *User network interface power feed status*

This information indicates the status of the user network interface at T reference point power feed, e.g. normal or restricted power feed mode.

vi) *User network interface power feed fault*

This information indicates a failure of the normal or restricted power source. It may be split into two reports and reported on request of the ET.

vii) *User network interface power feed overload*

This information indicates that the power drawn from any source within the NT1 exceeds the maximum power that is available. It is reported on request of the ET.

viii) *Defect indication information*

This information is transmitted automatically under conditions specified in 6.3.3.2.

The implementation status for the functions defined above is given in Table 4.

TABLE 4/G.960

Status report functions

Function	Location	Mandatory/Optional
Transmission errors	LT Regenerator NT1	M O M
Loopback 1 status (Note)	LT	M
Loopback 1A status (Note)	Regenerator	M
Loopback 2 status (Note)	NT1	M
T reference point power feed status	NT1	O
T reference point power feed fault	NT1	O
T reference point power feed overload	NT1	O
Defect conditions from Table 3	LT Regenerator NT1	M M M
NOTE – The information may be implicit (e.g. activation indication).		

6.3.6 System dependent status report functions

System status reports will be dependent upon the type of digital transmission system used and require further study.

Some examples of a particular system are given in Table 5.

7 Control channel C_{V_1}

This control channel provides, for each direction of transmission, the capability to transfer the commands, status report information and defect conditions.

Although described as a single channel, the control channel may be realized by a number of sub-channels which may use different transport mechanisms (as appropriate to the functions). Even though some of the functions mentioned in 6 have optional status, the C_{V_1} channel shall have the capability to convey all the control information to allow their implementation.

TABLE 5/G.960

System dependent status report functions

Function	Location
Line test relay state	LT
LT test relay state	LT
Remote power switch state	LT
Remote power feed	LT
Induced overvoltage on line	LT
Abnormal current condition	LT
Receive eye opening	LT, REG., NT1
Echo cancellation coefficients	LT, REG., NT1
Battery test	NT1

Annex A

System management requirements

(This annex forms an integral part of this Recommendation)

A.1 Introduction

This annex specifies requirements for interaction between the access digital section and the ET layer 1. In order to ensure correct operation, it is necessary to take into account the assumptions made about the management functions involved in the ET.

In this Recommendation, distinction is made between ET layer 1 and system management. Where the term system management is used, it corresponds to both system management and layer management as defined in Recommendation Q.940.

A.2 System management requirements

A.2.1 General

System management shall not initiate more than one action at a time towards the ET layer 1. An action is delimited by the primitive which is issued by system management and the corresponding primitive which confirms completion of the task.

A.2.2 Error indications

The management entity shall take into account the sequence of primitives before and after the reception of MPH-EI. From the sequence of primitives, the system management may determine the cause of the MPH-EI primitive (e.g. unsuccessful activation of the interface, unsuccessful activation of the access digital section, loss of synchronization or signal at the interface at reference point T).

Upon the occurrence of an error, the ET layer 1 shall notify this event to the system management by means of the primitive MPH-EI. The system management must decide which appropriate actions should be taken (e.g. hold or abandon call, initiate MPH-DR or MPH-DSDR).

A.2.3 Loopback operations

The system management shall take into account that when ET layer 1 is in loopback operation, it does not send any primitives to ET layer 2.

If a primitive is sent by ET layer 2 to ET layer 1 during loopback operation, it will be ignored by ET layer 1.

The setting of the loopbacks 1, 1A and 2 is confirmed to the system management by means of the MPH-AI primitive. The system management shall be able to interpret this MPH-AI as a loopback confirmation and not as a normal activation indication by taking into account the sequence of the primitives.

A.2.4 Continuity test

The continuity test is initiated by the system management using the primitive MPH-AR. The system management must decide when the test is passed (i.e. on reception of MPH-DSAI or MPH-AI). If the system management receives MPH-EI (expiry T1) the test is considered to have failed.

If the test is passed, the system management should check whether a call establishment has been progressed or if there is a call available before sending MPH-DR.

A.2.5 Information to be sent in the D-channel during loopback operation

The information sent in the D-channel shall be an invalid frame as defined in 2.9 “Invalid frames” of Recommendation Q.921.

A.2.6 Configuration control

The system management shall ensure that any action related to configuration control will be issued only when the interface at the T reference point is deactivated.

A.3 Description of the ET layer 1 state transition table

If connection between conflicting activation/deactivation requests from layer 2 and system management occurs it is resolved in the ET layer 1 state machine, which will then pass to the V_1 reference point a coordinated set of Function Elements (FEs). Table A.1 shows the ET layer 1 state machine priority order.

If connection between conflicting activation/deactivation requests from ET side and user side occurs it is resolved in the DS state machine. Table 1 shows the DS state machine priority order.

TABLE A.1/G.960

Priority order of request in the ET layer 1 state machine

Type of request	Priority order
Deactivation request	3 (highest)
Loopback	2
Call control activation request	1
Access digital section partial activation/deactivation request from the ET side	0 (lowest)

A.3.1 ET layer 1 states (ET-states)

Defined below are the states that the ET layer 1 may enter as a result of function elements (FEs) received from the DS across the reference point V_1, service primitives received (PH-, MPH-primitives), or internal events. They are classified according to the functionality they support as follows:

i) ET 1.x states for the support of access activation according to Recommendation I.430 (i.e. "ISDN Customer Access", as defined in Figure 1/I.414);

ii) ET 2.x states for the support of functionality related to loopbacks;

iii) ET 3.x states for the optional support of functionality related to permanent activation of the access digital section are defined in Annex B.

A.3.1.1 State ET 1.0 (Access deactivated)

The access is deactivated (indicated by the receipt of FE 6). Timer T1 is not running.

A.3.1.2 State ET 1.1 (Access activation intiated)

Activation of the access has been initiated (indicated by the receipt of FE 2 followed by FE 3) to establish a call. Timer T1 is running.

A.3.1.3 State ET 1.2 (Access activated)

The access is activated (indicated by the receipt of FE 4). Timer T1 has been stopped.

A.3.1.4 State ET 2.0 (Access in loopback state)

A loopback has been established in the access. Timer T1 is not running.

A..3.1.5 State ET 2.1 (Loopback requested)

A loopback within the access has been requested. Timer T1 is running.

A.3.2 Repertoire of MPH-primitives within the ET for the support of function associated with the DS.

i) MPH-DIGITAL SECTION ACTIVATE REQUEST (MPH-DSAR)

The MPH-DSAR primitive is used to activate the access digital section without activating the interface at the T reference point. This may be required for maintenance purposes. This primitive is also used to configure the access into the permanent activation of the access digital section mode of operation. The configuration control shall ensure that this primitive is issued only when the DS state machine is deactivated (state DS 1.0).

ii) MPH-DIGITAL SECTION ACTIVATE INDICATION (MPH-DSAI)

The MPH-DSAI primitive is issued when FE 3 is received from the access and indicates that the access digital section is fully synchronized. In the optional partial DS activation mode of operation this primitive is also used to indicate deactivation of the interface at reference point T.

iii) MPH-DIGITAL SECTION DEACTIVATE REQUEST (MPH-DSDR)

The MPH-DSDR primitive is used to restore the configuration of the access to the normal activation/deactivation mode of operation from the optional partial activation of the access digital section mode of operation. The configuration control shall ensure that this primitive is issued only when the interface at the T reference point is deactivated.

iv) MPH-AWAKE INDICATION (MPH-AWI)

The MPH-AWI primitive is issued when FE 2 is received from the access digital section to notify the system management that activation of the access has been initiated.

v) MPH-ERROR INDICATION (MPH-EI)

The MPH-EI primitive is issued when an activation or loopback operation attempt has failed, or when FE 7 (defect condition) or FE 12 (LOS/LFA at T) is received.

The primitives below are associated with maintenance functions based on loopbacks. The activate request primitives include the activation of the access digital section and possibly the user-network interface at reference point T. The establishment of the requested loopback is notified to the requester by means of the MPH-AI primitive. The deactivation of a loopback is invoked by means of the MPH-DSDR primitive, or alternatively the MPH-DR primitive, as appropriate.

MPH-L2AR Activation request for loopback 2.

MPH-L1AR Activation request for loopback 1.

MPH-L1AAR Activation request for loopback 1A.

The primitives below are used for other purposes than loopbacks (continuity test).

MPH-AR Request to activate the access for continuity testing.

MPH-AI Access activation indication.

A.3.3 ET layer 1 state transition table

The state transition table, Table A.2, specifies the procedures, showing actions to be taken in response to various events while in a specific state. It specifies the interactions with ET layer 2 and system management which are required to support the layer interface procedures defined in Recommendation I.430 and the interfaces across the layer interface between ET layer 1 and the system management for the support of functions associated with the access digital section.

Timer T1 is functionally part of the ET. For ease of description it is associated with layer 1 of the ET, but may be implemented anywhere.

A.3.4 Assumptions made in specifying the procedures (ET 1.x states)

a) The response to the receipt of an indication (FE) from the DS which should not normally occur in the current ET state shall be to issue the corresponding primitive to the management for interpretation with no state change of the ET.

b) The response to a request for an operation which is currently in progress shall be: no state change, no action (–).

c) Upon receipt of FE 7 from the access digital section, two alternatives exist for the ET state machine (see also 5.4.1.8):

   i) The ET shall issue FE 5 (deactivate access) to confirm the response of the access to the defect condition.

   ii) The ET may check persistence of the condition and issue FE 5 when appropriate.

d) Upon receipt of FE 12 (LOS/LFA at T) from the DS while in the access activated state (ET 1.2), the ET state machine shall issue MPH-EI to the management with no state change of the ET.

TABLE A.2/G.960

State transition table of ET layer 1
(ET layer 1 state machine)

State number	ET 1.0	ET 1.1	ET 1.2	ET 2.0	ET 2.1
State name Event:	Access deactivated T1 stopped	Access activation initiated T1 running	Access activated T1 stopped	Access in loopback state T1 stopped	Loopback requested T1 running
PH-AR/MPH-AR	Start T1 FE 1 ET 1.1	–	MPH-AI PH-AI –	PH-DI –	PH-DI –
MPH-DR	–	Stop T1 FE 5 ET 1.0	PH-DI FE 5 ET 1.0	FE 5 ET 1.0	|
FE 2	Start T1 MPH-AWI FE 1 (optional) ET 1.1	MPH-AWI –	MPH-AWI –	/	–
Expiry of timer T1	/	MPH-EI ET 1.0	/	/	MPH-EI ET 1.0
FE 3	(Note 2) MPH-DSAI –	MPH-DSAI –	MPH-DSAI –	To be specified	To be specified
FE 4	(Note 2) MPH-AI –	Stop T1 PH-AI MPH-AI ET 1.2	–	To be specified	Stop T1 MPH-AI ET 2,0
FE 8	MPH-DI –	MPH-DI –	MPH-DI –	To be specified	To be specified
FE 12 (Note 4)	/	–	MPH-EI –	To be specified	To be specified
FE 7	MPH-DI –	MPH-DI MPH-EI Stop T1 FE 5 (Note 5) ET 1.0	MPH-DI MPH-EI FE 5 (Note 5) ET 1.0	To be specified	To be specified
MPH-L2AR	Start T1 FE 8 ET 2.1	|	|	|	|
MPH-L1AR	Start T1 FE 9 ET 2.1	|	|	|	|
MPH-L1AAR	Start T1 FE 10 ET 2.1	|	|	|	|
MPH-DSAR (Note 1)	Start T1 FE 11 ET 3.0	–	|	|	|
MPH-DSDR (Note 1)	(Note 3) FE 5 –	–	|	FE 5 ET 1.0	|

– No state change, no action when event occurs

| Impossible event due to internal reasons or peer-to-peer procedures

/ Impossible event by definition of the layer 1 service

FE... Issue function element FE... across V_1 reference point

ET a.b Enter state ET a.b.

NOTE – A description of timer T1 can be found in Note 1 to Table 6/I.430.

TABLE A.2/G.960 *(end)*

State transition table of ET layer 1
(ET layer 1 state machine)

NOTES

1 The primitives MPH-DSAR and MPH-DSDR are allowed only if the T interface is deactivated. The management has to meet this requirement.

2 These events occur if timer T1 expires concurrently with the completion of a task which the access digital section indicates to ET layer 1 by means of the appropriate function element (FE 3 and FE 4). It is a situation caused by excessive delay within the access digital section. In some cases it is advantageous to issue the appropriate primitive to notify to management the status of the customer access subsequent to the error indication which would have been conveyed in an MPH-EI primitive. This provides the management with the information to initiate the optimum recovery procedure.

3 This event occurs if timer T1 expired and management invokes a deactivation as a consequence of the receipt of the MPH-EI primitive. In particular, this recovery seems to be useful in case of excessive delays (see Note 2).

4 The Function Element FE 12 is not available on all networks. FE 12 indicates to the ET state machine LOS/LFA at the user side of the T reference point.

5 This is the reaction relevant for case a), as defined in A.3.4 c). For case b), the reaction shall be MPH-EI (no state change).

Annex B

Partial activation of the access digital section

(This annex forms an integral part of this Recommendation)

B.1 Introduction

This annex describes the partial activation of the access digital section without activating the user network interface. However, the use of the functionalities provided are a network provider option. The necessary elements for the provision of these functionalities are reserved for this use (e.g. primitives, bit coding, bits) and cannot be reallocated to any other functions.

In this annex, the state transition tables for the DS and ET are complete, the specific parts relating to partial activation of the digital section are outlined. The DS state table is given in Table B.1 and the ET state table is given in Table B.2.

B.2 Description of the state transition tables

The description of states DS1.x and DS2.x can be found in 5.4.

B.2.1 State DS 3.0 (DS only activation initiated)

The access has entered this state from DS 1.0 following the receipt from the ET of FE 11. FE 2 is returned to the ET and INFO 0 is sent to the user. Viewed from the user side of the T reference point the network is in state G1 according to 6.2.1.2.1/I.430. The DS state machine remains in this state until the DS is synchronized in both directions.

B.2.2 State DS 3.1 (DS activated, T interface deactivated)

The DS is synchronized in both directions and this has been notified to the ET by FE 3. This is the stable deactivated state for the **partial** DS activatation mode of operation, so INFO 0 is sent to the user. Viewed from the user side of reference point T the network is in state G1 according to 6.2.1.2.1/I.430.

B.2.3 State DS 3.2 (DS activated, T interface activating)

Activation of the interface at the T reference point has been initiated either by the receipt of FE 1 from the ET or by the receipt of INFO 1 from the user, while the DS state machine was in state DS 3.1. FE 2 is sent to the ET, but as the access digital section is already fully synchronized, INFO 2 is sent to the user while the receipt of INFO 3 from the user is awaited. Viewed from the user side of reference point T the network is in state G2 according to 6.2.1.2.2/I.430. Upon receipt of INFO 3 from the user the DS state machine will change to state DS 3.3.

B.2.4 State DS 3.3 (Access activated)

The access is in its stable active state, equivalent to DS 1.4 in the normal mode of operation. INFO 3 has been received from the user and INFO 4 returned (see Note 4 of DS state transition table). FE 4 is sent to the ET. Viewed from the user side of reference point T the network is in state G3 according to 6.2.1.2.3/I.430.

B.2.5 State DS3.4 (LOS/LFA at T)

This state is equivalent to DS 1.5 in the normal mode of operation. The signal or frame alignment has been lost on the user side of the T reference point while the access is in its stable active state. This may have been caused, for example, by the temporary removal of the terminal (the terminal portability facility). INFO 2 is sent to the user to assis rapid re-synchronization of the terminal, and FE 12 is sent to the ET while awaiting either the receipt of INFO 3 from the user, or FE 11 from the ET (instruction to deactivate interface at T reference point). Viewed from the user side of reference point T the network is in state G2 according to 6.2.1.2.2/I.430. Upon receipt of INFO 3 from the user, the DS state machine returns to state DS 3.3

B.2.6 State DS 3.5 (T interface deactivating)

Deactivation of the interface at the T reference point has been initiated in response to the receipt of FE 11 from the ET. FE 3 is returned to the ET and INFO 0 is sent to the user. Viewed from the user side of reference point T the network is in state G4 according to 6.2.1.2.4/I.430. Upon the receipt of INFO 0 from the user or the expiry of timer T2, the DS state machine changes to state DS 3.1.

B.3 Description of the ET state transition table

The description of states ET1.x and ET2.x can be found in A.3.1.

B.3.1 State ET 3.0 (DS only activation initiated)

This state is entered from ET 1.0 in response to the receipt of MPH-DSAR. FE 2 is received from the DS. Timer T1 is running.

B.3.2 State ET 3.1 (DS activated, interface at T deactivated)

This is the deactivated state for the partial access digital section activation mode of operation. It is entered either from state ET 3.0 following the receipt of FE 3 from the DS or from states ET 3.2 or ET 3.3 in response to the receipt of MPH-DR. Timer T1 has been stopped.

B.3.3 State ET 3.2 (DS activated, interface at T activation initiated)

This state is entered from ET 3.1 in response to the receipt of PH-AR or MPH-AR, or FE 2 from the DS. Timer T1 is running.

B.3.4 State ET 3.3 (DS activated, interface at T activated)

This state is equivalent to ET 1.2 (Access activated) is the normal mode of operation. FE 4 has been received from the DS. Timer T1 has been stopped.

NOTE – The usual way to enter or to leave the optional partial activation of the access digital section mode of operation (the DS 3.x states) is by means of the primitives MPH-DSAR and MPH-DSDR, respectively. Thus, while the access is in this mode of operation, the primitives PH-/MPH-AR and MPH-DR serve only to activate and deactivate the interface at the T reference point, the access digital section remaining activated.

TABLE B.1/G.960

State transition table of digital section
(DS state machine)

State number	DS 1.0	DS 1.1	DS 1.2 (Note 5)	DS 1.3	DS 1.4	DS 1.5	DS 1.6	DS 1.7
State name	Access deactivated	Access activation:			Access activated	Access activated:	Access deactivation: Initiated	Network defect
		Initiated	DS synch. LT → NT	DS activated		LOS/LFA at T		
FE sent	FE 6	FE 2 (Note 7)	FE 2	FE 3	FE 4	FE 12 (Note 1)	FE 4	FE 7
INFO sent	INFO 0	INFO 0	INFO 2	INFO 2	INFO 4	INFO 2	INFO 0	(Note 2)
Event: Internal state	G1	G1	G2	G2	G3	G2	G4	(Note 2)
FE 1	DS 1.1	–	–	–	–	–	DS 1.1	–
FE 5	–	Start T2 DS 1.6	Start T2 DS 1.6	Start T2 DS 1.6	Start T2 DS 1.6	Start T2 DS 1.6	–	DS 1.0
Receiving INFO 0	–	–	–	–	DS 1.5	–	DS 1.0	–
Receiving INFO 1	DS 1.1	–	–	–	/	–	–	–
Receiving INFO 3	–	–	–	(Note 4) DS 1.4	–	DS 1.4 (Note 4)	–	–
LOS/LFA at T	/	–	–	–	DS 1.5	–	–	–
Expiry of timer T2 (Note 3)	–	–	–	–	–	–	DS 1.0	–
DS synchronized LT → NT		DS 1.2	–	–	–	–	–	–
DS activated	/	/	DS 1.3	–	–	–	–	(Note 6)
DS deactivated	–	–	–	/	/	/	DS 1.0	–
Elément FE 8	DS 2.x	|	|	|	|	|	|	|
Elément FE 9	DS 2.x	|	|	|	|	|	|	|
Elément FE 10	DS 2.x	|	|	|	|	|	|	|
LOS/LFA at either NT or LT line side; or Loss of NT power	–	DS 1.7	DS 1.7	DS 1.7	DS 1.7	DS 1.7	DS 1.7	–
FE 11	DS 3.0	–	–	–	–	–	–	–

TABLE B.1/G.960 *(continued)*

State transition table of digital section
(DS state machine)

State number	DS 3.0	DS 3.1	DS 3.2	DS 3.3	DS 3.4	DS 3.5
State name	DS only activation initiated	DS activated:		Access activated	Access activated:	
		T interface deactivated	T interface activating		LOS/LFA at T	T interface deactivating
FE sent	FE 2	FE 3	FE 2	FE 4	FE 12 (Note 1)	FE 3
INFO sent	INFO 0	INFO 0	INFO 2	INFO 4	INFO 2	INFO 0
Event: Internal state	G1	G1	G2	G3	G2	G4
FE 1	–	DS 3.2	–	–	–	DS 3.2
FE 5	Start T2 DS 1.6	Start T2 DS 1.6	Start T2 DS 1.6	Start T2 DS 1.6	Start T2 DS 1.6	DS 1.6
Receiving INFO 0	–	–	–	DS 3.4	–	DS 3.1
Receiving INFO 1	–	DS 3.2	–	/	–	–
Receiving INFO 3	–	–	(Note 4) DS 3.3	–	DS 3.3 (Note 4)	–
LOS/LFA at T	/	/	/	DS 3.4	–	–
Expiry of timer T2 (Note 3)	–	–	–	–	–	DS 3.1
DS synchronized LT → NT		–	–	–	–	–
DS activated	DS 3.1	–	–	–	–	–
DS deactivated	–	/	/	/	/	/
FE 8	|	|	|	|	|	|
FE 9	|	|	|	|	|	|
FE 10	|	|	|	|	|	|
LOS/LFA at either NT or LT line side; or Loss of NT power	DS 1.7	DS 1.7	DS 1.7	DS 1.7	DS 1.7	DS 1.7
FE 11	–	–	Start T2 DS 3.5	Start T2 DS 3.5	Start T2 DS 3.5	–

–	No state change, no action when even occurs
/	Impossible event due to internal reasons or peer-to-peer procedures
|	Impossible event due to definition of the layer 1 service
FE...	Issue function element FE... across V_1 reference point
DS a.b	Enter state DS a.b.

TABLE B.1/G.960 *(end)*

State transition table of digital section
(DS state machine)

NOTES

1 FE 12 may not be provided in some networks.

2 The INFO sent to the user and the corresponding G state depends on the NT1 state and also on the NT1 and LT state machine defined for the individual transmission system in Recommendation G.961.

3 A description of timer T2 can be found in Note 2 to Table 6/I.430.

4 As an implementation option, to avoid premature transmission of information (i.e. INFO 4), the DS state machine may introduce a delay before it changes state, i.e. see Note 4 to Table 6/I.430.

5 As an implementation option, INFO 2 shall be only sent when the DS is synchronized in both directions. Thus in the DS 1.2 state, INFO 0 is sent across the interfaces at the T reference point and the user perceives the DS to have the internal state G1.

6 A network unable to recover from a network defect shall take no action and make no state change when the even “DS activated” occurs. Networks able to recover from a network defect shall change to state DS 1.3.

7 FE 2 may not be sent in response to FE 1.

TABLE B.2/G.960

State transition table of ET layer 1
(ET layer 1 state machine)

State number	ET 1.0	ET 1.1	ET 1.2	ET 2.0	ET 2.1
State name Event:	Access deactivated T1 stopped	Access activation initiated T1 running	Access activated T1 stopped	Access in loopback state T1 stopped	Loopback requested T1 running
PH-AR/MPH-AR	Start T1 FE 1 ET 1.1	–	MPH-AI PH-AI –	PH-DI –	PH-DI –
MPH-DR	–	Stop T1 FE 5 ET 1.0	PH-DI FE 5 ET 1.0	FE 5 ET 1.0	|
FE 2	Start T1 MPH-AWI FE 1 (optional) ET 1.1	MPH-AWI –	MPH-AWI –	/	–
Expiry of timer T1	/	MPH-EI RT 1.0	/	/	MPH-EI ET 1.0
FE 3	(Note 2) MPH-DSAI	MPH-DSAI –	MPH-DSAI –	To be specified	To be specified
FE 4	(Note 2) MPH-AI –	Stop T1 PH-AI MPH-AI ET 1.2	–	To be specified	Stop T1 MPH-AI ET 2.0
FE 8	MPH-DI –	MPH-DI –	MPH-DI –	To be specified	To be specified
FE 12 (Note 4)	/	–	MPH-EI –	To be specified	To be specified
FE 7	MPH-DI –	MPH-DI MPH-EI Stop T1 FE 5 (Note 5) ET 1.0	MPH-DI MPH-EI FE 5 (Note 5) ET 1.0	To be specified	To be specified
MPH-L2AR	Start T1 FE 8 ET 2.1	|	|	|	|
MPH-L1AR	Start T1 FE 9 ET 2.1	|	|	|	|
MPH-L1AAR	Start T1 FE 10 ET 2.1	|	|	|	|
MPH-DSAR (Note 1)	Start T1 FE 11 ET 3.0	–	|	|	|
MPH-DSDR (Note 1)	(Note 3) FE 5 –	–	|	FE 5 ET 1.0	|

TABLE B.2/G.960 *(continued)*

State transition table of ET layer 1
(ET layer 1 state machine)

State number	ET 2.0	ET 2.1	ET 3.2	ET 3.3
State name Event:	Access only activation initiated T1 running	Access activated T deactivated T1 stopped	Access activated T activation initiated T1 running	Access activated T activated T1 stopped
PH-AR/MPH-AR	–	Start T1 FE 1 ET 3.2	–	MPH-AI PH-AI
MPH-DR	–	PH-DI	FE 11 ET 3.1	PH-DI FE 11 ET 3.1
FE 2	–	Start T1 MPH-AWI FE 1 ET 3.2	MPH-AWI –	MPH-AWI –
Expiry of timer T1	MPH-EI ET 1.0	/	MPH-EI ET 3.1	/
FE 3	Stop T1 MPH-DSAI ET 3.1	(Note 2) MPH-DSAI	–	MPH-DSAI –
FE 4	MPH-AI –	(Note 2) MPH-AI	Stop T1 PH-AI MPH-AI ET 3.3	–
FE 8	–	MPH-DI	MPH-DI	MPH-DI
FE 7	MPH-DI MPH-EI Stop T1 FE 5 (Note 5) ET 1.0	MPH-DI MPH-EI FE 5 (Note 5) ET 1.0	MPH-DI MPH-EI Stop T1 FE 5 (Note 5) ET 1.0	MPH-DI MPH-EI FE 5 (Note 5) ET 1.0
FE 12 (Note 4)	–	–	–	MPH-EI
MPH-L2AR	|	|	|	|
MPH-L1AR	|	|	|	|
MPH-L1AAR	|	|	|	|
MPH-DSAR (Note 1)	–	|	|	|
MPH-DSDR (Note 1)	Stop T1 FE 5 ET 1.0	FE 5 ET 1.0	|	|

– No state change, no action when event occurs

| Impossible event due to internal reasons or peer-to-peer procedures

/ Impossible event due to definition of the layer 1 service

FE... Issue function element FE... across V_1 reference point

ET a.b Enter state ET a.b.

NOTE – A description of timer T1 can be found in Note 1 to Table 6/I.430.

TABLE B.2/G.960 *(end)*

State transition table of ET layer 1
(ET layer 1 state machine)

NOTES

1 The primitive MPH-DSAR and MPH-DSDR are allowed only if the T interface is deactivated. The management has to meet this requirement.

2 These events occur if timer T1 expires concurrently with the completion of a task which the access digital section indicates to ET layer 1 by means of the appropriate function element (FE 3 and FE 4). It is a situation caused by excessive delay within the access digital section. In some cases it is advantageous to issue the appropriate primitive to notify to management the status of the customer access subsequent to the error indication which would have been conveyed in an MPH-EI primitive. This provides the management with the information to initiate the optimum recovery procedure.

3 This event occurs if timer T1 expired and management invokes a deactivation as a consequence of the receipt of the MPH-EI primitive. In particular, this recovery seems to be useful in case of excessive delays. (See Note 2.)

4 The Function Element FE 12 is not available on all networks. FE 12 indicates to the ET state machine LOS/LFA at the user side of the T reference point.

5 This is the reaction relevant for case a), as defined in A.3.4 c). For case b), the reaction shall be MPH-EI (no state change).