INTERNATIONAL TELECOMMUNICATION UNION

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THE INTERNATIONAL
TELEGRAPH AND TELEPHONE
CONSULTATIVE COMMITTEE

RED BOOK

VOLUME VI – FASCICLE VI.5

DIGITAL TRANSIT EXCHANGES IN INTEGRATED DIGITAL NETWORKS AND MIXED ANALOGUE-DIGITAL NETWORKS

DIGITAL LOCAL AND COMBINED EXCHANGES

RECOMMENDATIONS Q.501-Q.517

VIII[TH] PLENARY ASSEMBLY
MALAGA-TORREMOLINOS, 8-19 OCTOBER 1984

Geneva 1985

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PRELIMINARY NOTES

1 The Questions entrusted to each Study Group for the Study Period 1985-1988 can be found in Contribution No. 1 to that Study Group.

2 In this Fascicle, the expression "Administration" is used for shortness to indicate both a telecommunication Administration and a recognized private operating agency.

3 The strict observance of the specifications for standardized international signalling and switching equipment is of the utmost importance in the manufacture and operation of the equipment. Hence these specifications are obligatory except where it is explicitly stipulated to the contrary.

The values given in Fascicles VI.1 to VI.9 are imperative and must be met under normal service conditions.

FASCICLE VI.5

Recommendations Q.501 to Q.517

DIGITAL TRANSIT EXCHANGES IN INTEGRATED DIGITAL NETWORKS AND MIXED ANALOGUE DIGITAL NETWORKS

DIGITAL LOCAL AND COMBINED EXCHANGES

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SECTION 1

DIGITAL TRANSIT EXCHANGES IN INTEGRATED DIGITAL NETWORKS AND MIXED ANALOGUE DIGITAL NETWORKS

Recommendation Q.501

INTRODUCTION, FIELD OF APPLICATION AND BASIC FUNCTIONS

1 Introduction

This series of Recommendations Q.501-Q.507, applies to digital transit exchanges for telephony in Integrated Digital Networks (IDNs) and mixed analogue/digital networks. It will also form the basis for digital switching in Integrated Services Digital Networks (ISDNs) when other services are integrated with telephony.

The series of Recommendations comprises:

Q.501 Introduction, field of application and basic functions

Q.502 Interfaces

Q.503 Connections, signalling, control, call handling and ancillary functions

Q.504 Performance and availability design objectives

Q.505 Exchange measurements

Q.506 Operations and maintenance functions

Q.507 Transmission characteristics

Considerations have been based primarily on exchanges utilizing, at least in part, time division switching techniques. However, these Recommendations are implementation independent and other system implementations using alternative techniques (e.g. space division switching) may be possible, which would meet the requirements of these Recommendations.

2 Field of application

These Recommendations are intended to be applied as indicated below:

2.1 *Application and evolution to the ISDN*

The selection of features, functions and interfaces to be provided in a digital transit exchange in a particular network application will be determined by the Administration concerned. Not all the recommended features, functions and interfaces will necessarily be provided in every digital transit exchange.

These Recommendations are intended to facilitate the use of a digital transit exchange in an IDN or an ISDN and to allow for evolution of the network in which the exchange is used from analogue through to a full ISDN as described in Recommendation I.120.

2.2 *Relationship of design objective performance requirements to operational performance requirements*

Performance requirements as defined in this series of Recommendations should be considered as design objectives for systems under the conditions stated in the Recommendations. These conditions are defined by such parameters as average circuit occupancy, busy hour call attempts, etc. They should be distinguished from the operational performance requirements which Administrations and RPOAs establish for exchanges operating in their particular environment.

Further clarification of this point can be obtained in Recommendation G.102.

3 **Basic functions**

Reference to a function in these Recommendations including their diagrams, does not imply that it will necessarily be provided in every exchange configuration. Similarly, it is possible that some functions may be provided which are not mentioned. The actual exchange configurations are matters of choice for individual Administrations as discussed in § 2.1 above.

3.1 *Interfaces (Recommendation Q.502)*

The interface functions defined are those necessary for interworking with both digital and analogue transmission systems. They relate to circuits to other exchanges and to other networks.

Interfaces with non-voice handling facilities and with centralized operation and maintenance centres are also defined.

3.2 *Connections, signalling, control, call handling and ancillary functions (Recommendation Q.503)*

This Recommendation covers the following functions:

3.2.1 *Timing and synchronization*

Timing comprises the generation and distribution of timing signals and includes timing of outgoing signals. It enables those parts of the exchange which form the switched path of a connection to operate synchronously.

Synchronization will depend on the national synchronization plan and exchange timing arrangements.

Exchanges will usually extract syncronizing information from one or more incoming bit streams or a separate synchronization network and use this to adjust the timing signals generated in and distributed within the exchange.

3.2.2 *Connections through an exchange*

This includes the switch block(s) and the characteristics associated with connections through the exchange.

Switching may include one or more stages of time and/or space switching, providing a path for transmission through the exchange.

3.2.3 *Signalling*

Signalling includes reception of call-related and other information, interaction with the call control function and transfer of information to the network(s) as required.

Signalling may involve common channel and/or channel associated signalling.

3.2.4 *Control and call handling*

Control and call handling includes initiation, supervision and termination of most actions in the exchange.

Commands are initiated and information passed/received to/from the other functions within the exchange.

Control functions may be contained in one block or distributed throughout the exchange.

3.2.5 *Ancillaries*

Examples of such functions are:

– recorded announcements;

– tone generation;

– conferencing facilities.

Their location is dependent on the function itself and the exchange configuration.

3.3 *Performance and availability design objectives (Recommendation Q.504)*

Exchange performance and availability design objectives are defined for guiding system design and for comparing the capabilities of different systems. (Recommendations relating to provisioning and operational performance of exchanges in the network are covered in the E.500-E.543 series).

3.4 *Exchange measurements (Recommendation Q.505)*

Measurements that may be used for planning, operation, maintenance, and network management of exchanges and their associated networks are described. The measurement data consists primarily of event counts and traffic intensity levels experienced by the various traffic handling elements of the exchange.

3.5 *Operations and maintenance functions (Recommendation Q.506)*

This Recommendation defines the functions that a transit exchange should be capable of performing in order for it to be operated and maintained in its intended application.

3.6 *Transmission characteristics (Recommendation Q.507)*

This Recommendation defines, for the possible types of connection which might be set up by a transit exchange, the necessary levels of transmission performance to conform with overall objectives for the complete user-to-user connections in which the exchange might be involved.

Recommendation Q.502

INTERFACES

1 General

This Recommendation applies to digital transit exchanges for telephony in Integrated Digital Networks (IDNs) and mixed (analogue/digital) networks. It will form the basis for digital switching in Integrated Services Digital Networks (ISDNs) when other services are integrated with telephony. The field of application of this Recommendation is found in Recommendation Q.501.

2 Interfaces

Interfaces associated with a digital transit exchange are shown in Figure 1/Q.502. The transmission/switching boundary in the figure is for specification purposes and does not imply any particular arrangement.

2.1 *Characteristics of interfaces to other exchanges*

2.1.1 *Digital environment*

2.1.1.1 *Interface A*

Interface A is a digital interface described in Recommendations G.703, G.704 and G.705.

The characteristics of the multiplex structure and frame structure at interface A are given in Recommendations G.732, G.733, G.704 [1] and G.705.

The main characteristics:

- Nominal bit rate: 2048/1544 kbit/s;
- Number of bits per channel time slot: 8, numbered 1 to 8;
- Number of channel time slots per frame: 32/24, numbered 0-31/1-24;
- Additional signalling capacity. Where more signalling capacity is required between exchanges, additional channel time slots may be utilized for common channel signalling. For 2048 kbit/s systems they should be selected from the channel time slots allocated for data purposes in PCM multiplex equipment according to Recommendation G.735. When no such channel time slots are allocated or available, additional channel time slots may be selected from channel time slots allocated for voice channels.
- Timing in the transmitting direction will be derived within the digital exchange.

For 2048 kbit/s systems:

- Channel time slot 16 is primarily intended for signalling but should be switchable. On systems between exchanges (not involving PCM primary muldex), when channel 16 is not assigned to carry signalling it may be allocated to speech or other services.
- Channel time slot 0 is used for frame alignment, alarm indication network synchronization and other purposes.
- Although no specific application is at present foreseen for switching time slot 0, it is recommended that the possibility of read and write access to this time slot should be retained as a safeguard for future requirements. Such access would allow processing of some or all of the information contained in this time slot, in particular those bits reserved for national and international use. The need to switch channel time slot 0 as a normal channel, without special access, requires further study. In any case the incoming frame alignment signal will not be passed through the exchange to an outgoing system.

2.1.1.2 *Interface B*

Interface B is a digital interface described in Recommendations G.703, G.704 and G.705.

The characteristics of the multiplex structure and frame structure at interface B are given in Recommendations G.744, G.704, G.746 and G.705.

The main characteristics of Interface B are:

- Nominal bit rate: 8448/6312 kbit/s.
- Number of bits per channel time slot: 8, numbered 1 to 8.
- Number of channels: 132/98, numbered 0-131/1-98.
- Timing in the transmitting direction will be derived within the exchange.

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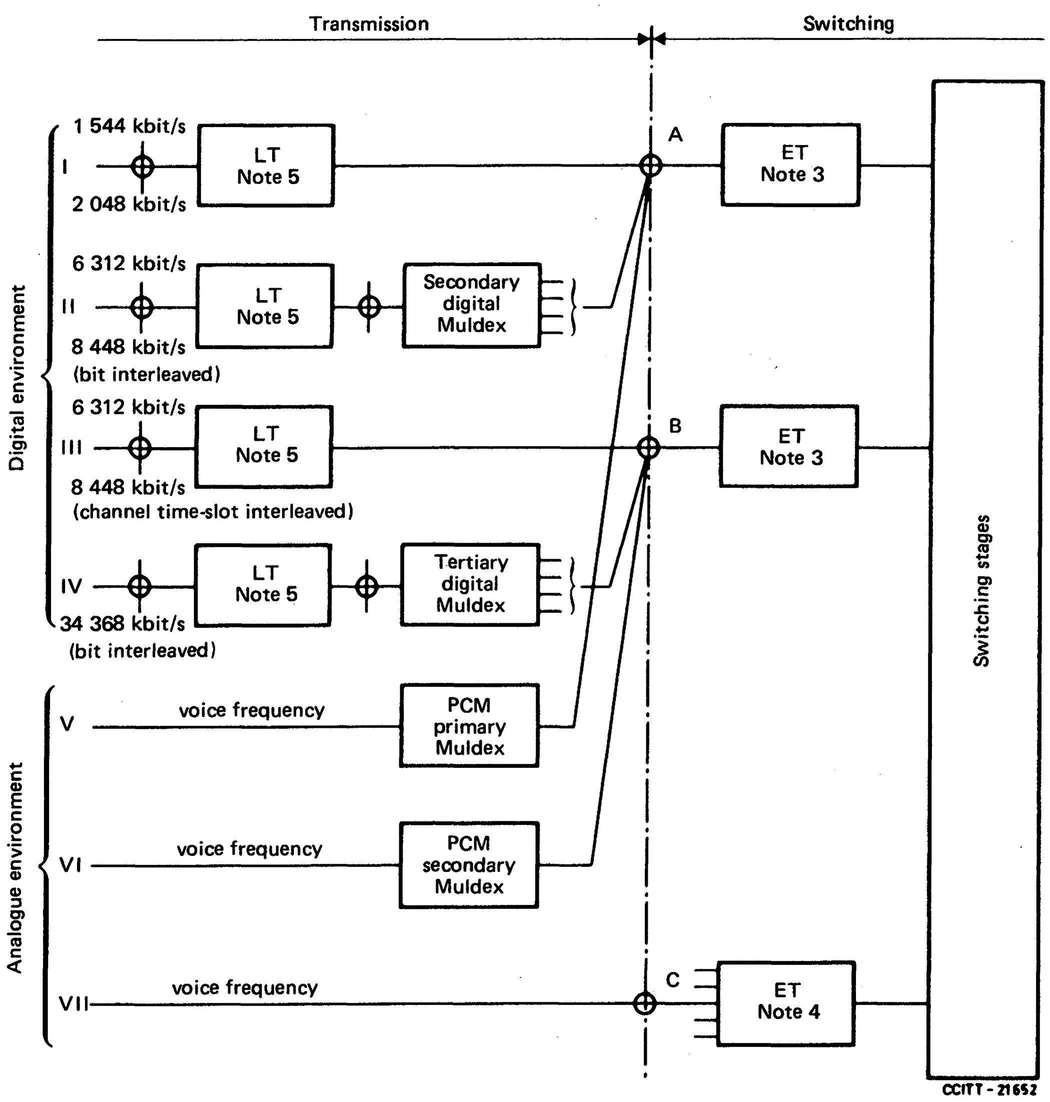
[1] The exchange implications of some aspects of Recommendation G.704 including the CRC check have not yet been considered. It should therefore be understood that at present digital exchanges need not incorporate the features/facilities necessary to comply with this CRC check procedure.



Note 1 – The G and Q Series CCITT Recommendations applicable to each interface are detailed in the text.

Note 2 – Other configurations, such as series connection of secondary, tertiary or higher order muldex, may be used.

Note 3 – Examples of functions of Exchange Termination (ET) – interfaces A & B:
- Signalling insertion and extraction
- Code conversion
- Frame alignment
- Alarms and fault indication.

Note 4 – Examples of functions of Exchange Termination (ET) – interface C:
- A/D conversion
- Signalling insertion and extraction
- Multiplexing
- 2-wire/4-wire conversion.

Note 5 – Examples of functions of Line Termination (LT):
- Power feed
- Fault location
- Regeneration
- Code conversion.

Note 6 – Not all interfaces will necessarily exist in every implementation.

FIGURE 1/Q.502

Interfaces associated with a digital transit exchange

i) For 8448 kbit/s systems:

- Frame structure: the frame structure, frame alignment procedures and standard channel time slot assignment will be as defined in Recommendations G.744, G.704 and G.705. Where signalling capacity is required between exchanges, time slots 67, 68, 69 and 70 can be utilized for signalling in this order of descending priority. Those channels not used for signalling can be used for speech or other purposes. If a channel time slot is reserved for service purposes within the switch, it shall be channel time slot 1.
- It is left for mutual agreement whether or not channel time slot 1 will carry traffic.
- 128 of the channel time slots may carry traffic through the exchange.

ii) For 6312 kbit/s systems:

- Fundamental characteristics – the multiplex structure contains 5 bits and 98 channel time slots, each of 64 kbit/s, of which 96 may carry traffic through the exchange.
- Frame structure: the frame structure, frame alignment procedures and standard channel time slot assignment will be defined in Recommendations G.746, G.704 and G.705. Five bits per frame are assigned for a frame alignment signal and for other signals. Time slots 97 and 98 are assigned to signalling between exchanges.
- Use of channel time slots 97 and 98 for common channel signalling is under study.
- Note from G.746: interface conditions and fundamental functions of digital ET equipment used to terminate bit interleaved 6312 kbit/s paths are under study.

2.1.2 *Analogue environment*

2.1.2.1 *Interface C*

Interface C is a 2 or a 4 wire analogue interface. This implies that a PCM codec, connected to this interface, is incorporated in the digital exchange. Voice-frequency connections over the interface C should conform to Recommendation Q.507. The equipment at the exchange side of interface C may include a muldex within the exchange terminal functions.

2.2 *Interfaces to operations, maintenance and network management centres (OMCs)*

§ 2.2.1 gives general considerations regarding the information to be transferred between digital transit exchanges and OMCs, and some possible access arrangements. The functional characteristics that the interfaces are required to provide are given in § 2.2.2, the recommended data transfer procedures are given in § 2.2.3, and the information transferred is specified in Recommendations Q.505 and Q.506.

Note that Man-Machine Language (MML) is recommended by CCITT (Z.300-series Recommendations), for exchange and OMC system man-machine interaction. The functional characteristics and procedures of the interface between exchange and OMC system should not preclude the effective use of MML at either the exchange or the OMCs.

2.2.1 *General aspects and access arrangements*

2.2.1.1 Interfaces are provided to facilitate the transfer of information between exchanges and locations where administrative, maintenance, network management and operation functions are performed. Items (a) and (b) below illustrate examples of information that may cross the interface and which may need to be catered for. (The choice of information that crosses the interface is a matter for each Administration/Operating Agency.)

a) The information transferred from the exchange to OMCs may include customer usage and charging data, exchange system status indication, system resource utilization data, system performance measurements, alarms and messages alerting operating personnel to the current state of the exchange.

b) The information transferred to the exchange from OMCs may include commands for system initializations and configuration control, data to effect changes in system operation, commands to initiate, terminate, or otherwise modify the services provided to customers, requests for status information and so forth.

2.2.1.2 An exchange may have access to one or more Operation, Maintenance and Network Management Centres.

2.2.1.3 Access may be provided using separate data links to each centre, multiplexed data links, or one or more data networks.

2.2.1.4 The choice between single and multiple physical links at the exchange, and the configuration of the centres is a national matter, not subject to CCITT Recommendation.

2.2.2 *Functional characteristics of the interface to OMCs*

2.2.2.1 The exchange should not depend for its basic operation on the correct functioning of the OMC(s).

2.2.2.2 The interface should provide basic initialization, error detection and automatic recovery procedures for the data link.

2.2.2.3 The interface should support data transport mechanisms that may be employed by the exchange and the OMC systems to assure the reliable transfer of particular information (e.g. charging data).

2.2.2.4 The interface should support the setting of priorities by the exchange or OMC system for the use of the transmission medium (data links).

2.2.2.5 The interface should support priority transfer of urgent messages.

2.2.2.6 The interface should support operation at one or more bit rates to cater for the efficient and economical transfer of types of information such as those described in § 2.2.1.1.

2.2.3 *Procedures for data transfer between transit exchanges and OMCs*

2.2.3.1 Procedures for control of the links between an exchange and the OMCs to which it has access, and for the transfer of data may be implemented using a transport service in accordance with either Recommendation X.25 or Signalling System No. 7 (an operation and maintenance application part is being defined for Signalling System No. 7 to provide higher level functions). The choice between these alternatives is a matter for further study by individual administrations.

2.3 *Interfaces to non-voice handling facilities*

The need for the recommendation of interfaces between digital local and combined exchanges and non-voice handling facilities remains for further study. (An example of such a non-voice facility is a packet switched data node.) Attention is drawn to Recommendation X.300 which describes the general principles for interworking between public data networks and other public networks.

2.4 *Other interfaces*

Study and recommendation of other interfaces may take place.

3 **Jitter and wander at the exchange input : Interfaces A and B**

Jitter and wander tolerance is the ability of the exchange to accept phase deviations on incoming facilities without introducing slips or errors.

The jitter and wander tolerance mask of Figure 2/Q.502 shall be used to specify jitter and wander at digital interface inputs A and B in Figure 1/Q.502 when not used for synchronization purposes.

Jitter and wander are similar phenomena. At frequencies above f_1 in Figure 2/Q.502, the term "jitter" is used. At frequencies below f_1 the term "wander" is used.

The recommended values for the mask of tolerable sinusoidal peak-to-peak jitter and wander are given in Table 1/Q.502. The value of f_0 for 1544 kbit/s systems is provisional.

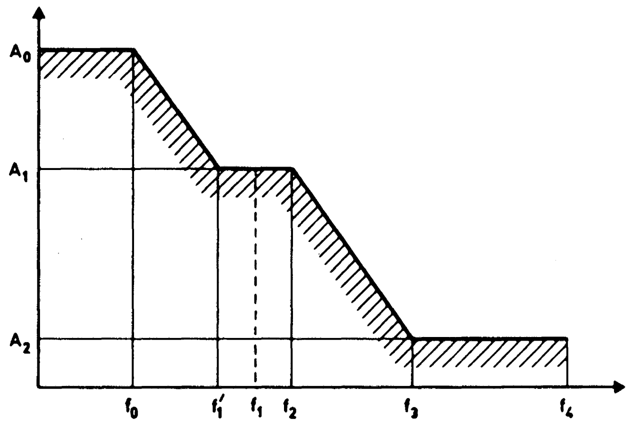


FIGURE 2/Q.502

Mask of tolerable sinusoidal jitter and wander at exchange input interfaces A and B

TABLE 1/Q.502

Values for the mask of tolerable peak-to-peak sinusoidal jitter and wander at the exchange input interfaces A and B

	2048 kbit/s	8448 kbit/s	1544 kbit/s	6312 kbit/s
A_0 (µs)	18	18	18	18
A_1 (IU)	1.5	1.5	2	See Note 5
A_2 (IU)	0.2	0.2	0.05	See Note 5
f_0 (Hz)	12×10^{-6}	12×10^{-6}	12×10^{-6}	See Note 5
f_1' (Hz)	See Note 3	See Note 3	See Note 3	See Note 3
f_1 (Hz)	20	20	10	See Note 5
f_2 (Hz)	2.4×10^3	400	200	See Note 5
f_3 (Hz)	18×10^3	3×10^3	8×10^3	See Note 5
f_4 (Hz)	100×10^3	400×10^3	40×10^3	See Note 5

Note 1 – See Figure 2/Q.502.

Note 2 – UI = Unit Interval
For 1544 kbit/s systems 1 UI = 648 ns.
For 2048 kbit/s systems 1 UI = 488 ns.
For 8448 kbit/s systems 1 UI = 118 ns.
For 6312 kbit/s systems 1 UI = 158 ns.

Note 3 – The value of f_1' needs further study.

Note 4 – For interfaces within national networks only, values of f_2 = 93 Hz and f_3 = 700 Hz for 2048 kbit/s interface, and f_2 = 10.7 kHz and f_3 = 80 kHz for 8448 kbit/s interface may be used.

Note 5 – For further study.

4 Exchange transfer function – jitter and wander

The exchange transfer function defines the limits of wander at the output of the exchange relative to wander in the timing information at the input.

It is recognized that the approach of using the exchange transfer function to specify the performance of an exchange is not applicable to all implementations (e.g. when mutual synchronization methods are used).

The exchange transfer mask is similar to that of a lowpass filter with a maximum gain of 0.2 dB, a break point at 0.1 Hz and a slope of 6 dB/octave, as shown in Figure 3/Q.502.

The higher frequency (jitter) portion of the exchange transfer mask is undefined, but must provide significant attenuation above 100 Hz.

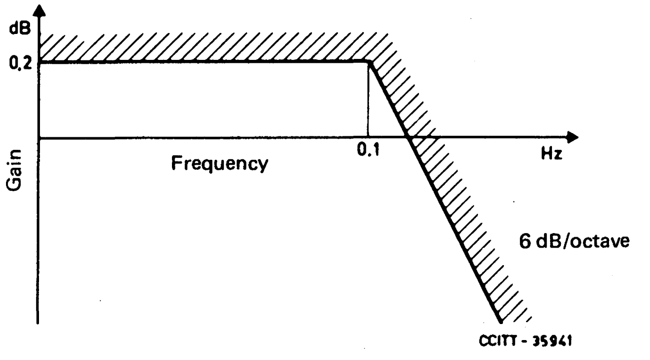


FIGURE 3/Q.502

Exchange transfer mask

5 Relative Time Interval Error (TIE) at the exchange output. Interfaces A and B

Relative Time Interval Error (TIE) at the exchange output is defined as the difference in time delay of a given timing signal when compared to a reference timing signal for a given measurement period (see Recommendation G.811).

The relative TIE at the output of the digital interfaces should not, over the period S seconds, exceed the following limits:

1) (100 S) ns + 1/8 UI for $S < 10$
2) 1000 ns for $S \geqslant 10$ (see Figure 4/Q.502).

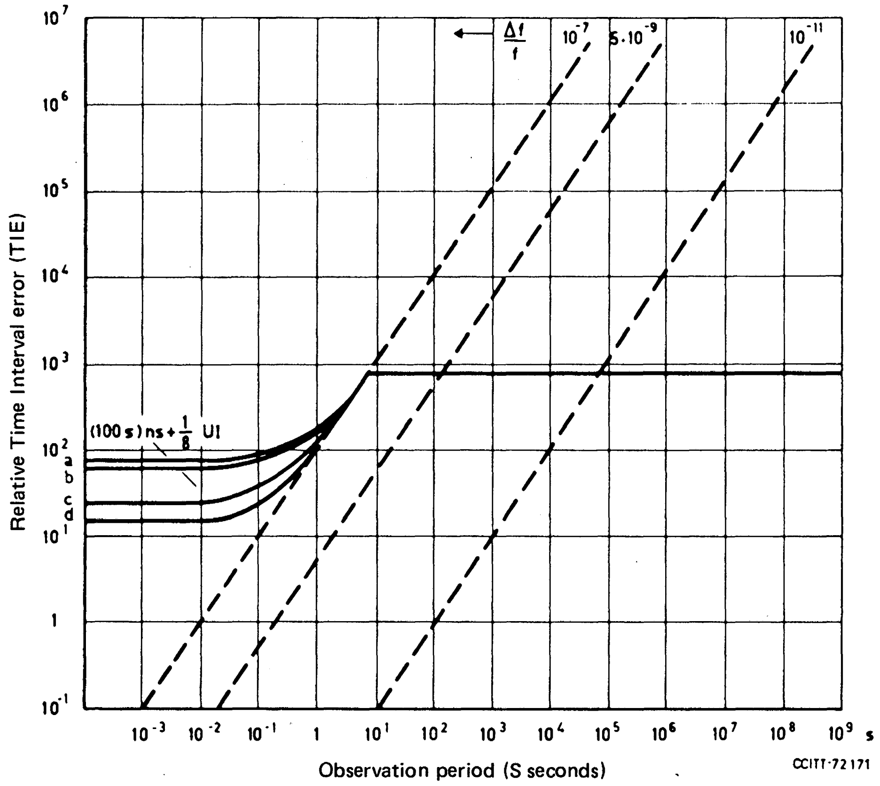
In the case of synchronous operation the limits are specified on the assumption of an ideal synchronizing signal (no jitter, no wander and no frequency deviation) on the line delivering timing information. In the case of asynchronous operation the limits are specified assuming no frequency deviation of the exchange clock (this is equivalent to taking the output of the exchange clock as the reference timing signal for the relative TIE measurements).

It is recognized that the approach of using relative TIE to specify the performance of an exchange in the case of synchronous operation in some implementations (e.g. when mutual synchronization methods are used) requires further study.

Any internal operation or rearrangement within the synchronization and timing unit or any other cause should not result in a phase discontinuity greater than 1/8 of a Unit Interval (UI) on the outgoing digital signal from the exchange.

The limits given above and shown in Figure 4/Q.502 may be exceeded in cases of infrequent internal testing or rearrangement operations within the exchange. In such cases, the following conditions should be met:

– The TIE over any period up to 2^{11} UI should not exceed 1/8 of a UI.
– For periods greater than 2^{11} UI the phase variation for each interval of 2^{11} UI should not exceed 1/8 UI up to a total maximum relative TIE defined in Recommendation G.811 for long periods.



a : 1544 kbit/s
b : 2048 kbit/s
c : 6312 kbit/s
d : 8448 kbit/s

FIGURE 4/Q.502

Limits of peak-to-peak relative TIE at the exchange output interfaces A and B

6 Overvoltage protection

For further study, (attention is drawn to the K-series Recommendations).

Recommendation Q.503

CONNECTIONS, SIGNALLING, CONTROL, CALL HANDLING AND ANCILLARY FUNCTIONS

1 General

This Recommendation applies to digital transit exchanges for telephony in Integrated Digital Networks (IDNs) and mixed (analogue/digital) networks. It will form the basis for digital switching in Integrated Services Digital Networks (ISDNs) when other services are integrated with telephony. The field of application of this Recommendation is found in Recommendation Q.501.

2 Timing and synchronization

2.1 *Exchange timing distribution*

The timing distribution system of an exchange will be derived from a highly reliable exchange clock system. The distribution of timing within the exchange must be designed so that the exchange will maintain synchronism on 64-kbit/s channel time slots in a connection through the exchange.

2.2 *Network synchronization*

2.2.1 *National networking*

Within a synchronized IDN different means of providing timing between exchanges may be used. It shall therefore be possible to synchronize the clock by one of the different methods of synchronization that will be provided within an IDN/ISDN. Plesiochronous operation should also be possible.

Synchronized national networks may be provided with exchange clocks not having the frequency accuracy required for international interworking. However when these synchronized networks within national boundaries are required to interwork internationally as part of the international IDN, it will be necessary to provide means to operate these national networks to the internationally recommended value of frequency accuracy in Recommendation G.811.

2.2.2 *International interworking*

Plesiochronous operation of international digital limits is covered in Recommendation G.811.

2.3 *Slip*

The design objective controlled slip rate at a digital exchange within a synchronized region should be zero, provided that jitter and wander remain within the limits given in this Recommendation.

The design objective controlled slip rate at a digital exchange in plesiochronous operation (or operating to another synchronized region) shall be not more than one slip in 70 days in any 64-kbit/s channel, provided that jitter and wander remain within the limits given in this Recommendation.

The operational performance objectives for the rate of octet slips on an international connection or corresponding bearer channel are covered in Recommendation G.822.

The occurrence of a controlled slip should not cause loss of frame alignment.

Note – A synchronized region is defined as a geographic entity normally synchronized to a single source and operating plesiochronously with other synchronized regions. It may be a continent, country, part of a country or countries.

2.4 *Synchronization requirements when interworking with a digital satellite system*

On a provisional basis, the following should apply:

The transfer from the timing of the terrestrial digital network to the timing of the satellite system, if required (plesiochronous operation), will not be performed by the digital exchange. The earth station will be equipped with buffer memories of suitable size to compensate for the time delay variations due to shifts of the satellite from its ideal position (and due to any other phenomena with similar effects) and to meet the slip performance requirements established in CCITT Recommendation G.822.

3 Connections through an exchange

3.1 *General*

The characteristics of the connections detailed in § 3 refer to an established connection when it is made available to the users.

An exchange must be able to provide bidirectional connections between input and output interfaces for telephony and other services as required. Also, unidirectional connections may be required.

3.2 *Bit rate of a connection through an exchange*

3.2.1 *Basic bit rate*

The exchange should be able to make connections between channel time slots with the basic bit rate of 64 kbit/s. The channel time slots to be connected are contained in primary or higher order frame structures appearing at the digital interfaces of the exchange or derived from analogue channels appearing at the analogue interfaces.

Switching at rates other than 64 kbit/s is for further study.

3.2.2 *Services offered at bit rates less than 64 kbit/s*

Services requiring less than 64 kbit/s for a connection should be switched as 64-kbit/s connections. They should be presented to the exchange as 64-kbit/s channels by digitally filling or by being multiplexed to a 64-kbit/s channel before entering the exchange via a primary or higher frame structure at the transmission/switching interface. The process by which this is performed is not the subject of this Recommendation. Lower bit rate channels multiplexed into a 64-kbit/s bit stream will be switched as a 64-kbit/s entity.

3.2.3 *Services offered at bit rates requiring more than 64 kbit/s*

Services requiring more than 64 kbit/s for a connection are offered as a multiple of 64-kbit/s connections. They are called multislot connections and referred to as $n \times 64$ kbit/s connections.

It should be noted that an $n \times 64$ kbit/s connection can seriously affect the blocking probability of an exchange and the network, particularly if all n slots are routed in a defined order in the same multiplex. The ability to handle multislot traffic will be influenced by the traffic loading of the exchange at any instant and the number of circuits available on the required route.

All aspects of the provision of a multislot service, both switched and semipermanent, are therefore the subject of further study.

The interim requirements for a multislot service should be satisfied by the establishment of a number of separate semi-permanent connections, each of which would be set up to preserve the sequence with the other slots forming the multislot connection. A restriction on the maximum value of n or on the percentage of multislot connections carried by an exchange is not appropriate until further studies are complete. The n slots forming a semi-permanent multislot connection shall all appear in the same multiplex (defined in interface A or B) incoming to the exchange and shall be switched all on the same outgoing multiplex. The channel timeslots received at the output of the exchange may occur in the same frame or the individual timeslots may occur in successive frames.

3.3 *Mode of establishment*

3.3.1 *Switched connections*

Circuit switched connections are set up at any time on demand in response to signalling information received from other exchanges or other networks.

3.3.2 *Semi-permanent connections*

The exchange should have the capability of establishing semi-permanent connections which pass through the exchange switching network.

Other features of semi-permanent connections, e.g., grade of service, the need for an out-slot signalling channel associated with the connection, etc., are for further study.

3.4 *Bit sequence independence*

A limitation should not be imposed by the exchange on the number of consecutive binary ones or zeros or any other binary pattern within the 64-kbit/s path through the exchange.

3.5 *Bit integrity*

Bit integrity is said to be maintained when the binary values of bits in an octet at the input of an exchange are exactly reproduced at the output.

Bit integrity will be maintained if required to support 64 kbit/s non-telephony services.

Note – It is understood that to meet this requirement, digital processing devices such as μ/A law converters, echo suppressors and digital pads must be disabled for non-telephony calls requiring bit integrity. The means of disabling these devices has yet to be determined (see also § 7.3).

3.6 *Bit patterns generated by the exchange in idle channel time slots*

At interfaces A and B, the following patterns are recommended for the idle condition where the leftmost digit is the polarity digit:

01111111 for 1544 kbit/s systems;

01010100 for 2048 and 8448 kbit/s systems.

The patterns should not be used as an indication of the idle or barred condition of a channel since this information should be derived from the control or signalling functions.

3.7 *Error performance*

The design objective long-term mean Bit Error Ratio (BER) for a single pass of a 64-kbit/s connection through an exchange between the digital transmission/switching interfaces should be 1 in 10^9 or better. This corresponds to 99.5% error-free minutes assuming that the occurrence of errors has a Poisson distribution.

3.8 *In-call rearrangement*

In-call rearrangement is the rearrangement by the exchange of the established connections across the switchblock in a more efficient manner. When it is provided, it is essential that the recommendations for error performance, quality of service, etc., be met.

3.9 *Transmission performance characteristics*

For transit telephony connections Recommendation Q.507 applies.

4 Signalling

The exchange should be able to interwork with other exchanges as required using the signalling systems indicated in Recommendations Q.7.

4.1 *Through-connection of signalling channels*

64-kbit/s signalling channels entering the exchange via a multiplex structure may be connected through the exchange as semi-permanent channels.

5 Control functions associated with call handling

The requirements for the control function are implicit in the requirements recommended for the other functions of the exchange. However, recommendation of a number of new requirements for the control functions associated with the operation of a digital transit exchange in the ISDN may be necessary.

6 Control functions associated with maintenance and automatic supervision

For further study.

7 Ancillary functions

7.1 *Connection of ancillary equipment*

Ancillary equipment may be connected in the following ways:

a) Serially. This may require more than one connection through the exchange. Examples of serially connected equipment include:
   - encoding law converters,
   - echo control devices,
   - manual board access equipment (for operator-controlled traffic).

b) As terminal connected equipment usually requiring one connection through the exchange. Examples of such equipment include:
   - recorded announcements,
   - manual board terminations,
   - speech codecs,
   - data terminal facilities,
   - test equipment (such as test call sender),
   - tone generators,
   - signalling receivers.

The interface between the exchange and the items of equipment listed above may be left to the national designers. However, the use of internationally standardized interfaces is preferred.

Note – In some cases it may be necessary to establish more than one connection to one timeslot at the same time.

7.2 *Digitally generated tones and frequencies*

When tones and frequencies are digitally generated the following minimum requirements apply on a provisional basis.

7.2.1 *Service tones*

Digitally generated tones should meet the recommended limits specified in Recommendation Q.35 when decoded.

7.2.2 *Signalling frequencies*

Digitally generated signalling frequencies should be such that they can be detected after decoding by any analogue receivers designed to CCITT recommendations.

7.3 *Echo control devices*

The exchange should be able to be equipped with echo control devices (echo suppressors/echo cancellers conforming to CCITT Recommendations G.164 and G.165, respectively). When required, the exchange shall be able to control such devices to meet the requirements of CCITT Recommendation Q.115. The means of control by the exchange is for further study.

Note – It is recognized that there is a need for an internationally agreed method of disabling and enabling echo control devices for the purposes of making end-to-end circuit transmission maintenance measurements, e.g., as recommended in CCITT Recommendation V.25.

Recommendation Q.504

PERFORMANCE AND AVAILABILITY DESIGN OBJECTIVES

1 General

This Recommendation applies to digital transit exchanges for telephony in Integrated Digital Networks (IDN) and mixed (analogue/digital) networks. It will form the basis for digital switching in Integrated Services Digital Networks (ISDN) when other services are integrated with telephony. Performance objectives for functions required to furnish ISDN services are not included and are a subject for further study. The field of application of this Recommendation is found in Recommendation Q.501.

These performance and availability design objectives relate to the technical capabilities of exchange designs. They are intended to assure that exchanges operating in their own environment will be capable of supporting the recommended network grades of service covered in the E.500 series of Recommendations when engineered and provisioned to do so, at all points in their growth cycle up to and including their maximum computed capacity.

These reference loads and performance and availability objectives are primarily intended to guide the design of exchanges. The performance parameters may also be used by Administrations or RPOAs in evaluating a specific exchange design or for comparing different exchange designs. *These parameters and values are not intended for use as operational or grade of service requirements.*

2 Performance design objectives

2.1 *Reference loads*

The given reference loads are traffic load conditions under which the performance design objectives stated in §§ 2.2 to 2.6 are to be met. Administrations or Operating Agencies may specify hypothetical exchange models for use in applying reference loads and computing exchange capacity. These hypothetical models should characterize the sets of traffic parameters and functions that are considered to be typical in the intended application of the exchange, and should include the signalling mix and any other pertinent characteristics.

2.1.1 *Load on incoming interexchange circuits*

a) *Reference load A*

- 0.7 Erlang average occupancy on all incoming circuits;

$$\text{Call attempts/h} = \frac{0.7 \times \text{Number of incoming circuits}}{\text{Average holding time in hours}}$$

Note – Ineffective call attempts must be included in reference call attempts.

b) *Reference load B*

- 0.8 Erlang average occupancy on all incoming circuits;
- 1.2 times the call attempts/hr for reference load A.

2.2 *Inadequately handled call attempts*

Inadequately handled call attempts are attempts which are blocked or excessively delayed [1)] within the exchange.

1) For further study.

It is recommended that the probability of inadequately handling a call not exceed the values in Table 1/Q.504.

TABLE 1/Q.504

	Reference load A	Reference load B
Probability	10^{-3}	10^{-2}

The requirement for multislot connections and/or ISDN services requires further study.

The definition of objectives under failure conditions requires further study.

2.3 *Delay probability*

In the delay tables appearing in the following paragraphs:

§ 2.3.1 Incoming response delay

§ 2.3.5 Exchange signal transfer delay

it is understood that delay timing begins after completion of signal verification and does not include line-dependent delays for recognition of induced voltage conditions and line transients.

In the following the term "mean value" is understood as the expected value in the probabilistic sense.

2.3.1 *Incoming response delay*

The incoming response delay is a characteristic that is applicable where channel associated signalling is used. It is defined as the interval from the instant an incoming circuit seizure signal is recognizable until a proceed-to-send signal is sent backwards by the exchange.

The values in Table 2/Q.504 are recommended.

TABLE 2/Q.504

	Reference load A	Reference load B
Mean value	$\leq$ 300 ms	$\leq$ 400 ms
0.95 probability of not exceeding	400 ms	600 ms

Note – Different call set-up procedures are used with common channel signalling operation and a requirement covering incoming response delay as defined above is not relevant.

2.3.2 *Exchange call set-up delay*

Call set-up delay of an exchange is defined as the interval from the instant when the digits required for setting-up a call are available for processing in the exchange, or the address information required for call set-up is received at the incoming signalling data transmission control of the exchange, to the instant when the seizing signal has been sent to the subsequent exchange or the corresponding address information is sent from the outgoing signalling data transmission control.

The values in Table 3/Q.504 are recommended.

TABLE 3/Q.504

	Reference load A	Reference load B
Mean value	$\leqslant$ 250 ms	$\leqslant$ 400 ms
0.95 probability of not exceeding	300 ms	600 ms

Note – Since the exchange will provide connections between circuits that may use either channel associated or common channel signalling systems in various combinations, the above requirement applies to all possible combinations. For connections involving the same common channel signalling system, the requirements of that signalling system recommendation should apply.

2.3.3 *Through-connection delay*

Through-connection delay is the interval from the instant at which the information required for setting-up a through connection in an exchange is available for processing in the exchange, to the instant that the switching network through connection is established and available for carrying traffic between the incoming and outgoing exchange terminations. For certain interconnection cases this interval will commence upon the completion of digit sending.

The exchange through-connection delay does not include an interoffice continuity check if provided but does include a cross office check if one occurs during the defined interval.

When the through-connection in an exchange is not established during the exchange call set-up interval, the through-connection delay may then contribute to the network call set up delay.

The values in Table 4/Q.504 are recommended.

TABLE 4/Q.504

	Reference load A		Reference load B	
	Without ancillary equipment	With ancillary equipment	Without ancillary equipment	With ancillary equipment
Mean value	$\leqslant$ 250 ms	$\leqslant$ 350 ms	$\leqslant$ 400 ms	$\leqslant$ 500 ms
0.95 probability of not exceeding	300 ms	500 ms	600 ms	600 ms

More stringent values may be appropriate in some national networks.

When the through connection is established as soon as the last digit of the address information required for through connection is received, then the requirements for call set up delay apply.

The requirements for multislot connections require further study.

2.3.4 *Exchange call release delay*

Exchange call release delay is the interval from the instant at which the last information required for releasing a call in an exchange is available for processing in the exchange to the instant that the switching network through connection is no longer available for carrying traffic and the disconnection signal is sent to the subsequent exchange, if applicable. This interval does not include the time taken to detect the release signal, which might become significant during certain failure conditions, e.g. transmission system failures.

The values in Table 5/Q.504 are recommended.

2.3.4.1 *For transit traffic connections*

TABLE 5/Q.504

	Reference load A	Reference load B
Mean value	≤ 250 ms	≤ 400 ms
0.95 probability of not exceeding	300 ms	600 ms

For common channel signalling the relevant signalling system specification should apply.

2.3.5 *Exchange signal transfer delay*

The exchange signal transfer delay is the time taken for the exchange to transfer a signal, no other exchange action being required.

For common channel signalling this delay is measured from the instant when the last bit of the signal unit leaves the incoming signalling data link to the instant when the last bit of the signal unit enters the outgoing signalling data link for the first time. It also includes the queueing delay in the absence of disturbances but not the additional queueing delay caused by retransmission.

The parameters in the appropriate common channel signalling system recommendations apply.

For channel associated signalling, the signal transfer delay is the interval from the instant when the incoming signal is recognizable to the instant when the corresponding outgoing signal has been transmitted. More stringent values are recommended for the *answer signal transfer delay* where connections involve inband line signalling. The objective of these requirements is to minimize the possible interruption of the transmission path, for any significant time during the initial voice response by the called party.

The values in Table 6/Q.504 are recommended:

TABLE 6/Q.504

	Reference load A		Reference load B	
	Answer signal [a]	Other signals	Answer signal [a]	Other signals
Mean value	≤ 50 ms	≤ 100 ms	≤ 50 ms	≤ 150 ms
0.95 probability of not exceeding	100 ms	150 ms	100 ms	300 ms

[a] Applicable where in-band line signalling may be encountered in the national part of a built-up connection. The values for Answer signal transfer delay probability are provisional where CCITT Signalling System No. 5 is used.

2.4 *Call processing performance objectives*

2.4.1 *64 kbit/s switched connections*

2.4.1.1 *Premature release*

The probability that an exchange malfunction will result in the premature release of an established connection in any one minute interval should be:

$$P \leqslant 2 \times 10^{-5}$$

2.4.1.2 *Release failure*

The probability that an exchange malfunction will prevent the required release of a connection should be:

$$P \leqslant 2 \times 10^{-5}$$

2.4.1.3 *Incorrect charging or accounting*

The probability of a call attempt receiving incorrect charging or accounting treatment due to an exchange malfunction should be:

$$P \leqslant 10^{-4}$$

2.4.1.4 *Misrouting*

The probability of a call attempt being misrouted following receipt by the exchange of a valid code should be:

$$P \leqslant 10^{-4}$$

2.4.1.5 *No tone*

The probability of a call attempt encountering no tone following receipt of a valid code by the exchange should be:

$$P \leqslant 10^{-4}$$

2.4.1.6 *Other failures*

The probability of the exchange causing a call failure for any other reason not identified specifically above should be:

$$P \leqslant 10^{-4}$$

2.4.2 *64 kbit/s semi-permanent connections*

To be studied taking into consideration:

- need to recognize an interruption;
- probability of an interruption;
- requirements for re-establishment of interrupted connection;
- any other unique requirements.

2.4.3 *n × 64 kbit/s switched connections*

To be recommended if/when specific services are defined.

2.4.4 *n × 64 kbit/s semi-permanent connections*

To be recommended if/when specific services are defined.

2.5 *Transmission performance*

2.5.1 *64 kbit/s switched connections*

The probability of a connection being established with an unacceptable transmission quality across the exchange should be:

$$P\,(\text{Unacceptable transmission}) \leqslant 10^{-5}$$

The transmission quality across the exchange is said to be unacceptable when the bit error ratio is above alarm condition.

Note – The alarm condition has yet to be defined.

2.5.2 *64 kbit/s semi-permanent connections*

To be recommended.

2.5.3 *n × 64 kbit/s switched connections*

To be recommended if/when specific services are defined.

2.5.4 *n × 64 kbit/s semi-permanent connections*

To be recommended if/when specific services are defined.

2.6 *Slip rate*

2.6.1 *Normal conditions*

The slip rate under normal conditions is covered in Recommendation Q.503.

2.6.2 *Temporary loss of timing control*

The slip rate resulting from temporary loss of timing control is the subject of further study taking into account the requirements of Recommendation G.822.

2.6.3 *Abnormal conditions at the exchange input*

The slip rate in case of abnormal conditions (wide phase deviations, etc.) at the exchange input is the subject of further study taking into account the requirements of Recommendation G.823.

3 Exchange performance under overload conditions

For further study.

4 Availability design objectives

4.1 *General*

Availability is one aspect of the overall quality of service of an exchange.

Availability objectives are important factors to be considered in the design of a switching system and may also be used by Administrations to judge the performance of a system design and to compare the performance of different system designs.

Availability may be estimated by using the ratio of the accumulated time during which the exchange (or a part of it) is capable of proper operation to a time period of statistically significant duration called the mission time.

$$\text{Availability (A)} = \frac{\text{accumulated up-time}}{\text{mission time}} = \frac{\text{accumulated up-time}}{\text{accumulated up-time} + \text{accumulated down-time}}$$

Sometimes it is more convenient to use the term unavailability (instead of availability) which is defined as,

$$\text{Unavailability (U)} = 1 - \text{A}$$

The terms used in this section, when they already exist, are in accordance with CCITT Recommendation G.106.

4.2 *Causes of unavailability*

This Recommendation deals with availability as observed from the exchange termination point of view. Both planned and unplanned outages need to be considered, and both types need to be minimized. Unplanned outages reflect on the inherent reliability of the exchange and are therefore considered separately from planned outages in this Recommendation.

Unplanned unavailability counts all failures that cause unavailability. Thus hardware failure, software malfunctions and unintentional outages resulting from craftperson activity are to be counted.

4.3 *Intrinsic and operational unavailability*

Intrinsic unavailability is the unavailability of an exchange (or part of it) due to exchange (or unit) failure itself, excluding the logistic delay time (e.g. travel times, unavailability of spare units, etc.) and planned outages.

Operational unavailability is the unavailability of an exchange (or part of it) due to exchange (or unit) failure itself, including the logistic delay time (e.g. travel times, unavailability of spare units, etc.).

4.4 *Planned outages*

Planned outages are those intentionally induced to facilitate exchange growth or hardware and/or software modifications. The impact of these activities on service depends on their duration, the time of day they are introduced and on the particular system design.

4.5 *Total and partial unavailability*

Exchange unavailability may be either total or partial. Total unavailability affects all terminations, and consequently, all traffic that is offered during the outage is equally affected. A partial outage has an effect only on some terminations.

From the point of view of one termination on an exchange (e.g. an interexchange circuit termination), the numerical value of mean accumulated downtime (and hence the unavailability) for a specified period of time should not depend on the exchange size or its traffic handling capacity. Similarly, from the point of view of a group of terminations of size n, the mean accumulated downtime for a specified period of time, *in case they are simultaneously unavailable*, should not depend on exchange size. However, for two groups of terminals of differing size n and m such that n is greater than m $(n > m)$, the mean accumulated downtime (and hence the unavailability) for n will be less than the mean accumulated downtime (MADT) or the unavailability for m,

Thus:

$$\mathrm{MADT}(n) < \mathrm{MADT}(m) \text{ where } n > m$$

and

$$\mathrm{U}(n) < \mathrm{U}(m)$$

The lower limit of m is one termination, and it can be specified as having a mean value of T minutes per year.

4.6 *Statistical basis*

Any estimation of unavailability is of necessity a statistical quantity, because outages are presumed to occur randomly and they are of random duration. Therefore, availability measurements are significant when made over a statistically significant number of exchanges. It follows then, that a single exchange may exceed the unavailability objectives. Further, to be statistically significant the mission time must be adequate in order to have sufficient collected data. The accuracy of the result is dependent on the amount of collected data.

4.7 *Relevant failure events*

Different types of failure events may occur in an exchange. In order to evaluate the unavailability of an exchange (or part of it) only those events having an adverse effect on the exchange's ability to process calls as required should be taken into account.

A failure event which is short in duration and results only in call delay rather than in a call denial can be disregarded.

4.8 *Availability independence*

The design objectives for the unavailability of a single termination or any group of terminations of size n are independent of exchange size or internal structure.

4.9 *Intrinsic downtime and unavailability objectives*

The recommended measure for use in determining *intrinsic unavailability* is mean accumulated intrinsic downtime (MAIDT) for individual or groups of terminations for a given mission time, typically one year.

For one termination:

$$\text{MAIDT}(1) \leqslant 30 \text{ minutes per year}$$

For an exchange termination group of size n:

$$\text{MAIDT}(n) < \text{MAIDT}(m) \text{ where } n > m.$$

This reflects the consequences (e.g. traffic congestion, social annoyance, etc.), of the simultaneous outage of a large number of terminations.

The above expression is a statement of principle and means that units serving larger group sizes shall have lower MAIDT.

4.10 *Operational unavailability objectives*

4.10.1 *Logistic delay time*

Due to differing national conditions logistic delay times may vary from country to country and therefore may not be subject to international Recommendation.

Nevertheless, for design guidance, an indication of the Administration's logistic delays is considered desirable to establish overall operational performance objectives. It is left for the operating Administration to determine how it should be accounted for in the determination of operational unavailability.

4.10.2 *Planned outages*

Planned outages are to be minimized to the greatest extent practicable. They should be scheduled so as to have least impact on service practicable.

4.11 *Initial exchange availability performance*

A system rarely meets all long-term design objectives when first placed into service. The objectives contained in this Recommendation may therefore not be fulfilled for a limited period of time after the newly designed switched system has been put into service; this period of time should be minimized to greatest extent practicable.

5 **Hardware reliability objectives**

A bound on the rate of hardware failures is recommended. It includes all types of hardware failures and the failures counted are independent of whether or not there is a resulting service degradation.

An acceptable hardware failure rate for an exchange is a function of the exchange size and the types of terminations.

The following formula can be used to verify that the maximum failure rate does not exceed the Administration's requirements:

$$F_{\max} = C_0 + \sum_{i=1}^{n} C_i T_i$$

where

$F_{\max}$ the maximum acceptable number of hardware failures per unit of time

T_i the number of terminations of type i

n the number of distinct types of terminations

C_0 to be determined taking into account all failures which are independent of exchange size

C_i coefficients for terminations of type i, reflecting the number of failures associated with individual terminations of that type. Different hardware used with different types of terminations may result in different values for C_i.

Recommendation Q.505

EXCHANGE MEASUREMENTS

1 General

This Recommendation applies to digital transit exchanges for telephony in Integrated Digital Networks (IDN) and mixed (analogue/digital) networks. It will form the basis for digital switching in Integrated Services Digital Networks (ISDN) when other services are integrated with telephony. The field of application of this Recommendation is found in draft Recommendation Q.501.

This Recommendation includes measurements for digital transit (local and combined local/transit) exchanges that are necessary for provisioning and operating exchanges so as to satisfy grade of service objectives covered in the E.500 series of Recommendations. These measurements are typically performed during specified periods and intervals after which the results are sent to designated local and/or remote exchange terminals or operation and maintenance centres (OMC) or any other appropriate data handling centre. In some cases, data may be utilized in its original form whereas in other cases data may need to be processed to determine when pre-set thresholds are exceeded and/or to recognize an abnormal condition when it occurs. In this Recommendation, no particular system design requirement is implied. Different designs may have more or less data accumulated and processed within the exchange or by an external system.

Different types and sizes of exchanges may require different sets of measurements. Also, different administrations may have different requirements for measurements depending on policies, procedures or national network considerations. An Administration may thus find it desirable in some applications to measure items that are not covered by this Recommendation whereas in other applications some measurements may not be desired.

Exchange Measurements are required for both National and International service. Requirements for International service take into consideration the following CCITT Recommendations:

- Recommendations E.401 to E.427: International Telephone Network Management and checking of Service Quality;
- Recommendations E.230 to E.277: Operational provisions relating to Charging and Accounting in the International Telephone Service.

The aspects of traffic engineering are given in Recommendations E.500 to E.543. Recommendations on traffic measurements for SPC exchanges are provided by Recommendation E.502.

Note – For the terms and definitions of teletraffic used in this Recommendation see *Yellow Book*, Volume II.3, Supplement No. 7.

2 Measurement processes

2.1 *General*

The activities involved by Exchange Measurements can be split in four processes as represented by Figure 1/Q.505.

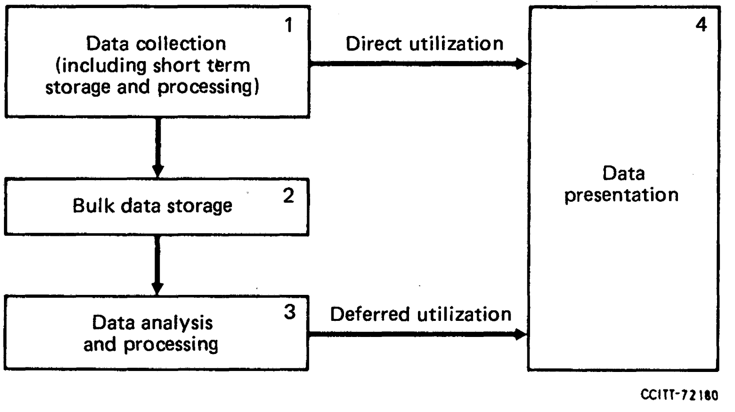


FIGURE 1/Q.505

Measurements processes

On choice of each individual National Administration, the above 4 processes can be fully or partially integrated into the exchanges.

It is nevertheless recommended that:

a) *Data collection* be fully integrated into the exchange for all type of data.

b) *Data presentation* be integrated into the exchange and/or at the O&M centre at least for the measurements required by O&M personnel.

Presentation of data required for Planning and Administration activities could be performed at the O&M personnel premises or in other locations which could be more centralized and generally takes place at a deferred time.

2.2 *Data collection*

Three different activities of data collection can be identified:

– event Registration;

– traffic Registration (traffic intensity and/or volume of traffic);

– call Records Registration.

The data generated by Event Registration and Traffic Registration are suitable for direct utilization (immediate presentation).

Call Records can only be utilized after off-line analysis. Processing of Call Records can generate any type of data, including the Event Registration and Traffic Registration.

2.3 *Bulk data storage, analysis and processing*

Data storage for Collected Data can be required for accumulation of a massive data base suitable for subsequent analysis and processing. These data can be held in the exchange for processing at the exchange location or transferred to Administrative and Engineering centres.

2.4 *Data presentation*

It is the function through which the collected data are becoming readable. Features related to the Data Presentation are:

a) Location of presentation.

b) Time frame of presentation – It is dependent on the nature of the data and their utilization. The activities of Maintenance and Network Management require immediate presentation.

c) Physical support of the displayed data and relevant format – These aspects are mainly related to the type of data and are to be left to individual implementations.

3 **Types of measurements data**

Measurement data primarily consists of counts of various events and the traffic intensity on various resources. For certain measurement data, sampling, or time averaging techniques may provide an acceptably accurate result. In some cases, externally generated test calls may provide the most practical method of obtaining the data. In other cases, call records, such as detailed charging records, may be used.

3.1 *Event counts*

Events, for example incoming seizures, call attempts encountering busy, and call attempts to specified destination codes should be countable. Some event counts may be accumulated over the whole exchange whereas others may be accumulated only over a subset such as an inter-exchange circuit group. In some cases, event counts may be accumulated several ways.

3.2 *Traffic intensity*

Traffic intensity on a pool of resources is the traffic volume divided by the duration of observation. It is thus equal to the average number of busy resources. As in the case of event counts, traffic intensity data may be for the whole exchange or for various subsets.

3.3 *Call records*

Call records contain data used by the exchange for the setting up of calls. The data may include the identity and classification of the incoming circuit, the dialled number, the call routing and disposition, and possibly the time of occurrence of certain events during the entire call period.

Call records can be generated and outputted by the exchange to allow the establishment of a data base suitable for off-line processing to determine traffic values and characteristics. A statistical sample of the total number of call records may be sufficient for this purpose.

4 **Measurement administration**

Exchanges should provide capabilities for operating personnel to establish measurement schedules and direct the output routing of measurement results. It should be possible to have a number of measurements simultaneously active with different schedules and output routings. The number of measurement types running concurrently may be limited to conserve exchange storage and processing resources. Criteria for measurement and recording of traffic may be found in Recommendation E.500 and other related E-series Recommendations.

4.1 *Scheduling*

4.1.1 *Recording periods*

A recording period is the time interval during which a measurement is performed. Measurements can be activated either on-demand or according to a time schedule.

Different measurement periods may be schedulable for different days of the week. For example, a measurement may be scheduled for 0900 to 1800 on Monday through Friday and 0900 to 1200 on Saturday. The measurements for an entire week may be programmed and the weekly cycle may be repeated until a new command will stop it.

4.1.2 *Result accumulation periods*

A recording period contains one or more result accumulation periods. The beginning and ending of the recording period must correspond to the beginning and ending of result accumulation periods.

The measurement result outputs are to be made available at the end of each result accumulation period and shall refer to that period.

More than one result accumulation period may be required for an individual measurement.

4.2 *Data output criteria*

4.2.1 *On schedule*

Measurement data output typically occurs shortly after the end of each result accumulation period specified by the measurement schedule. Alternatively, the exchange may store the data in its memory for limited periods, e.g. in the event of contention for output resources.

4.2.2 *On demand*

For further study.

4.2.3 *On exception*

The exchange should be able to provide measurement data when specified criteria are met, for example, when the rate of incoming call attempts exceeds a particular value.

4.3 *Data output routing*

4.3.1 *To a local or remote terminal*

Measurement data should be able to be routed for printing or display on designated terminals which are either directly connected to the exchange or remotely connected via dedicated or switched circuits.

4.3.2 *To an external processing centre*

Measurement data should be routable to external locations such as OMC that provide data collection and analysis functions for multiple exchanges.

4.3.3 *To local storage media*

An Administration may require exchanges to store measurement data in bulk memories such as magnetic tapes for later processing and analysis. This could be an alternative to sending the data to an OMC.

5 Application of measurements

5.1 *Planning and engineering*

Measurement data is essential for planning efficient telecommunication networks that meet specified grade-of-service standards. Analysis of data accumulated over a period of time provides information needed to forecast future demand and to plan and engineer extensions to the network.

5.2 *Operation and maintenance*

Operation and maintenance functions are supported by the following types of measurement data:

i) Performance data pertaining to call handling irregularities and delays.

ii) Availability data for the exchange, its subsystems, and its interexchange circuits.

iii) Traffic data for the various traffic components of the exchange.

The above data may be used to evaluate exchange and network performance and to plan rearrangements to improve the service provided by the existing network equipment.

5.3 *Network management*

Data for network management includes certain traffic and performance measurements and status indications. These are used to detect abnormalities in the network and to automatically enable, or allow manual operation of, network management controls. In some cases, the data must be analysed to determine whether specified thresholds are being exceeded. Since the effectiveness of network management actions depends upon their responsiveness to changing conditions in the network as a whole, it may be appropriate to perform this analysis by a data processing system serving one or more exchanges and display the results at a network management centre. Network management functions are covered in Recommendations E.410 through E.413 and Q.506.

5.4 *Accounting in international service*

Accounting in international service needs to be mutually agreed between Administrations; Recommendations E.230 to E.277 apply.

5.5 *Subdivision of revenue*

Subdivision of revenue is a matter of agreement between RPOAs of the same country. Requirements in this area are a national matter.

5.6 *Tariff and marketing studies*

These studies are intended to identify subscriber needs and trends. Requirements in this area are a national matter.

6 **Traffic measurements**

6.1 *General*

Traffic measurements that are generally applicable to transit exchanges are identified in § 6.2 through § 6.7. Additional measurements may be appropriate in specific applications, e.g. as a result of national network considerations.

6.2 *Interexchange circuit groups*

The measurements apply to individual circuit groups. All circuit groups should be measurable. For traffic intensity, it may be desirable to measure all circuit groups simultaneously. Information for estimating the average number of circuits in service during the result accumulation period should be provided in addition to the traffic data for each circuit group.

6.2.1 *Incoming traffic*

Incoming traffic is understood to be:

- the traffic on incoming circuit groups,
- the incoming traffic on both-way circuit groups.

The following parameters should be measured:

a) traffic intensity,

b) number of seizures.

6.2.2 *Outgoing traffic*

Outgoing traffic is understood to be:

- the traffic on outgoing circuit groups,
- the outgoing traffic on both-way circuit groups.

The following parameters should be measured:

a) traffic intensity,

b) number of seizures,

c) number of call attempts overflowing from the group,

d) answered call attempts.

6.3 *Auxiliary circuit groups*

Auxiliary circuits provide functions such as multifrequency signalling, tones, announcements, and access to operators. Grouping of auxiliary circuits may vary with system implementation characteristics. Groups in this section refer to system independent functional groups. Some systems may allow calls to wait for an auxiliary circuit if one is not immediately available.

The measurements indicated below are intended to provide information for the dimensioning of auxiliary circuits. They should be provided for each group which may require dimensioning. Measurements may be activated for any specified list of auxiliary circuit groups. Information for estimating the average number of circuits in service during the result accumulation period should be provided in addition to the traffic data for each circuit group.

The following parameters should be measured:

a) traffic intensity,

b) number of seizures,

c) number of bids not served.

6.4 *Destination codes*

These measurements are used to assess the probability of success on calls to various destinations and may be used in deciding on any network management actions considered necessary. The number of destination codes specified for measurement at any one time may be limited. For any specified destination code, the following parameters should be measured:

a) Number of call attempts.

b) Number of call attempts resulting in an outgoing seizure.

c) Number of answered calls.

Parameter a) would typically be most applicable to network planning whereas b) and c) would be applicable to network management. Intensity measurements for specified destination codes may be required by some Administrations or RPOAs for traffic engineering purposes.

6.5 *Control equipment*

These measurements are highly system dependent and therefore no specific recommendations can be made. However, it is essential that systems will have provisions for determining the utilization of control equipment, such as processors, for dimensioning, planning, and grade of service monitoring of the exchange.

6.6 *Total exchange*

The following measurements are applicable to the total traffic of an exchange. Owing to the variability of signalling methods and switching system designs, some variation of the measurements for the following traffic categories might be appropriate. For example, Administrations may require more detailed, but system dependent counts to allow them to conduct a meaningful call failure analysis. Furthermore, the traffic categories to which any measurement relates may vary from that shown in the following list, depending on system design, since, for example, there may be certain causes of failure which affect all traffic categories.

Figure 2/Q.505 illustrates the traffic categories and call disposition events referenced in the following paragraphs.

6.6.1 *Incoming traffic*

a) Incoming seizures.

b) Invalid call attempts for example:
   - incomplete dialling,
   - invalid number dialled.

c) Call attempts not routed due to the exchange, for example, due to:
   - blocking through the switching network,
   - unavailability of system resources,
   - system faults.

d) Transit call attempts.

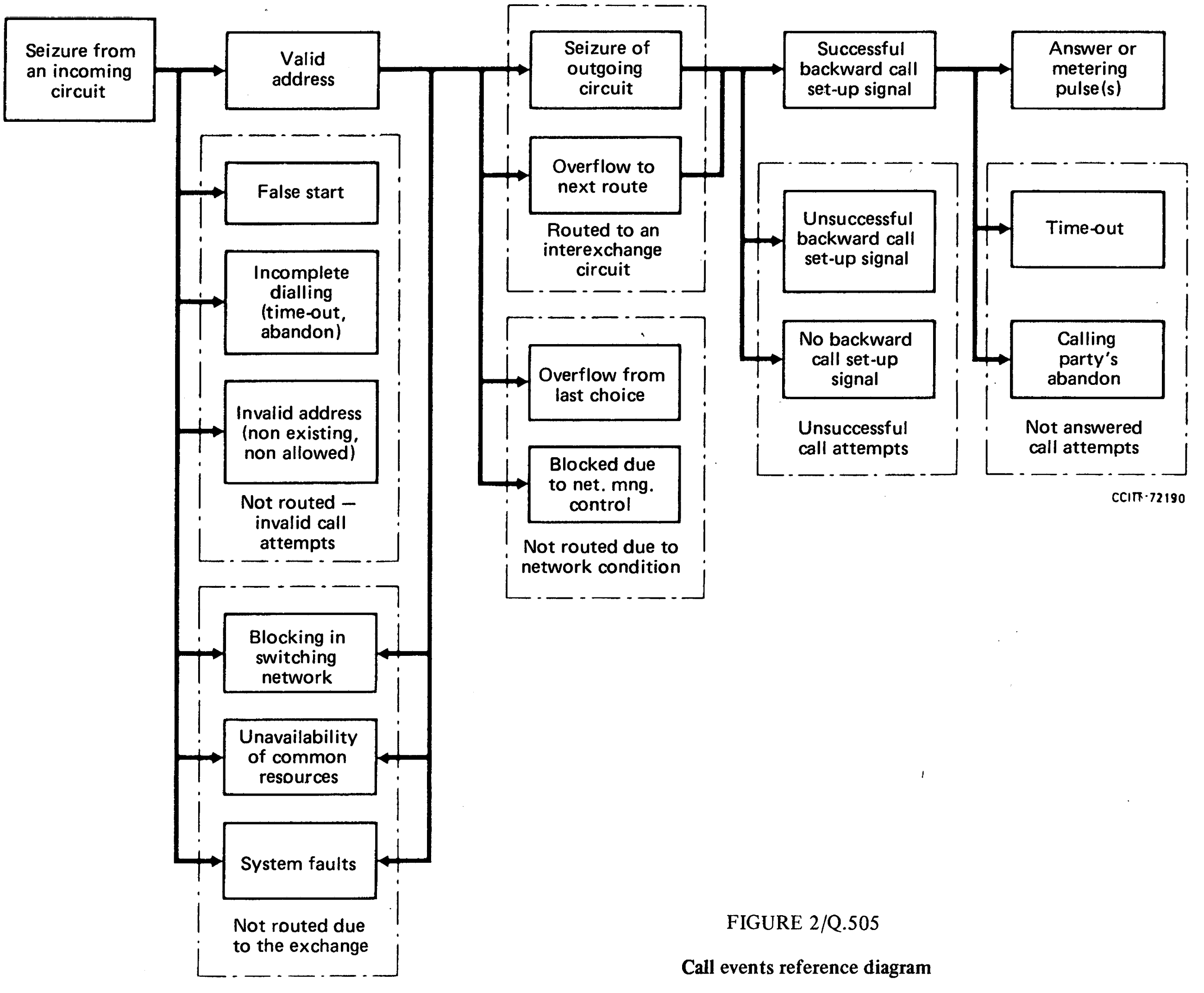


FIGURE 2/Q.505

Call events reference diagram

6.6.2 *Outgoing traffic*

a) Outgoing call attempts routed to an interexchange circuit.

b) Call attempts not routed due to network condition.

c) Unsuccessful call attempts.

6.6.3 *Service utilization*

The exchange should be able to measure the utilization of each type of basic and supplementary service it provides. The mix of services and the corresponding exchange measurements depends upon switching system capabilities and Administration policies.

7 Exchange performance and availability measurements

7.1 *Performance measurements*

For monitoring the exchange grade of service, a certain number of parameters should be observed. They may include the measurements given in Recommendation E.502 for Delay Grade of Service monitoring. However, other processing delays (see relevant sections of Recommendation Q.504) may be observed for complete monitoring of the exchange grade of service.

Measuring processing delays on a per call or statistical basis could be burdensome to the exchange. Moreover, some processing delays may not be measurable with an acceptable time accuracy and others may not be easily measured by the exchange itself.

Operating procedures of Administrations will impose constraints on the accuracy of the measurements for grade of service monitoring purposes. When such accuracy requirements allow, it may be possible to measure processing delays on a sample or test call basis. Requirements in this area are therefore a national matter.

7.2 *Availability measurements*

The exchange should record the beginning and ending time of all detected instances, during which service is unavailable to one or more exchange terminations. The recorded information should permit the determination of the number and identity of terminations affected if possible.

8 Data for network management

Procedures for network management are specified in Recommendation E.410through E.413. Those procedures make use of data from exchanges to determine overall network performance and, when required, appropriate control actions. Much of the data required for network management is also needed for other operation and maintenance functions. However, effective network management requires control actions to be executed quickly in response to changing network and traffic conditions. Therefore, exchanges that Administrations have designated to provide network management functions must be able to provide traffic and status data to other exchanges and network management centres on a pre-arranged basis or when triggered by a specific event, such as an overload condition. The network management functions provided by any specific exchange will depend upon factors such as its size, position in the network, and Administration policies.

Data for network management includes measurement items specified within this Recommendation in the following sections:

§ 6.2 Inter-exchange circuit groups.

§ 6.3 Auxiliary circuit groups.

§ 6.5 Destination codes.

§ 6.6 Control equipment.

Data on the following is also applicable:

- equipment status,
- signalling system status,
- network management controls in effect.

Analysis of the above data and status information to activate controls or exception indicators may be provided as an exchange function. However, it is desirable to implement network management techniques centrally on a regional or national basis, in order to take account of conditions over a large number of exchanges and transmission systems. Factors such as overall network size, signalling and switching systems in use and Administration policies have a bearing on the implementation of this analysis function which is, therefore, not subject to CCITT Recommendation.

Recommendation Q.506

OPERATIONS AND MAINTENANCE FUNCTIONS

1 General

This Recommendation applies to digital transit exchanges for telephony in Integrated Digital Networks (IDN) and mixed (analogue/digital) networks. It will form the basis for digital switching in Integrated Services Digital Networks (ISDN) when other services are integrated with telephony. The field of application of this Recommendation is found in draft Recommendation Q.501.

The exchange and/or any associated operations and maintenance systems/centers shall have the capabilities needed to allow the exchange to be operated and administered efficiently while providing service in accordance with an Administration's performance requirements.

A detailed list of operation and maintenance functions to be performed at input/output terminals using CCITT Man-Machine-Language (MML) appears in Recommendation Z.331.

2 Operations functions

2.1 *Exchange modifications and growth*

The exchange should be capable of having hardware and/or software added or changes made without causing a significant impact on service (see Recommendation Q.504, §§ 4.4, 4.10.2 Planned outages).

2.2 *Provisioning and records*

There should be efficient means of putting into service, testing, removing from service and maintaining accurate records for:

– ancillary equipment,

– interexchange circuits.

2.3 *Translations and routing information*

There should be efficient means of establishing, testing and changing call processing information, such as translation and routing information.

2.4 *Resource utilization*

There should be efficient means of measuring performance and traffic flows and to arrange equipment as required to insure efficient use of system resources and to provide the required grade of service to all subscribers (e.g. load balancing).

3 Maintenance functions

3.1 *Status and other information*

The exchange shall provide information to maintenance personnel so that they can quickly ascertain:

– equipment/system status,

– critical load levels,

– trouble conditions,

– network management controls in effect.

3.2 *Inputs and outputs*

The exchange shall be able to transmit and receive maintenance information and respond to commands from on-site and if appropriate, from remote maintenance centre(s) or systems over the recommended interface(s) (§ 2.3, Recommendation Q.502).

The exchange shall use CCITT MML at its input/output terminals as covered in the Z.300 series of Recommendations.

3.3 *Physical design*

The exchange shall have a good physical design that provides:

– adequate space for maintenance activities,

– conformance with environmental requirements,

– uniform equipment identification (conforming with the Administration's requirements),

– a limited number of uniform power up/down procedures for all component parts of the exchange.

3.4 *Routine testing*

The exchange shall have facilities for performing or directing routine test activities on its component parts and possibly with interfacing equipment or systems.

3.5 *Trouble localization*

The exchange shall have adequate facilities for diagnosing and locating faults within the exchange.

3.6 *Fault and alarm detection and response*

The exchange shall interact with transmission systems as required to detect fault and alarms and take appropriate actions.

3.6.1 *At interfaces A and B*

3.6.1.1 *Fault detection*

The following fault conditions should be detected:

- failure of local power supply (if practicable),
- loss of incoming signal,

  Note – The detection of this fault condition is required only when the fault does not result in an indication of loss of frame alignment.
- loss of frame alignment (Recommendations G.732, G.733, G.744 and G.746);
- excessive error ratio.

The criteria for activating and deactivating the indication of the fault condition are given in Recommendations G.732 and G.744.

3.6.1.2 *Alarm detection*

The following alarm indications should be detected:

- alarm indication (remote alarm) received from the remote end,
- AIS (Alarm Indication Signal) for 2048 and 8448 kbit/s systems. The equivalent binary content of the Alarm Indication Signal (AIS) is a continuous stream of "1"s at 2048 or 8448 kbit/s.

The strategy for detecting the presence of the AIS should be such that the AIS is detectable even in the presence of an error ratio of 1 in 10^3. However, a signal with all bits except the frame alignment bit in the 1 state should not be mistaken as an AIS.

3.6.1.3 *Consequent actions*

3.6.1.3.1 *Generation of alarm signals for action within the exchange*

- The Service Alarm indication should be generated to signify that the service is no longer available (see Table 1/Q.506).
- The Prompt Maintenance Alarm indication should be acceptable generated to signify that performance is below standards and that immediate maintenance attention is required locally (see Table 1/Q.506).

3.6.1.3.2 *Generation of alarms transmitted by the exchange*

- Alarm signals sent "upstream" towards the exchange interface.

  The relevant alarm bits for the Remote Alarm indication, as recommended in G.732, G.733, G.744 and G.746, should be effected as soon as possible (see Table 1/Q.506).
- Alarm signals sent "downstream" towards the switching function. Alarm Indication Signal applied in all received time-slots containing speech, data and/or signalling should be applied as soon as possible and not later than 2 ms after the detection of the fault condition (see Table 1/Q.506).

  Note – The terms "upstream" and "downstream" are defined in Recommendation G.704.

TABLE 1/Q.506

Fault conditions and alarms detected by exchange terminal function and consequent actions

Fault conditions and alarms detected (see § 3.6.1)	Consequent actions (see § 3.6.1)			
	Service alarm indications generated	Prompt maintenance alarm indication generated	Alarm indication to remote end generated	AIS towards the switching stages
Failure of power supply	Yes	Yes	Yes, if practicable	Yes, if practicable
Loss of incoming signal	Yes	Yes	Yes	Yes
Loss of frame alignment	Yes	Yes	Yes	Yes
Excessive error ratio	Yes	Yes	Yes	Yes
Alarm indication received from remote end	G.732 + G.744: Yes G.733 + G.746: optional	G.733 + G.746: Yes		
AIS received	Yes		Yes	Yes

Note – As *Yes* in the table signifies that an action should be taken. An open space in the table signifies that the relevant action should *not* be taken if this condition is the only one present. If more than one fault condition or alarm is simultaneously present, action should be taken if for at least one of the conditions a *Yes* is shown, except in the case of AIS received for which § 3.6.1 applies.

3.6.1.3.3 *Removal of alarm indications*

When all fault conditions have been cleared and Alarm Indication Signal is no longer received, the Alarm Indication Signal and remote alarm indication should be removed within the same respective time limits as specified in § 3.6.1.3.4 after the conditions have cleared.

3.6.1.3.4 *Alarm processing*

The following items are required to ensure that equipment is not removed from service due to short breaks in transmission (e.g. due to noise or transient fault) and to ensure that maintenance action does not result where no direct maintenance action is required.

- The persistence of service alarm and of the prompt maintenance alarm indications may be verified for 100 ms before action is taken.
- When the AIS is detected, the prompt maintenance alarm indication, associated with loss of frame alignment and excessive error rate in the frame alignment pattern, should be inhibited.
- When the fault conditions cease, the service alarm and prompt maintenance alarm indications, if given, should be removed. Again, the persistence of this change in condition may be verified for 100 ms before action is taken.

- It is possible that some systems could suffer from frequent transient faults resulting in an unacceptable quality of service. For this reason, if a persistence check is provided, fault rate monitoring should also be provided for each digital transmission system. This monitoring will result in permanent removal from service of digital transmission systems which are frequently removed from the service or frequently produce transient alarm conditions. The threshold for removal from service needs study. When this action is taken the Service Alarm indication and the Prompt Maintenance Alarm indication shall be given.

Note to § 3.6.1 – The utilization of these indications will depend upon the switching and signalling arrangements provided nationally. Separate indications for some of the fault conditions listed may be provided nationally if required.

3.6.2 *Transmission systems*

Fault and alarms which cannot be directly detected by the exchange terminal function but which are detected by transmission equipment (e.g. group pilot failure) should be accepted by the exchange as needed to take appropriate action.

3.6.3 *Signalling function*

3.6.3.1 *Channel associated signalling (2048 and 8448 kbit/s systems)*

3.6.3.1.1 *Fault detection*

The exchange signalling function should detect the following fault conditions for each multiplex carrying a 64 kbit/s signalling channel:

- failure of local power supply (if practicable),
- loss of 64 kbit/s incoming signal,

  Note – The detection of this fault condition is required only when the fault does not result in an indication of loss of multi-frame alignment.
- loss of multi-frame alignment.

The criteria for activating and deactivating the indication of the fault condition are given in Recommendations G.732 and G.744.

3.6.3.1.2 *Alarm detection*

The exchange signalling function should detect the alarm indication (remote alarm) received from the remote end.

3.6.3.1.3 *Consequent actions*

3.6.3.1.3.1 *Generation of alarm signals for action within the exchange*

- The service alarm inidcation should be generated by the exchange signalling function to signify that the service is no longer available (see Table 2/Q.506).
- The prompt maintenance alarm indication should be generated to signify that performance is below acceptable standards and that immediate maintenance attention is required locally (see Table 2/Q.506).

3.6.3.1.3.2 *Alarm transmitted by the exchange*

An alarm indication (remote alarm) should be applied "upstream" towards the transmission/switching interface as soon as possible (see Table 2/Q.506. The relevant alarm bit for the remote alarm indication is given in Recommendation G.732.

3.6.3.1.3.3 *Removal of alarm indication*

When all fault conditions have been cleared and AIS is no longer received, the remote alarm indication should be removed as soon as possible.

TABLE 2/Q.506

Fault conditions and alarms detected by the exchange signalling function and consequent actions

Fault conditions and alarms detected (see § 3.6.3)	Consequent actions (see § 3.6.3)		
	Service alarm indication generated	Prompt maintenance alarm indication generated	Alarm indication to remote end generated
Failure of power supply	Yes	Yes	Yes, if practicable
Loss of 64 kbit/s incoming signal	Yes	Yes	Yes
Loss of multiframe alignment	Yes	Yes	Yes
Alarm indication received from remote end	Yes		

Note – A *Yes* in the table signifies that an action should be taken. An open space in the table signifies that the relevant action should *not* be taken if this condition is the only one present. If more than one fault condition or alarm is simultaneously present, action should be taken if for at least one of the conditions a *Yes* is shown.

3.6.3.1.3.4 *Alarm processing*

Same as in § 3.6.1.

3.6.3.2 *Channel associated signalling (1544 kbit/s)*

Requires further study.

3.6.3.3 *Common channel signalling*

Requirements specified in relevant Recommendations apply.

3.6.4 *Fault and alarm detection and consequent actions – other functions of the exchange*

3.6.4.1 *Faulty circuits*

The exchange should not switch any new calls to a detected faulty circuit.

The exchange should remove from service all circuits found to be permanently faulty as detailed in §§ 3.6.1, 3.6.2 and 3.6.3.

3.6.4.2 *Master clock distribution*

The absence of timing information distributed from a master clock located at the exchange or received from an external master clock shall be recognized and a prompt maintenance alarm shall be given.

Changeover to an alternate timing source shall be operated so as to fulfil the requirements of § 2.6.2 and § 2.6.3 of Recommendation Q.504.

3.6.4.3 *Internal timing distribution*

The distribution of timing information to the major elements of the exchange shall be supervised as required. A service alarm shall be given when a failure is detected. A maintenance alarm shall be given if it is appropriate.

Note – Remote elements may have to be taken into consideration.

3.7 *Supervision or testing of interface function*

The exchange shall have the capability of verifying the proper operation of the interface functions, including the fault detection and supervision functions.

Routine tests, statistical tests, manual activities and/or other means may be used to verify proper operation of these functions.

Information shall be given to the far end exchange when new calls cannot be established on the circuits on which routine tests are being initiated. Established calls, including semi-permanent connections, must not be interrupted. During the tests, the generation of alarms at the far end exchange due to the removal of circuits from service should be avoided, if possible.

3.7.1 *ET functions – interfaces A and B*

The verification of the proper operation of Exchange Terminal (ET) function can be performed by the means of statistical observations or by testing. Testing may be manual or automatic.

3.7.2 *ET functions – interface C*

i) Failures of codecs (except those covered in ii) below) should be recognized by the exchange using the criteria defined in Recommendation G.732.

ii) Supervision or testing of codecs of one or a small number of channels may be accomplished according to i) above or by inter-office transmission measurement and testing on circuits between exchanges or by statistical measurements.

3.8 *Supervision or testing of signalling functions*

In addition to fault detection required in § 3.6.3 the following applies.

3.8.1 *Channel associated signalling*

The exchange should be able to verify the proper operation of the signalling functions by generating and responding to test calls or by a statistical observation.

3.8.2 *Common channel signalling*

The exchange should be able to verify the proper operation of the signalling functions as required by common channel signalling recommendations.

3.9 *Supervision or testing of exchange performance*

3.9.1 *Exchange error performance*

A means of determining that the operational bit error ratio requirement is being met should be provided.

3.9.2 *Through connection supervision*

The exchange should provide adequate supervision of the cross office path continuity.

3.9.3 *Switched connections*

The requirements of § 2.5.1 of Recommendation Q.504 are considered to be sufficient in order to guarantee the cross office path continuity. The method by which this is performed may be on per call basis, continuously, statistically or by other means.

3.9.4 *Semi-permanent connections*

Semi-permanent connections may require special supervision procedures.

3.9.5 *n × 64 kbit/s connections*

This item requires further study for both switched and semi-permanent connections.

3.10 *Supervision or testing of digital facilities performance*

The exchange shall have the capability of monitoring digital link performance to detect when bit error ratio and loss of framing threshold exceed operational objectives. The exchange will then take subsequent action to give appropriate trouble indications or alarms and perform other appropriate actions, such as removing circuits from service.

3.11 *Supervision or testing of analogue facilities performance*

3.11.1 *Interexchange circuit continuity check*

The exchange should be capable of performing circuit continuity checks in accordance with appropriate signalling system recommendations. Circuits failing circuit continuity checks should be removed from service and repair procedures initiated as required.

3.11.2 *Interexchange transmission measurement and testing on circuits between exchanges*

The exchange may also be equipped within itself or give access to external equipment to perform other transmission tests on circuits. Faulty circuits should be removed from service and repair procedures initiated as required.

4 Network management functions

4.1 *General*

Network management is the function of supervising the performance of a network and taking action to control the flow of traffic, when necessary, to promote the maximum utilization of network capacity.

These functions have application in exchanges within the IDN, and may or may not have application in national networks during the transition period to IDN.

The implementation of network management features and functions in national networks and in specific exchanges will be at the option of Administrations or RPOA's. Likewise, the choice of which controls and features to use will be the option of each Administration or RPOA.

4.1.1 *Network management objectives*

Information on network management objectives can be obtained from Recommendation E.410, and from the CCITT "Handbook on service quality, network maintenance and management" ITU, Geneva 1984.

4.1.2 *The application of network management in exchanges*

In considering the application of network management capability in transit exchanges in addition to the normal engineering and economic considerations the following factors will need to be evaluated:

- the role and importance of the exchange in its own network, or as an access exchange interfacing with other networks (for example, international or other interexchange networks);
- the size of the exchange and of the circuit groups which it serves;
- the need for managing network resources effectively when overload conditions occur in its own network or interfacing networks;

- the requirement for the exchange to interact for network management purposes with other domestic exchanges or international exchanges and/or with network management centres.

Factors to be considered in selecting or implementing network management features for/in an exchange include:

- the network management organization, its equipment and functions;
- the potential impact of network management functions on the engineering design and administration of the network and the exchange;
- the evolution towards IDN and the interworking of SPC and non-SPC exchanges in the transition period;
- the extent to which automated and/or manual features are to be implemented and the rate of introduction of various features;
- the possible interactions of both the circuit switched and signalling networks when network management actions are applied under various traffic conditions or network configurations;
- alternate approaches that may be appropriate to control unusual network traffic conditions.

4.2 *Network management elements in an exchange*

The basic elements of a network management system to be provided by an exchange or by network management centres are:

- information on which network management decisions can be made,
- the capability to activate/deactivate controls resulting from decisions made in the exchange, or at a network management centre,
- feedback of status in response to control actions.

Descriptions of the functions required to support these elements are given in §§ 4.3 and 4.4.

4.3 *Information provided by an exchange for network management purposes*

4.3.1 *General*

The term "information" is used here as meaning all messages, signals or data in any form, used or provided by the exchange or network management centre.

4.3.2 *Sources of information*

The information provided by an exchange for network management will be based on the status, availability and performance of:

- circuit groups,
- exchange processes,
- common channel signalling link sets,
- other exchanges with direct links to this exchange,
- destination exchanges.

Details of network management measurements are given in Recommendation Q.505.

4.3.3 *Processing of network management information in an exchange*

Information collected at an exchange for network management purposes may or may not require some form of sorting and assembly (processing) before being used for network management.

Where processing is required this may be done by the exchange processor, or by a data processing system serving one or more exchanges, or by a network management centre.

4.3.4 *Transmittal of information*

Network management information may be sent as required on a near real-time basis:

- within the originating exchange,
- to distant exchanges,
- between the exchange and a network management centre.

Information may be carried over a dedicated telemetry or data facility, over a common channel signalling network, or over other telephony network facilities as appropriate.

For each mode of transmittal the appropriate interface and protocol requirements where covered by CCITT Recommendations should be satisfied.

Information may be sent automatically on a pre-arranged basis, or when triggered by an event such as an overload situation. Alternatively information may be sent in response to an external request from a network management centre.

4.3.5 *Presentation of information*

Indications of network management controls in effect in an exchange shall be presented on visual indicators and/or printing-type or video display unit terminals for purposes of advising on-site personnel.

Similar displays and/or indicators may also be provided in a co-located and/or distant network management centre.

4.4 *Exchange controls for network management*

4.4.1 *General*

Network management controls may be classified as expansive, or protective depending on the action produced when they are applied. Some controls may fall into both categories.

Definitions of these categories of control and their application are given in the E.400 series of Recommendations, and in the "Handbook on service quality, network maintenance and management".

4.4.2 *Activation and deactivation of controls*

Network management controls in exchanges may be activated as a result of decisions made by one of the following methods:

- pre-established logic in an exchange responding to pre-set levels (or thresholds) being exceeded. For example, overloads of traffic, excessive processing delays, or blocking;
- by manual, semi- or fully-automatic over-rides by external request;
- other methods appropriate to specific exchange configurations or technology.

Controls will usually be activated or deactivated in steps (stages) that are intended to avoid surge effects in the network that could be caused by too much control being added or removed too quickly.

A low-level threshold may be required to remove controls as appropriate, when conditions have stabilized.

4.4.3 *Network management controls*

The following is a list of typical network management controls to be considered for implementation in a given exchange.

4.4.3.1 *Code blocking control (protective)*

This control bars or restricts routing to a specific destination code. Code blocking can be done on a country code, an area code, an exchange identifying code and, in some cases, on an individual line number. The last is the most selective control available.

4.4.3.2 *Cancellation of alternative routing (protective)*

There are several variations of this control. One is to prevent traffic from the selected route overflowing onto the next alternate route. Another is to prevent overflow traffic from all sources from accessing a specific route.

4.4.3.3 *Restriction of direct routing (protective)*

This control limits the amount of direct routed traffic accessing a route.

4.4.3.4 *Skip route (expansive and/or protective)*

This control allows traffic to bypass a specific route and advance instead to the next route in its normal routing pattern.

4.4.3.5 *Temporary alternative routing (expansive)*

This control redirects traffic from congested routes to routes not normally available which have idle capacity at the time. This can be done for subscriber, and/or operator originated traffic.

4.4.3.6 *Circuit directionalization (protective/expansive)*

This control changes both-way operated circuits to one-way operated circuits. At the end of the circuit for which access to the route is inhibited this is a protective action, whereas at the other end of the circuit (where access is still available) it is an expansive action.

4.4.3.7 *Circuit turndown/busying (protective)*

This control removes one-way and/or both-way operated circuits from service.

4.4.3.8 *Operator controls (traffic operator actions) (protective)*

These controls reduce the number of attempts to a particular destination or provide special handling instructions for emergency calls during serious congestion or failure.

4.4.3.9 *Recorded announcements (protective)*

These are announcements which given special instructions to operators and subscribers, such as to defer their call to a later time, during congestion, failures, or other abnormal events.

4.4.3.10 *Circuit reservation (protective)*

This control reserves the last few idle circuits in a circuit group for a particular type of traffic such as, for example, direct routed traffic or operator originated traffic.

4.4.3.11 *Switching system controls (protective)*

These are internally provided automatic controls that are part of the exchange design. They improve switching performance during overloads by:

- inhibiting second trials;
- inhibiting low-priority tasks;
- reducing the acceptance of new calls based on the availability of major components, or other load reduction actions;
- informing connected exchanges that protective controls should be activated.

4.4.4 *Range and application of controls*

It is desirable that these controls be activated to affect a variable percentage of traffic (for example, 25%, 50%, 75% or 100%). Alternatively the number of call attempts routed in a particular period may be controlled (for example 10 calls per minute). It may also be desirable to apply controls on a destination code basis.

Many of the controls specified above can be activated by manual or automatic means. When automatic activation is provided, however, an ability for manual override must also be provided.

TRANSMISSION CHARACTERISTICS

1 Introduction

1.1 *General*

This Recommendation applies to digital transit exchanges for telephony in Integrated Digital Networks (IDN) and mixed analogue/digital networks. The field of application of this Recommendation is found in Recommendation Q.501.

The signals taken into consideration are passed through the following interfaces as described in Recommendation Q.502 and in Figure 1/Q.507:

- interface A, for primary PCM multiplex signals at 2048 kbit/s or 1544 kbit/s;
- interface B, for secondary PCM multiplex signals at 8448 kbit/s or 6312 kbit/s;
- interface C, comprising both 4-wire and 2-wire interfaces. Interfaces C1 and C2 are analogue interfaces and represent possible applications of interface C in Figure 2/Q.502.

In the present recommendation, values given for transmission characteristics relate to complete paths connecting input and output analogue interfaces. It is envisaged that, as a result of further studies, a later revised Recommendation will give the characteristics in a different form, relating to the path from an exchange test point to an analogue interface and vice versa; the overall characteristics for connections involving two interfaces will be obtainable by suitably combining these values.

In the future, other interfaces may be defined, and at that time, this Recommendation will be extended to include those interfaces.

At this time this Recommendation considers analogue signals which are encoded in accordance with Recommendation G.711. Other coding laws may be defined in the future and this Recommendation will need to take them into account.

In addition, for parameters such as transmission delay or transmission loss, values for signals passing between interface C and interfaces A or B ("analogue-to-digital") are given. Corresponding values are also given for signals of the same type, e.g. related to telephony or similar services, when passing between interface A or B and interface A or B ("digital-to-digital").

Some of the transmission characteristics for connections involving a 64-kbit/s channel timeslot at the recommended digital interfaces are still under study and therefore are not yet included in this Recommendation.

The transmission characteristics of voice-frequency (VF) connections through a digital transit exchange should in principle provide performance in accordance with Recommendations G.712, G.713 and, where applicable, Q.45 (see also Recommendation G.142).

The limit values are not necessarily identical with those specified for equipment, since in the case of a connection through the exchange additional allowances generally have been made for cabling – see § 2.

The values given are to be considered as either "design" or "performance objectives" according to the explanations of the terms given in Recommendation G.102 (Transmission performance objectives and recommendations) and the particular context.

1.2 *Definitions*

1.2.1 *Exchange test points and exchange input and output*

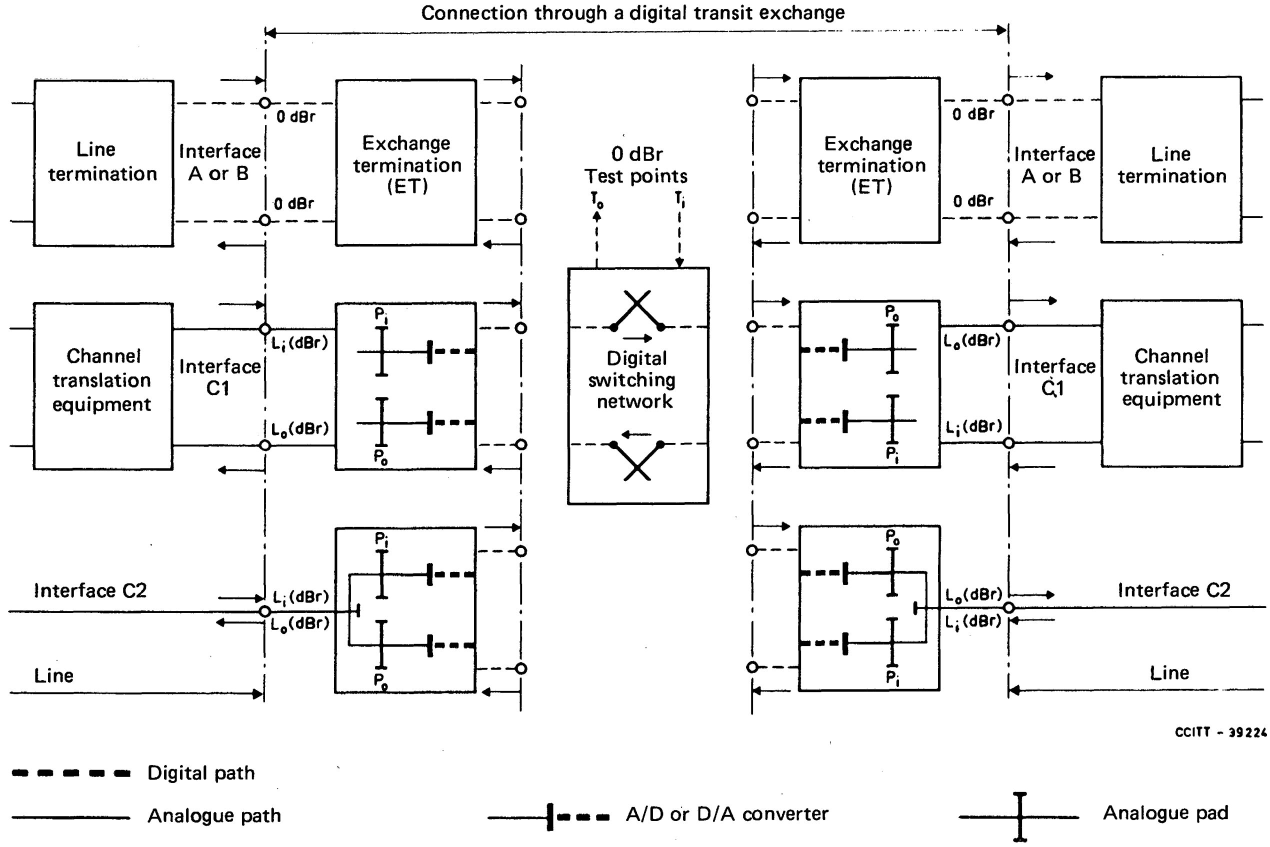
1.2.1.1 **exchange test points**

The exchange test points, shown in Figure 1/Q.507, are defined for specification purposes. They may not actually exist in an exchange. They are located such that end-to-end performance can be determined by suitably combining performances between each interface and the exchange test points.

1.2.1.2 **exchange input and output**

The interfaces identified in § 1.1 and shown in Figure 1/Q.507 for a connection through a digital transit exchange constitute the exchange input and output.

The exact positions of each of these points depends on national practice, and it is not necessary for the CCITT to define it. Only the authority responsible for each digital exchange can fix the position of these points in each case, taking due account of § 2 of Recommendation Q.507.



Note 1 – Digital loss pads, if required, may be located in the digital switching network or the exchange terminals (see § 1.2.3.1).

Note 2 – The values of L_i and L_o for 2-wire interfaces may not necessarily be equal to those of 4-wire interfaces.

Note 3 – The value of L_o is nominally equal to the negative of the loss of the P_o pad. The value of L_i is nominally equal to the loss of the P_i pad.

FIGURE 1/Q.507

Transmission levels and test points at a digital transit exchange

1.2.2 *Relative levels*

1.2.2.1 *Exchange test points*

The nominal relative level at the input and output exchange test points is assigned the value 0 dBr.

1.2.2.2 *Analogue interfaces*

The nominal relative level at the exchange input point is designated L_i.

The nominal relative level at the exchange output point is designated L_o.

1.2.2.3 *Digital interfaces*

The relative level to be associated with a point in a digital path carrying a digital bit stream generated by a coder lined-up in accordance with the principles of Recommendation G.101 is determined by the value of the digital loss or gain between the output of the coder and the point considered. If there is no such loss or gain the relative levels at the exchange input and output points (i.e. digital interfaces A and B) are by convention said to be 0 dBr. For further information see Recommendation G.101, § 5.3.2.

Note – The digital level may be established using measuring equipment in accordance with Recommendation O.133.

Relative level has no meaning for digital bit streams that are not derived from real or simulated analogue sources.

1.2.3 *Measurement conditions*

1.2.3.1 *Reference frequency*

The nominal reference frequency, on which values of relative level, transmission loss, attenuation/frequency distortion etc. are based, is 1000 Hz. For measurements performed with analogue sine-wave oscillators, a frequency of 1004 to 1020 Hz should be used.

To avoid level errors produced as a result of the use of test frequencies which are sub-multiples of the PCM sampling rate the choice of test frequencies should accord with Supplement No. 35 of Fascicle IV.4 of the CCITT *Yellow Book*. In addition, it is considered that the use of other integer sub-multiples of the sampling rate should be avoided. In particular where a nominal frequency of 1000 Hz is indicated, the actual frequency should be chosen in the range 1004-1020 Hz as appropriate. Within this range, frequencies above 1010 Hz may permit faster measurement by avoiding fluctuations due to the "stroboscopic effect".

1.2.3.2 *Impedance*

Unless otherwise specified, measurements at analogue interfaces shall be made under nominally matched conditions, i.e. the interface is terminated with the nominal exchange impedance.

1.2.3.3 **test levels at analogue interfaces**

At the reference frequency, test levels are defined in terms of the apparent power relative to 1 mW. At frequencies different from the reference frequency, test levels are defined as having the same voltage as the test level at the reference frequency. Measurements are based on the use of a test generator with a frequency-independent e.m.f. and which has an impedance equal to the nominal impedance.

1.2.4 **nominal transmission loss**

A connection through the exchange (see Figure 1/Q.507) is established by connecting in both directions an input located at one interface to an output located at another interface.

The nominal transmission loss for a connection through an exchange is equal to the difference of the relative levels at the input and the output:

$$NL = (L_i - L_o) \text{ dB}$$

The nominal transmission loss between the input at an analogue interface and the exchange test point is defined as:

$$NL_i = L_i$$

The nominal transmission loss between the exchange test point and the output of an analogue interface is defined as:

$$NL_o = -L_o$$

This is equal to the nominal "composite loss" (see definition in the *Yellow Book*, Fascicle X.1) at the reference frequency. See also supplement 9 to the *Red Book* of the CCITT Volume VI.

Note 1 – The nominal transmission loss, NL, may be implemented by an analogue loss pad. It may also be implemented by a digital loss pad. In the latter case, the digital loss pad may be on the incoming side of the digital switching network, or on the outgoing side of the digital switching network or both.

As a general principle the use of digital loss pads should be avoided because bit integrity is lost for digital services and additional transmission impairments are introduced for analogue services.

However, it is recognized that during the transition stage to a completely digital network, existing national transmission plans may require digital pads to be inserted for speech.

In addition, connections in a future ISDN used for voice can be expected to contain other devices which destroy bit integrity of the 64 kbit/s path (e.g. code converters, digital echo control devices, digital speech interpolation apparatus, or all-zero-suppressors) provision must be made to render all such devices inoperative when necessary (see Recommendation Q.503, § 3.5).

Note 2 – The nominal transmission loss of the exchange may be different in the two directions.

1.2.5 **attenuation/frequency distortion**

The attenuation/frequency distortion (loss distortion) is the logarithmic ratio of output voltage at the reference frequency (nominally 1000 Hz), U(1000 Hz), divided by its value at frequency f, $U(f)$:

$$LD = 20 \log \left| \frac{\mathrm{U(1000\ Hz)}}{U(f)} \right|$$

See Supplement 9 to Volume VI, CCITT *Red Book*.

2 Characteristics of interfaces

The interfaces taken into account are those of Figure 1/Q.502. For voice-frequency interfaces (C), the electrical parameters refer to the appropriate distribution frame (DF), on the assumption that the length of the cabling between the DF and the actual exchange does not exceed 100 m (exchange cables). In this respect Recommendation Q.45, Section 7 applies.

For corresponding limitations on the location of digital interfaces, see Recommendation G.703 (§§ 2.6 and 6.3 for A interfaces) (§§ 3.6 and 7.3 for B interfaces).

2.1 *Interface C*

2.1.1 *Impedance of VF ports*

2.1.1.1 *Nominal value*

2.1.1.1.1 *4-wire interfaces*

The nominal impedance at the 4-wire VF input and output ports should be 600 ohms, balanced.

2.1.1.1.2 *2-wire interfaces*

Nominal impedance to be defined depending on national conditions (e.g. for loaded and unloaded cables).

2.1.1.2 *Return loss*

The return loss has to be measured against the nominal impedance given in § 2.1.1.1.

2.1.1.2.1 *4-wire interfaces*

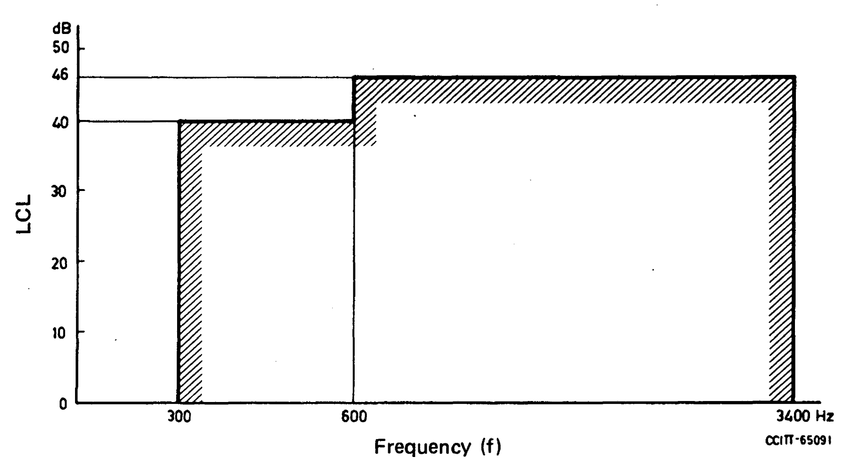
The return loss, measured against the nominal impedance, should not be less than 20 dB over the frequency range 300 to 3400 Hz.

2.1.1.2.2 *2-wire interfaces*

Under study.

2.1.1.3 *Impedance unbalance about earth*

The value for the longitudinal conversion loss (LCL) defined in Recommendation G.117, § 4.1.3) should exceed the minimum values of Figure 2/Q.507 which is in accordance with Recommendations Q.45 and K.10 with the equipment under test in normal speech condition.



Note 1 – Some Administrations may adopt other values and in some cases wider bandwidths depending upon the actual conditions in their telephone network.

Note 2 – A limit may also be required for the tranverse conversion loss (TCL) (as defined in Recommendation G.117, § 4.1.2) if the exchange termination is not reciprocal with respect to the transverse and longitudinal paths. A suitable limit would be 40 dB to ensure an adequate near-end crosstalk attenuation between interfaces.

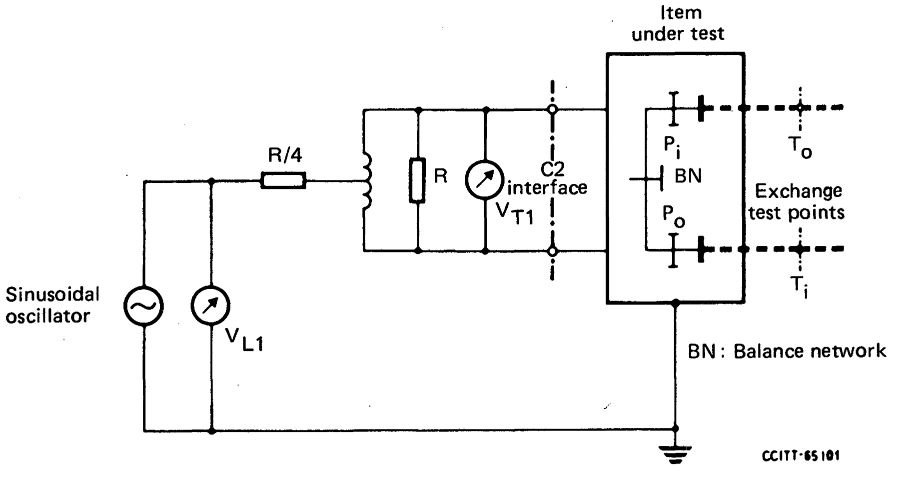
FIGURE 2/Q.507

Minimum values of LCL measured in the arrangement shown in Figure 3/Q.507

Test method

LCL should be measured in accordance with the principles given in Recommendation O.121, §§ 2.1 and 3. Figure 3/Q.507 shows an example for the basic measuring arrangement for digital transit exchanges (interface C2).

Measurements of the longitudinal and transversal voltages should preferably be performed by means of a selective level meter.



R should be in the range of 600-900 Ω.

Longitudinal conversion loss (LCL) = $20 \log_{10} \left| \frac{V_{L1}}{V_{T1}} \right|$ dB.

Note 1 – Special care must be taken in those applications using active hybrids.

Note 2 – The exchange test point, T_i, must be driven by a PCM signal corresponding to the decoder output value number 0 for the μ-law or decoder output value number 1 for the A-law.

FIGURE 3/Q.507

Arrangement for measuring LCL

2.1.2 *Values of relative levels*

2.1.2.1 *Basic nominal values*

The nominal input and output relative levels at the exchange test points of a digital transit exchange should in general be 0 dBr.

The minimum and maximum relative levels at the analogue input and output ports of the exchange need to be specified. The item is still under study.

Some explanations concerning the concept of relative levels can be found in Recommendation G.101.

2.1.2.2 *Tolerances of relative levels*

The difference between the actual relative level and the nominal relative level should lie within the following limits. (These terms are defined in Recommendation G.101, § 5.3.2.)

a) input relative level: −0.3 to +0.7 dB;

b) output relative level: −0.7 to +0.3 dB.

These differences may arise from design tolerances, adjustment increments, or time variation.

Note – It is assumed that for the equipment ports, the adjustment is made in accordance with Recommendation G.712, § 16. The asymmetry of the tolerance at the DF takes the existence of cabling between the DF and the exchange equipment into account.

2.1.2.3 *Difference in transmission loss*

Recommendation G.121, § 6.3 deals with the "difference in transmission loss between the two directions of transmission". For the national extension this is the value "loss (*t-b*) – loss (*a-t*)". (See the text in the cited Recommendation for guidance.) This difference is limited to ± 4 dB. However, to make allowance for additional asymmetry of loss in the rest of the national network only part of this difference can be used by the transit exchange (see also § 3.2.2.)

2.1.3 *Requirements for echo and stability control*

This applies to exchanges to which 2-wire circuits are connected. Recommendation G.122, § 1 (with respect to stability) and Recommendation G.122, § 2 (with respect to echo) have to be observed. This Recommendation gives values of the necessary loss of the path "*a-t-b*" which is determined by relative levels and by the balance return loss.

Note – A wide variety of values of pads P_o and P_i (see legends to Figure 1/Q.507) as well as of balance networks can be encountered because of the differences among national practices. The choice of pad and balance values is governed not only by the transmission requirements of the individual national networks but also by the need to comply with CCITT Recommendations (Volume III) concerning echo, stability, crosstalk, etc., on international connections.

3 Voice-frequency (VF) parameters of a connection between two C interfaces of the same exchange

3.1 *General*

This paragraph of Recommendation Q.507 may involve measurements at 2-wire points. These may be at a DF, i.e. including the exchange cabling, if the Administration has so defined the exchange input and output (see § 1.2.1.2). This necessitates appropriate considerations for each parameter.

In measuring transmission parameters with 2-wire ports (interface D2) involved, it is necessary to interrupt the opposite direction of transmission in order to avoid disturbing effects due to reflections at hybrids.

Separate transmission performance requirements for paths between an analogue input and an exchange test point, as well as between an exchange test point and an analogue output are under study.

3.2 *Transmission loss through the exchange*

3.2.1 *Nominal value of transmission loss*

The nominal transmission loss corresponds to the difference of the nominal relative levels at the interfaces used for the connection through the exchange (cf. § 2.1.2). In accordance with the definition of relative levels (cf. § 1.2.2.2) the value of nominal loss is valid at 1000 (1004-1020) Hz.

3.2.2 *Difference in transmission loss between the two directions*

The difference in actual transmission loss at the reference frequency between the two directions of transmission should not exceed 1 dB. The value of 1 dB is provisional.

3.2.3 *Short-term variation of loss with time*

When a sine-wave signal at a level of –10 dBm0 at the reference frequency is applied to any C interface input, the level measured at the corresponding C interface output should not vary from the value at the beginning of the interval by more than ± 0.2 dB during any 10-minute interval of typical operation.

Note – The specification for the short-term stability is of a provisional nature.

3.2.4 *Attenuation/frequency distortion*

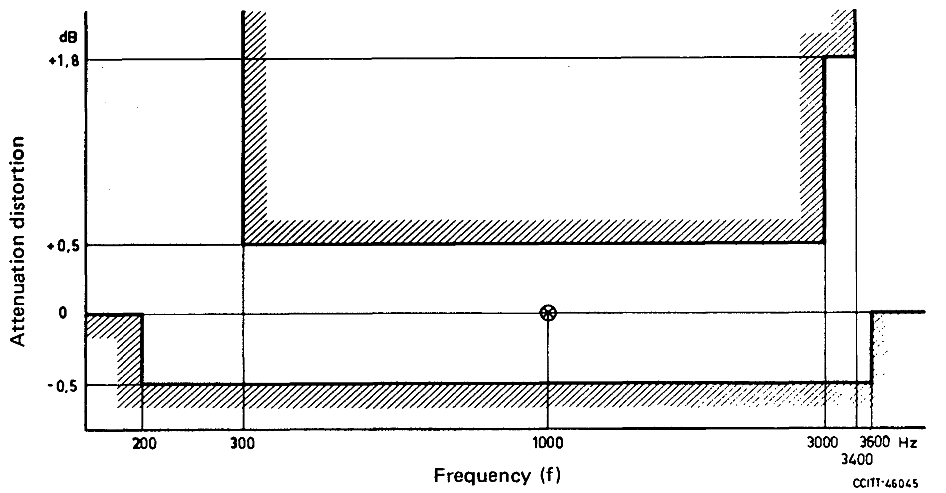
The attenuation/frequency distortion can be measured in two ways with regard to the terminating impedances. Using the nominal exchange impedances as defined in § 2.1.1.1, the measurement closely represents the attenuation/frequency distortion the exchange will introduce in a real connection. An alternative method is to measure with a low-impedance generator and a high-impedance level meter.

In general, the results from the two methods will differ slightly unless the return loss of the exchange input and output impedances against the nominal are extremely high (40 dB for 0.1 dB accuracy). However, in many cases, the difference in measured distortion resembles the distortion of a very short subscriber cable and, therefore, is of no practical importance, hence, either method may be used.

The influence of line-signalling equipment using the same wires as for v.f. transmission is not included. This topic is under study.

3.2.4.1 *Between 4-wire (C1) interfaces*

The attenuation/frequency distortion of any connection between two C1 interfaces should lie within the limits of Figure 4/Q.507. The input power level is -10 dBm0. The results are referred to the output at the reference frequency defined in § 3.2.1.



Note – The reference frequency of 1000 Hz is chosen because this frequency is used for adjustment in accordance with Recommendations G.711, § 4, and G.712, § 15.

FIGURE 4/Q.507

Attenuation/frequency distortion limits between 4-wire interfaces with signalling on separate wires

3.2.4.2 *Between 2-wire (C2) interfaces or 2-wire (C2) and 4-wire (C1) interfaces*

Under study.

3.2.5 *Variation of gain with input level*

Two alternative methods are recommended.

3.2.5.1 *Method 1*

With a band limited noise signal, as defined in Recommendation O.131, applied to the input of any channel at a level between -55 dBm0 and -10 dBm0, the gain variation of that channel, relative to the gain at an input level of -10 dBm0, should lie within the limits of the mask of Figure 5a/Q.507. The measurement should be limited to the frequency band 350-550 Hz in accordance with the filter characteristic defined in Recommendation O.131, § 3.2.1.

Furthermore, with a sine-wave signal in the frequency range 700-1100 Hz applied to the input of any channel at a level between −10 dBm0 and +3 dBm0, the gain variation of that channel relative to the gain at an input level of −10 dBm0, should lie within the limits of the mask of Figure 5b/Q.507. The measurement should be made selectively.

Note – The impact of attenuation-frequency distortion on the measurement accuracy is under study.

3.2.5.2 *Method 2*

With a sine-wave signal in the frequency range 700-1100 Hz (excluding submultiples of 8 kHz) applied to the input port of any channel at a level between −55 dBm0 and +3 dBm0, the gain variation of that channel relative to the gain at an input level of −10 dBm0, should lie within the limits of the mask of Figure 5c/Q.507. The measurement should be made selectively.

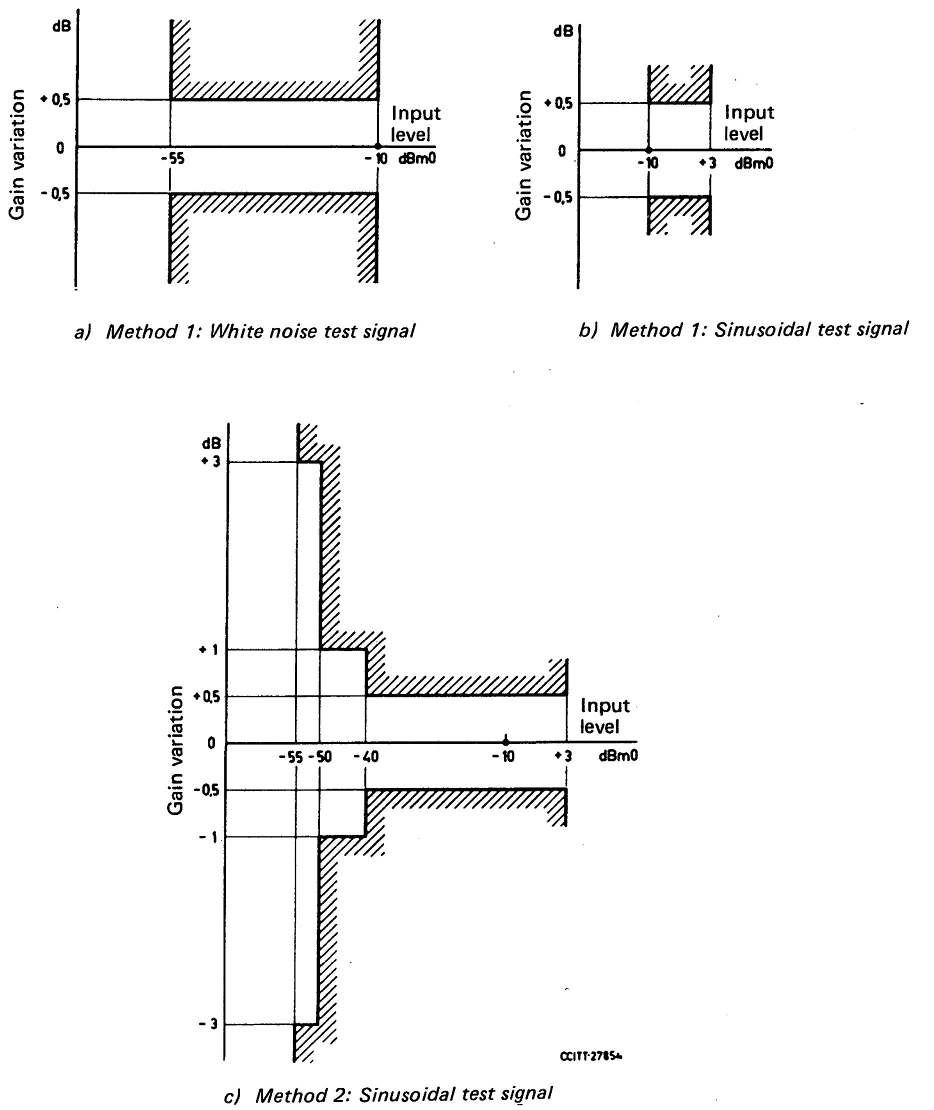


FIGURE 5/Q.507

Variation of gain with input level

3.3 *Group delay through the exchange*

"Group delay" is defined in the *Yellow Book*, Fascicle X.1.

3.3.1 *Absolute group delay*

"Absolute group delay" is the group delay at that frequency where it has its smallest value in the frequency range from 500 Hz to 2800 Hz.

The sum of the separately measured absolute group delays for passing in both directions through an exchange should meet the requirements given in Table 1/Q.507, where the term "mean value" is understood as the expected value in the statistical sense.

The absolute group delay includes delay due to electronic devices such as frame aligners and time stages of the switching matrix but does not include delays due to ancillary functions, such as echo suppression or echo cancellation.

TABLE 1/Q.507

Absolute group delays through an exchange

Interconnection	Mean value	0.95 Probability of not exceeding
Digital – digital	$\leq$ 900 μs	1500 μs
Digital – analogue	$\leq$ 1500 μs	2100 μs
Analogue – analogue	$\leq$ 2100 μs	2700 μs

Note – These values for the absolute group delays are applicable under reference load A conditions as defined in Recommendation Q.504, § 2.1.

The recommended values for digital-digital and digital-analogue delay should be included in a different paragraph of Recommendation Q.507 in accordance with the plan for restructuring Recommendation Q.507.

3.3.2 *Group delay distortion with frequency*

Taking the absolute group delay (cf. § 3.3.1) as reference, the group delay distortion for a single direction of transmission between C1 interfaces should lie within the limits shown in Figure 6/Q.507.

3.3.3 *Input level*

The requirements of §§ 3.3.1 and 3.3.2 should be met at an input level of -10 dBm0.

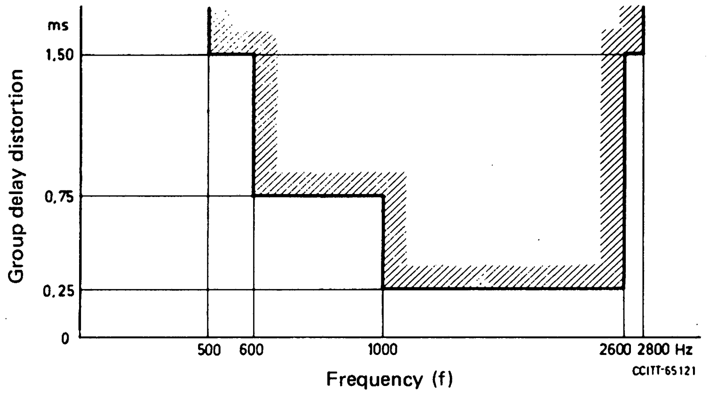
3.4 *Noise and crosstalk*

3.4.1 *Idle channel noise*

3.4.1.1 *General*

For the specification of noise, the fact must be taken into account that the exchange equipment can provide only a finite rejection of the noise superimposed on the main power supply voltage (e.g. 48 V or 60 V). The specification of the power supply noise and the rejection ratio is under study.

Information about the subject of the noise on the DC power supply is given in Supplement No. 13 to the G-series Recommendations (*Orange Book*, Volume III-3).



Note – The possible need for relaxation of this mask at $f < 1$ kHz, in order to take into account the effects of filter hybrid, etc., is under study.

FIGURE 6/Q.507

Group delay distortion limits with frequency between C1 interfaces with signalling on separate wires

3.4.1.2 *Weighted noise*

It is necessary to consider two components of noise: noise arising from the encoding process and noise via signalling circuits from the exchange power supply and other analogue sources (e.g. analogue coupling). The first component is limited by Recommendation G.712, § 4.1 to −65 dBm0p; the other component by Recommendation G.123, § 3 to −67 dBm0p. This results in the maximum value for the overall weighted noise at the v.f. ports of a digital transit exchange of: −63 dBm0p

3.4.1.3 *Unweighted noise*

This noise will be more dependent on the noise on the power supply and on the rejection ratio.

Note – The need for and value of this parameter are both under study. Recommendations Q.45, § 5.1 and G.123, § 3 must also be considered.

3.4.1.4 *Single frequency noise*

The level of any single frequency (in particular the sampling frequency and its multiples), measured selectively, should not exceed −50 dBm0.

Note – The frequency range for this parameter is under study.

3.4.1.5 *Impulsive noise*

It will be necessary to place limits on impulsive noise arising from sources within the exchange; these limits are under study. Pending the results of this study, Recommendation Q.45, § 5.2 may give some guidance on the subject of controlling impulsive noises with low frequency content.

Note 1 – The sources of impulsive noise are often associated with signalling functions (or in some cases the power supply) and may produce either transverse or longitudinal voltage at C interface.

Note 2 – The disturbances to be considered are those to speech or modem data at audio frequencies, and also those causing bit errors on parallel digital lines carried in the same cable. This latter case, involving impulsive noise with high frequency content, is not presently covered by the measurement procedure of Recommendation Q.45.

3.4.2 *Crosstalk*

3.4.2.1 *Crosstalk between different connections*

The crosstalk between any two connections through the exchange should be such that a sine-wave signal in the frequency range 700-1100 Hz (excluding submultiples of 8 kHz) and a level of 0 dBm0 applied to an input port, the crosstalk level received at either output port of the other connection should not exceed −65 dBm0.

When a white noise signal shaped in accordance with Recommendation G.227 at a level of 0 dBm0 is applied to up to four input ports the level of the crosstalk received at the output port of any other connection should not exceed −60 dBm0p. Uncorrelated noise should be used when more than one input port is energized.

3.4.2.2 *Go-to-return crosstalk of the same path*

The crosstalk between the two directions of a connection through an exchange should be such that with a sine-wave signal at any frequency in the range 300-3400 Hz and at a level of 0 dBm0 applied to an input port, the crosstalk level measured at the associated output port should not exceed −60 dBm0. This applies for four-wire (C1) interfaces only.

3.4.2.3 *Crosstalk measurements (for sine-wave signals)*

For measurement, an auxiliary signal (a low level activating signal) should be injected into the disturbed connection: for example a pseudo random noise signal as specified in Recommendation O.131 at a level of −60 to −50 dBm0 is suitable. It is necessary to use a frequency selective detector when performing this measurement.

Note – Further study is required concerning the effects of the activating signal. Further study is also required to determine if more stringent limits or measurements at additional frequencies should be specified.

3.5 *Distortion*

3.5.1 *Total distortion, including quantizing distortion*

Two alternative methods are recommended.

3.5.1.1 *Method 1*

With a noise signal corresponding to Recommendation O.131 applied to the input port of a channel, the ratio of signal-to-total distortion power measured at the output port should lie above the limits shown in Figure 7/Q.507.

Note 1 – These limits are based on a noise signal having a gaussian distribution of amplitudes and the derivation of the limits is given in Annex A of Recommendation G.712.

Note 2 – The limits and the method of taking into account the effects of attenuation/frequency distortion, when signalling is not on separate wires, and noise weighting is under study.

3.5.1.2 *Method 2*

With a sine-wave signal at a nominal frequency of 820 Hz or preferably 1020 Hz (see Recommendation O.132) applied to the input port of a connection, the ratio of signal-to-total distortion power measured with the proper noise weighting (see Table 4 of Recommendation G.223), should lie above the limits shown in Figure 8/Q.507 for signalling on separate wires and in Figure 9/Q.507 for signalling on the speech wires.

The values of Figure 9/Q.507 include the limits for the encoding process given in Figure 5/G.712 and the allowances for the noise contributed via signalling circuits from the exchange power supply and other analogue sources (e.g. analogue coupling) which is limited to −67 dBm0p by Recommendation G.123, § 3.

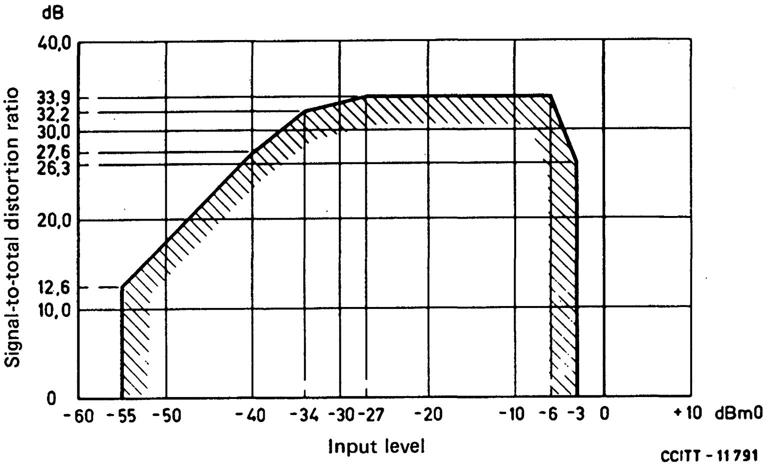


FIGURE 7/Q.507

Limits for signal-to-total distortion ratio as a function of input level for connections between C1 interfaces with signalling on separate wires (Method 1)

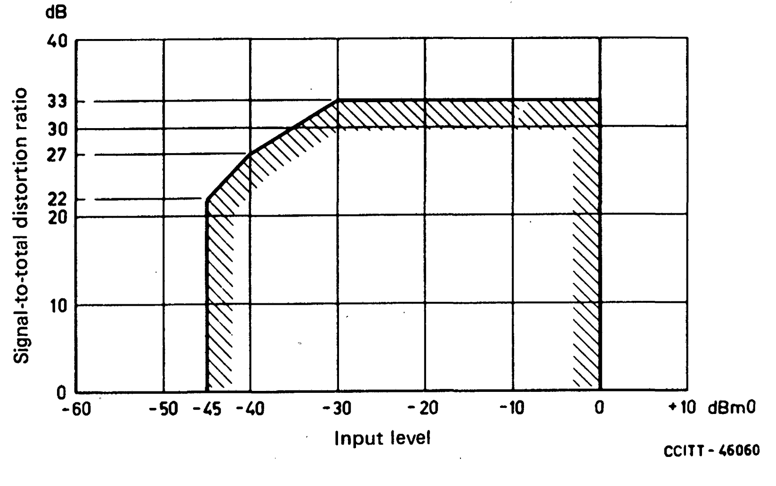


FIGURE 8/Q.507

Limits for signal-to-total distortion ratio as a function of input level for connections between C1 interfaces with signalling on separate wires (Method 2)

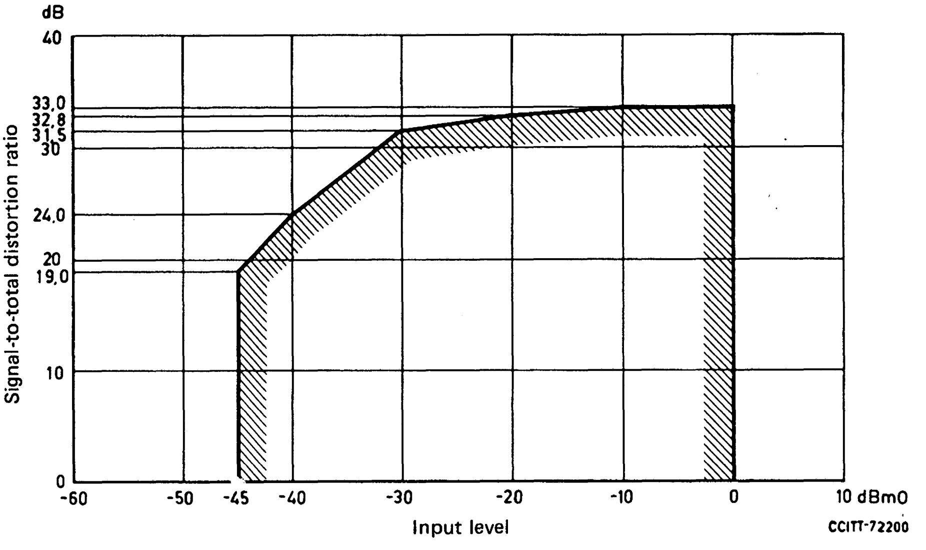


FIGURE 9/Q.507

Limits for signal-to-total distortion ratio as a function of input level for connections between C1 interfaces with signalling on separate wires (Method 2)

3.5.2 *Intermodulation*

1) Two sine-wave signals of different frequencies f_1 and f_2 not harmonically related, in the range 300-3400 Hz and of equal levels in the range -4 to -21 dBm0, applied simultaneously to the input port of a channel should not produce any $2f_1 - f_2$ intermodulation product having a level greater than -35 dB relative to the level of one of the two input signals.

2) A signal having a level of -9 dBm0 at any frequency in the range 300-3400 Hz and a signal of 50 Hz at a level of -23 dBm0 applied simultaneously to the input port should not produce any intermodulation product of a level exceeding -49 dBm0.

Note 1 – These requirements are in practice always met if the requirements according to §§ 3.5.1 and 3.2.5 are met.

Note 2 – For measurement purposes, a simplified method as defined in Recommendation Q.45, § 6.1 is preferred.

3.5.3 *Spurious in-band signals at the output ports*

With a sine-wave signal in the frequency range 700-1100 Hz (excluding submultiples of 8 kHz) and at a level of 0 dBm0 applied to the input port of a connection, the output level at any frequency other than the frequency of the applied signal, measured selectively in the frequency band 300-3400 Hz, should be less than -40 dBm0.

3.6 *Discrimination against out-of-band signals*

3.6.1 *Discrimination against out-of-band signals at the input port*

1) With any sine-wave signal above 4.6 kHz applied to the input port of the connection at a suitable level, the level of any image frequency produced at the output port of the connection should, as a minimum requirement, be at least 25 dB below the level of the test signal. The upper limit of the frequency range should be chosen such that, in a given application, possible disturbances of the input filter are adequately covered.

Note – It has been found that a suitable test level is -25 dBm0.

2) Under the most adverse conditions encountered in a national network, the PCM channel should not contribute more than 100 pW0p of additional noise in the band 0-4 kHz at the output port, as a result of the presence of out-of-band signals at the input port.

Note 1 – The discrimination required depends on the performance of FDM channel equipments and telephone instruments in national networks and individual Administrations should carefully consider the requirements they should specify, taking into account the comments above and the requirement of 2) above. In all cases at least the minimum requirement of 1) above should be met.

Note 2 – Attention is drawn to the importance of the attenuation characteristic in the range 3400 to 4600 Hz. Although other attenuation characteristics can satisfy the requirements 1) and 2) above, the filter template of Figure 10/Q.507 gives adequate protection against the out-of-band signals.

Note 3 – An additional requirement for 2-wire interfaces may be needed in order to suppress frequency at 16 2/3 Hz and 50 or 60 Hz (e.g. fundamental waves of interference from power lines and electrical railways) and is under study.

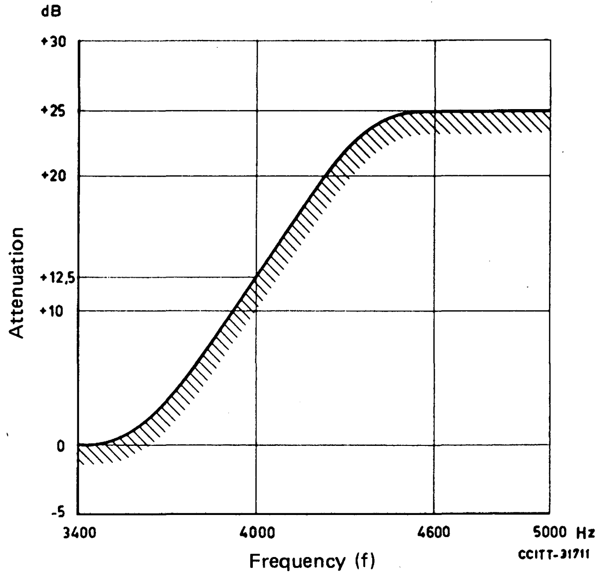
3.6.2 *Spurious out-of-band signals at the output port*

1) With any sine-wave signal in the range 300-3400 Hz at a level of 0 dBm0 applied to the input port of a connection, the level of spurious out-of-band image signals measured selectively at the ouput port should be lower than −25 dBm0.

2) The spurious out-of-band signals should not give rise to unacceptable interference in equipment connected to the output port. In particular, the intelligible or unintelligible crosstalk in a connected FDM channel should not exceed a level of −65 dBm0 as a consequence of the spurious out-of-band signals at the output port.

Note 1 – The discrimination required depends on the performance of FDM channel equipment and telephone instruments in national networks and individual Administrations should carefully consider the requirements they should specify, taking into account the comments above and the requirement of 2) above. In all cases, at least the minimum requirement of 1) above should be met.

Note 2 – Attention is drawn to the importance of the attenuation characteristic in the range 3400 to 4600 Hz. Although other attenuation characteristics can satisfy the requirements 1) and 2) above, the filter template of Figure 10/Q.507 gives adequate protection against the out-of-band signals.



Note – The curved portion of the graph conforms to the equation:

$$\text{Attenuation } X = 12.5 \left[1 - \sin \frac{\pi(4000 - f)}{1200}\right] \text{ dB}$$

for the range $3400 \leq f \leq 4600$ Hz.

FIGURE 10/Q.507

Attenuation relative to attenuation at 1000 Hz

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SECTION 2

DIGITAL LOCAL AND COMBINED EXCHANGES

Recommendation Q.511

INTRODUCTION, FIELD OF APPLICATION AND BASIC FUNCTIONS

1 Introduction

This series of Recommendations Q.511-Q.517 applies to digital local and combined[1] exchanges for telephony in Integrated Digital Networks (IDNs) and mixed analogue/digital networks. It will also form the basis for digital switching in Integrated Services Digital Networks (ISDNs) when other services are integrated with telephony.

The series of Recommendations comprises:

Q.511 Introduction, field of application and basic functions

Q.512 Interfaces

Q.513 Connections, signalling, control, call handling and ancillary functions

Q.514 Performance and availability design objectives

Q.515 Exchange measurements

Q.516 Operations and maintenance functions

Q.517 Transmission characteristics

Considerations have been based primarily on exchanges utilizing, at least in part, time division switching techniques. However, these Recommendations, are implementation independent, and other system implementations using alternative techniques (e.g. space division switching) may be possible, which would meet the requirements of these Recommendations.

2 Field of application

These Recommendations are intended to be applied as indicated below:

2.1 *Application and evolution to the ISDN*

The selection of features, functions and interfaces to be provided in a digital local or combined exchange in a particular network application will be determined by the Administration concerned. Not all the recommended features, functions and interfaces will necessarily be provided in every digital local or combined exchange.

These Recommendations are intended to facilitate the use of a digital local or combined exchange in an IDN or an ISDN and to allow for evolution of the network in which the exchange is used from analogue through to a full ISDN as defined in Recommendation I.120.

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1) A "combined" digital exchange is one which includes both local exchange and transit exchange functions (see definition 1005 in Recommendation Q.9).

2.2 *Relationship of design objective performance requirements to operational performance requirements*

Performance requirements as defined in this series of Recommendations should be considered as design objectives for systems under the conditions stated in the Recommendations. These conditions are defined by such parameters as average circuit occupancy, busy hour call attempts, etc. They should be distinguished from the operational performance requirements which Administrations and RPOAs establish for exchanges operating in their particular environment.

Further clarification of this point can be obtained in Recommendation G.102.

3 Basic functions

Reference to a function in these Recommendations, including their diagrams, does not imply that it will necessarily be provided in every exchange configuration. Similarly, it is possible that some functions may be provided which are not mentioned. The actual exchange configurations are matters of choice for individual Administrations as discussed in § 2.1 above.

3.1 *Interfaces (Recommendation Q.512)*

The interface functions defined are those necessary for interworking with both digital and analogue transmission systems. They relate, on the one hand, to circuits to other exchanges and on the other to subscriber lines.

Interfacing to PABXs is not always shown separately. In these cases it should therefore be understood that these interfaces are included among those to subscriber lines or circuits to other exchanges. The interface functions depend on the size of the PABX and its capabilities.

Interfaces with non-voice handling facilities and with centralized operation and maintenance centres are also defined.

3.2 *Connections, signalling, control, call handling and ancillary functions (Recommendation Q.513)*

This Recommendation covers the following functions:

3.2.1 *Timing and synchronization*

Timing comprises the generation and distribution of timing signals and includes timing of outgoing signals. It enables those parts of the exchange which form the switched path of a connection to operate synchronously.

Synchronization will depend on the national synchronization plan and exchange timing arrangements.

Exchanges will usually extract syncronizing information from one or more incoming bit streams or a separate synchronization network and use this to adjust the timing signals generated in and distributed within the exchange.

3.2.2 *Connections through an exchange*

This includes the switch block(s) and the characteristics associated with connections through the exchange.

Switching may include one or more stages of time and/or space switching, providing a path for transmission through the exchange.

3.2.3 *Signalling*

Signalling includes reception of call-related and other information, interaction with the call control function and transfer of information to subscribers and network(s) as required.

Signalling may involve common channel and/or channel associated signalling.

3.2.4 *Control and call handling*

Control and call handling includes initiation, supervision and termination of most actions in the exchange.

Commands are initiated and information passed/received to/from the other functions within the exchange.

Control functions may be contained in one block or distributed throughout the exchange.

3.2.5 *Ancillaries*

Examples of such functions are:

- recorded announcements;
- tone generation;
- conferencing facilities.

Their location is dependent on the function itself and the exchange configuration.

3.3 *Performance and availability design objectives (Recommendation Q.514)*

Exchange performance and availability design objectives are defined for guiding system design and for comprising the capabilities of different systems. (Recommendations relating to provisioning and operational performance of exchanges in the network are covered in the E.500-E.543 series.)

3.4 *Exchange measurements (Recommendation Q.515)*

Measurements that may be used for planning, operation, maintenance and network management of exchanges and their associated networks are described. The measurement data consists primarily of event counts and traffic intensity levels experienced by the various traffic handling elements of the exchange.

3.5 *Operations and maintenance functions (Recommendation Q.516)*

This Recommendation defines the functions that an exchange should be capable of performing in order for it to be operated and maintained in its intended application.

3.6 *Transmission characteristics (Recommendation Q.517)*

This Recommendation defines, for internal connections which might be set up by a local or combined exchange, the necessary levels of transmission performance to conform with overall objectives for the complete user-to-user connections in which the exchange might be involved.

Recommendation Q.512

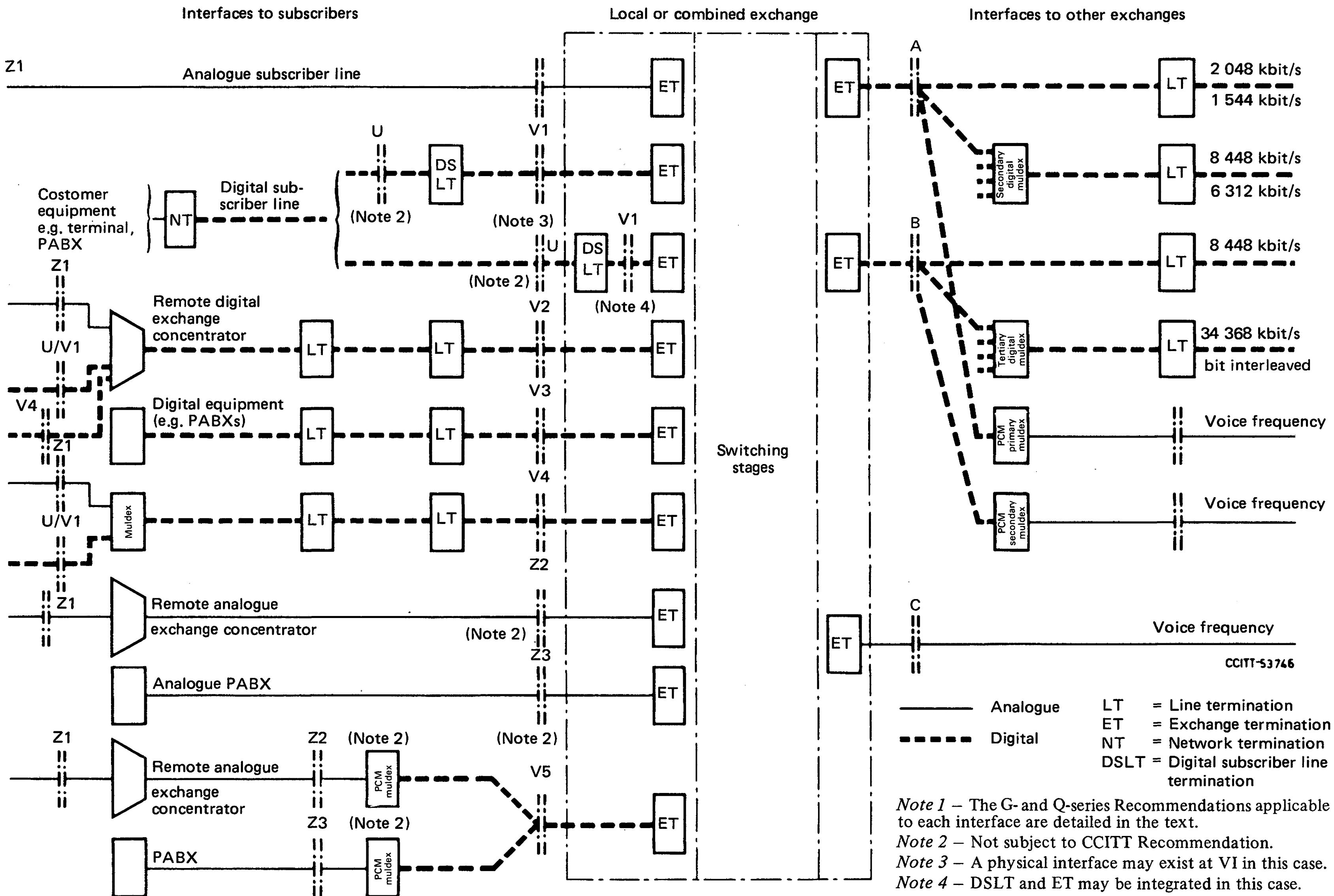
INTERFACES

1 General

This Recommendation applies to digital local and combined exchanges for telephony in Integrated Digital Networks (IDN) and mixed (analogue/digital) networks. It will form the basis for digital switching in Integrated Services Digital Networks (ISDN) when other services are integrated with telephony. The field of application of this Recommendation is found in Recommendation Q.511.

2 Interfaces

Interfaces associated with digital local and combined exchanges are shown in Figure 1/Q.512. The interfaces to other exchanges are the same as those described in Recommendation Q.502 for a digital transit exchange. For completeness, all interfaces to subscribers that have been studied in detail are shown, but it is not intended to specify every interface (e.g. Interfaces Z2 and Z3 are not subject to recommendation). Other interfaces are for further study (e.g. those for broadband access).



Note 1 – The G- and Q-series Recommendations applicable to each interface are detailed in the text.

Note 2 – Not subject to CCITT Recommendation.

Note 3 – A physical interface may exist at VI in this case.

Note 4 – DSLT and ET may be integrated in this case.

Note 5 – Not all interfaces will necessarily exist in every implementation.

FIGURE 1/Q.512

Functional interfaces associated with a digital local or combined exchange

2.1 *Characteristics of interfaces to other exchanges*

2.1.1 *Digital environment*

2.1.1.1 *Interface A*

Interface A is a digital interface described in Recommendations G.703, G.704[1)] and G.705.

The characteristics of the multiplex structure and frame structure at Interface A are given in Recommendations G.732, G.733, G.704 and G.705.

The main characteristics of interface A are:

- Nominal bit rate: 2048/1544 kbit/s.
- Number of bits per channel timeslot: 8, numbered 1 to 8.
- Number of channel timeslots per frame: 32/24, numbered 0-31/1-24.
- Additional signalling capacity. Where more signalling capacity is required between exchanges, additional channel timeslots may be utilized for common channel signalling. For 2048 kbit/s systems, they should be selected from the channel timeslots allocated in PCM multiplexes for data purposes according to Recommendation G.735. When no such channel timeslots are allocated or available, additional channel timeslots may be selected from channel timeslots allocated for voice channels.
- Timing in the transmitting direction will be derived within the digital exchange.

For 2048 kbit/s systems:

- Channel timeslot 16 is primarily intended for signalling but should be switchable. On systems between exchanges (not involving PCM primary muldex) when channel 16 is not assigned to carry signalling it may be allocated to speech or other services.
- Channel timeslot 0 is used for frame alignment, alarm indication, network synchronization and other purposes.
- Although no specific application is at present foreseen for switching timeslot 0, it is recommended that the possibility of read and write access to this timeslot should be retained as a safeguard for future requirements. Such access would allow processing of some or all of the information contained in this timeslot, in particular those bits reserved for national and international use. The need to switch channel timeslot 0 as a normal channel, without special access, requires further study. In any case the incoming frame alignment signal will not be passed through the exchange to an outgoing system.

2.1.1.2 *Interface B*

Interface B is a digital interface described in Recommendations G.703, G.704 and G.705.

The characteristics of the multiplex structure and frame structure at interface B are given in Recommendations G.744, G.746, G.704 and G.705.

The main characteristics of interface B are:

- Nominal bit-rate: 8448/6312 kbit/s.
- Number of bits: per channel timeslot 8, numbered 1 to 8.
- Number of channels: 132/98 numbered 0-131/1-98.
- Timing in the transmitting direction will be derived within the exchange.

i) For 8448 kbit/s systems:

   - Frame structure: the frame structure, frame alignment procedures and standard channel timeslot assignment will be as defined in Recommendations G.744, G.704 and G.705. Where signalling capacity is required between exchanges, timeslots 67, 68, 69 and 70 can be utilized for signalling in this order of descending priority. Those channels not used for signalling can be used for speech or other purposes. If a channel timeslot is reserved for service purposes within the switch, it shall be channel timeslot 1.

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1) The exchange implications of some aspects of Recommendation G.704 including the CRC check have not yet been considered. It should therfore be understood that at present digital exchanges need not incorporate the features/facilities necessary to comply with this CRC check procedure.

- It is left for mutual agreement whether or not channel timeslot 1 will carry traffic.
- 128 of the channel timeslots may carry traffic through the exchange.

ii) For 6312 kbit/s systems:

- Fundamental characteristics: the multiplex structure contains 5 bits and 98 channel timeslots, numbered 1-98, each of 64 kbit/s, of which 96 may carry traffic through the exchange.
- Frame structure: the frame structure, frame alignment procedures and standard channel timeslot assignment will be defined in Recommendations G.746, G.704 and G.705. Five bits per frame are assigned for a frame alignment signal and for other signals. Timeslots 97 and 98 are assigned to signalling between exchanges.
- Use of channel timeslots 97 and 98 for common channel signalling is under study.
- Note from G.746: interface conditions and fundamental functions of digital ET equipment used to terminate bit interleaved 6312 kbit/s paths are under study.

2.1.2 *Analogue environment*

2.1.2.1 *Interface C*

Interface C is a 2-wire or a 4-wire analogue interface. This implies that a PCM codec, connected to this interface, is incorporated in the digital exchange. Voice frequency transit connections over the interface C should conform to Recommendation Q.507. The equipment on the exchange side of interface C may include a muldex within the exchange terminal functions.

2.2 *Characteristics of interfaces to subscribers*

2.2.1 *Digital environment*

2.2.1.1 *Interface U*

Interface U may be used to connect customer equipment via the basic access (see Recommendation I.412) and a subscriber line.

The requirements for an implementation of interface U depends on a great number of different conditions in the various countries. Interface U is not recommended by CCITT. (For jitter and wander and TIE see §§ 3.1 and 5.1 of this Recommendation respectively.)

2.2.1.2 *Interface V1*

Interface V1 may be used to connect customer equipment via the basic access (see Recommendation I.412) and a digital subscriber line.

The characteristics of interface V1 have still to be fully defined, but the following requirements should apply:

a) Interface V1 will initially be functionally defined allowing flexibility of implementation taking into account different exchange realizations, line transmission systems and national requirements. Physical definition of interface V1 is for further study.

b) The channel structure associated with interface V1 will include 2B + D as defined at the user network interface in Recommendation I.412. Other channel structures at interface V1 are for further study.

c) A B channel may be used to carry a variety of information streams on a dedicated, alternate or simultaneous basis, consistent with its capacity and the service applications. These information streams may include encoded voice (designated *v*) and circuit or packet switched data (designated *d*).

d) A D channel is used to carry signalling information (*s*) and may be used to carry teleaction data (*t*) and packet-switched data (*p*).

e) The D channel will access a function that separates the *s* and (if carried) *t* and *p* messages from each other. The treatment of *p* and *t* messages is the subject of further study.

f) The subscriber/network signalling on the digital subscriber line at interface U/V1 should comply with Recommendations I.430, Q.920 and Q.930.

2.2.1.3 *Interface V2*

Interface V2 is a digital interface for connecting digital remote exchange concentrators. The electrical characteristics of interface V2 are described in CCITT Recommendation G.703.

2.2.1.4 *Interface V3*

Interface V3 is a digital interface for connecting digital equipment (e.g. PABXs). The electrical characteristics of interface V3 are described in Recommendation G.703.

The frame structure at interface V3 should be identical to that of the primary and secondary multiplexes described in CCITT Recommendations G.704 and G.705.

The primary rate interface structures associated with interface V3 are:

a) at 2048 kbit/s: 30B + D or 30 B + E
   - where D and E are 64 kbit/s channels used primarily for signalling, and
   - where the signalling on the D channel should comply with Recommendations I.431, Q.920 and Q.930 and the signalling on the E channel should comply with Recommendations Q.701, Q.702, Q.703 and Q.930.

b) at 1544 kbit/s: 23B + D or 23 B + E
   - where D and E are 64 kbit/s channels used primarily for signalling, and
   - where the signalling on the D channel should comply with Recommendations I.431, Q.920 and Q.930, and the signalling on the E channel should comply with Recommendations Q.701, Q.702, Q.703 and Q.930.

Note – When the signalling for the B channels in one primary rate structure is carried by the D or E channel in another primary rate structure, the channel timeslot normally used for signalling may be used to provide an additional B channel.

Note – At Interface V3 the designated number of B channels is always present within the multiplexed channel structure, but one or more of the B channels may not be used in any given application.

2.2.1.5 *Interface V4*

Interface V4 is a digital interface for connecting remote digital muldex equipments. The electrical characteristics of interface V4 are described in CCITT Recommendation G.703.

The frame structure at interface V4 should be identical to that of the primary or secondary multiplexes described in CCITT Recommendations G.704 and G.705.

Each B channel of a basic digital subscriber access on the muldex should be allocated to a discrete channel timeslot in the multiplex structure. In the 2048 kbit/s case, channel timeslot 0 should comply with Table 1/G.704.

The signalling and other channel structure aspects at interface V4 are the subject of further study.

2.2.1.6 *Interface V5*

Interface V5 is a digital interface for connecting PCM muldex equipments which are associated with analogue private automatic branch exchanges and remote analogue exchange concentrators. The electrical characteristics of interface V5 are described in CCITT Recommendation G.703.

The frame structure at interface V5 should be identical to that of the primary or secondary multiplexes described in CCITT Recommendations G.704 and G.705.

The signalling and channel structure at interface V5 may be the subject of further study.

2.2.1.7 *Broadband access*

(For further study.)

2.2.2 *Analogue environment*

2.2.2.1 *Interface Z1*

Interface Z1 is an analogue subscriber line interface that is used to connect individual subscribers. The transmission characteristics of interface Z1 are described in Recommendation Q.517.

The characteristics of interface Z1 vary considerably from country to country and therefore it is not intended that this interface should be the subject of CCITT Recommendation beyond those aspects covered in Recommendation Q.517.

2.2.2.2 *Interfaces Z2 and Z3*

Interfaces Z2 and Z3 are analogue interfaces used for connecting remote analogue exchange concentrators and analogue pabx's respectively.

These interfaces are not subject to CCITT Recommendation.

2.2.3 *Hybrid environment*

In the evolution towards an ISDN, subscriber side accesses may exist which have a combination of both analogue and digital interfaces.

Hybrid accesses are not presently considered to be a matter for CCITT Recommendation.

2.3 *Interfaces to operations, maintenance and network management centres (OMCs)*

Paragraph 2.3.1 gives general considerations regarding the information to be transferred between digital local or combined exchanges and OMCs, and some possible access arrangements. The functional characteristics that the interfaces are required to provide are given in § 2.3.2, the recommended data transfer procedures are given in § 2.3.3, and the information transferred is specified in Recommendations Q.515 and Q.516.

Note that Man-Machine Language (MML) is recommended by CCITT (Z.300 series Recommendations), for exchange and OMC system man-machine interaction. The functional characteristics and procedures of the interface between exchange and OMC system should not preclude the effective use of MML at either the exchange or the OMCs.

2.3.1 *General aspects and access arrangements*

2.3.1.1 Interfaces are provided to facilitate the transfer of information between exchanges and locations where administrative, maintenance, network management and operation functions are performed. Items (a) and (b) below illustrate examples of information that may cross the interface and which may need to be catered for. (The choice of information that crosses the interface is a matter for each Administration/Operating Agency.)

a) The information transferred from the exchange to OMCs may include customer usage and charging data, exchange system status indication, system resource utilization data, system performance measurements, alarms and messages alerting operating personnel to the current state of the exchange.

b) The information transferred to the exchange from OMCs may include commands for system initializations and configuration control, data to effect changes in system operation, commands to initiate, terminate, or otherwise modify the services provided to customers, requests for status information and so forth.

2.3.1.2 An exchange may have access to one or more operation, maintenance and network management centres.

2.3.1.3 Access may be provided using separate data links to each centre, multiplexed data links, or one or more data networks.

2.3.1.4 The choice between single and multiple physical links at the exchange, and the configuration of the centres is a national matter, not subject to CCITT Recommendation.

2.3.2 *Functional characteristics of the interface to OMCs*

2.3.2.1 The exchange should not depend for its basic operation on the correct functioning of the OMC(s).

2.3.2.2 The interface should provide basic initialization, error detection and automatic recovery procedures for the data link.

2.3.2.3 The interface should support data transport mechanisms that may be employed by the exchange and the OMC systems to assure the reliable transfer of particular information (e.g. charging data).

2.3.2.4 The interface should support the setting of priorities by the exchange or OMC system for the use of the transmission medium (data links).

2.3.2.5 The interface should support priority transfer of urgent messages.

2.3.2.6 The interface should support operation at one or more bit rates to cater for the efficient and economical transfer of types of information such as those described in § 2.3.1.1.

2.3.3 *Procedures for data transfer between local and combined exchanges and OMCs*

2.3.3.1 Procedures for control of the links between an exchange and the OMCs to which it has access, and for the transfer of data may be implemented using a transport service in accordance with either Recommendation X.25 or Signalling System No. 7 (an operation and maintenance application part has been defined for Signalling System No. 7 to provide higher level functions, see Recommendation Q.795). The choice between these alternatives is a matter for further study by individual Administrations.

2.4 *Interfaces to non-voice handling facilities*

The need for the recommendation of interfaces between digital local and combined exchanges and non-voice handling facilities remains for further study. (An example of such a non-voice facility is a packet switched data node.) Attention is drawn to Recommendation X.300 which describes the general principles for interworking between public data networks and other public networks.

2.5 *Other interfaces*

Study and recommendation of other interfaces may take place.

3 **Jitter and wander at the exchange input**

Jitter and wander tolerance is the ability of the exchange to accept phase deviations on incoming facilities without introducing slip or errors.

3.1 *Interfaces U and V1*

Input jitter and wander at the digital subscriber line Interfaces U (where DSLT and ET are integrated) and/or V1 requires further study.

3.2 *Interfaces A, B and V3*

The jitter and wander tolerance mask of Figure 2/Q.512 shall be used when specifying jitter and wander at digital interface inputs A, B and V3 (Figure 1/Q.512) when not used for synchronization purposes.

Jitter and wander are similar phenomena. At frequencies above f_1 in Figure 2/Q.512 the term jitter is used. At frequencies below f_1 the term wander is used.

The recommended values for the mask of tolerable sinusoidal peak to peak jitter and wander are given in Table 1/Q.512. The value of f_0 for 1544 kbit/s systems is provisional.

3.3 *Interfaces V2, V4 and V5*

Input jitter and wander at Interfaces V2, V4 and V5 is for further study.

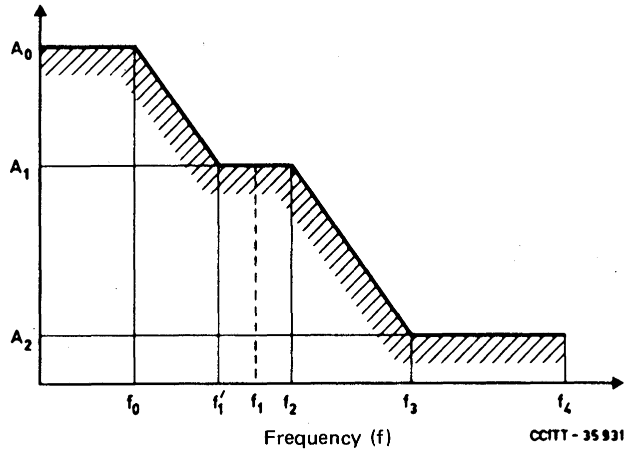


FIGURE 2/Q.512

Mask of tolerable sinusoidal jitter and wander at interfaces A, B and V3

TABLE 1/Q.512

Values for the mask of tolerable peak-to-peak sinusoidal jitter and wander at the exchange input interfaces A, B and V3

	2048 kbit/s	8448 kbit/s	1544 kbit/s	6312 kbit/s
A_0 (μs)	18	18	18	18
A_1 (UI)	1.5	1.5	2	See Note 5
A_2 (UI)	0.2	0.2	0.05	See Note 5
f_0 (Hz)	12×10^{-6}	12×10^{-6}	12×10^{-6}	See Note 5
f_1' (Hz)	See Note 3	See Note 3	See Note 3	See Note 3
f_1 (Hz)	20	20	10	See Note 5
f_2 (Hz)	2.4×10^3	400	200	See Note 5
f_3 (Hz)	18×10^3	3×10^3	8×10^3	See Note 5
f_4 (Hz)	100×10^3	400×10^3	40×10^3	See Note 5

Note 1 – See Figure 2/Q.502.

Note 2 – UI = Unit Interval
For 1544 kbit/s systems 1 UI = 648 ns.
For 2048 kbit/s systems 1 UI = 488 ns.
For 6312 kbit/s systems 1 UI = 158 ns.
For 8448 kbit/s systems 1 UI = 118 ns.

Note 3 – The value of f_1' needs further study.

Note 4 – For interfaces within national networks, only values of f_2 = 93 Hz and f_3 = 700 Hz for 2048 kbit/s interface, and f_2 = 10.7 kHz and f_3 = 800 kHz for 8448 kbit/s interface, may be used.

Note 5 – For further study.

4 Exchange transfer function – jitter and wander

The exchange transfer function relates wander at the output of the exchange to wander at the inputs used for synchronization purposes. It is recognized that the approach of using the exchange transfer function to specify the performance of an exchange is not applicable to all implementations (e.g. when mutual synchronization methods are used). The exchange transfer mask is similar to that of a low pass filter with a maximum gain of 0.2 dB, a break point at 0.1 Hz and slope of 6 dB/octave as shown in Figure 3/Q.512.

The higher frequency (jitter) portion of the mask is undefined, but must provide significant attenuation above 100 Hz.

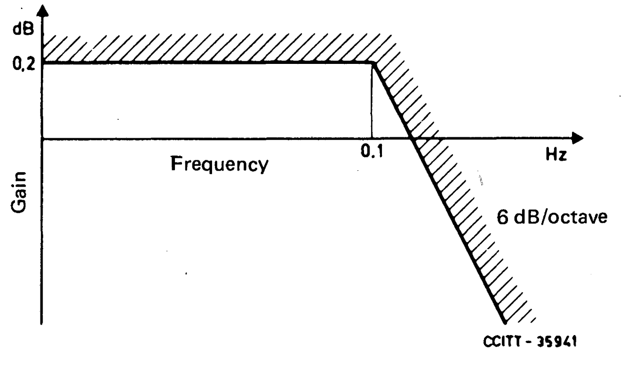


FIGURE 3/Q.512

Exchange transfer function mask

5 Relative Time Interval Error (TIE) at the exchange output

Relative Time Interval Error (TIE) at the exchange output is defined as the difference in time delay of a given timing signal when compared to a reference timing signal for a given measurement period (see Recommendation G.811).

5.1 *Interfaces U and V1*

Relative Time Interval Error (TIE) at the exchange output at interface U (where DSLT and ET are integrated) and/or V1 requires further study.

5.2 *Interfaces A, B and V3*

The relative TIE at the output of the digital interfaces A, B and V3 over the period S seconds should not exceed the following limits:

1) (100 S)ns + 1/8 UI for $S < 10$.

2) 1000 ns for $S \geq 10$ (see Figure 4/Q.512).

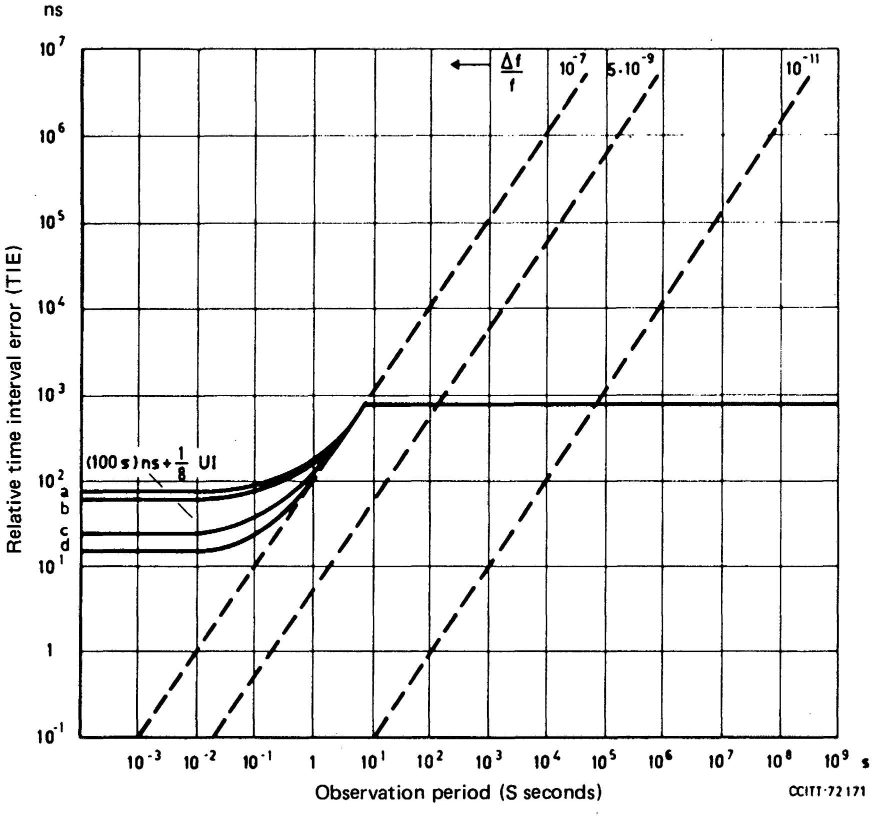
In the case of synchronous operation the limits are specified on the assumption of an ideal incoming synchronizing signal (no jitter, no wander and no frequency deviation) on the line delivering the timing information. In the case of asynchronous operation the limits are specified assuming no frequency deviation of the exchange clock, (this is equivalent to taking the output of the exchange clock as the reference timing signal for the relative TIE measurements).

It is recognized that the approach of using relative TIE to specify the performance of an exchange in the case of synchronous operation in some implementations (e.g. when mutual synchronization methods are used) requires further study.

Any internal operation or rearrangement within the synchronization and timing unit or any other cause should not result in a phase discontinuity greater than 1/8 of a Unit Interval (UI) on the outgoing digital signal from the exchange.

The limits given in Figure 4/Q.512 and may be exceeded in cases of infrequent internal testing or rearrangement operations within the exchange. In such cases, the following conditions should be met:

The Relative Time Interval Error (TIE) over any period up to 2^{11} unit intervals should not exceed 1/8 of a UI. For periods greater than 2^{11} UI, the phase variation for each interval of 2^{11} UI should not exceed 1/8 UI up to a maximum total Relative TIE defined in Recommendation G.811 for long time periods.



a : 1544 kbit/s
b : 2048 kbit/s
c : 6312 kbit/s
d : 8448 kbit/s

FIGURE 4/Q.512

Limits of relative peak-to-peak TIE at the exchange output interfaces A, B and V3

5.3 *Interfaces V2, V4 and V5*

Relative Time Interval Error (TIE) at the exchange output at Interfaces V2, V4 and V5 requires further study.

6 Overvoltage protection

For further study, (attention is drawn to the K series Recommendations).

Recommendation Q.513

CONNECTIONS SIGNALLING, CONTROL, CALL HANDLING AND ANCILLARY FUNCTIONS

1 General

This Recommendation applies to digital local and combined exchanges for telephony in Integrated Digital Networks (IDN) and mixed (analogue/digital) networks. It will form the basis for digital switching in Integrated Services Digital Networks (ISDN) when other services are integrated with telephony. The field of application of this Recommendation is found in Recommendation Q.511.

2 Timing and synchronization

2.1 *Exchange timing distribution*

The timing distribution system of an exchange will be derived from a highly reliable exchange clock system. The distribution of timing within the exchange must be designed so that the exchange will maintain synchronism on 64 kbit/s channel timeslots in a connection through the exchange.

2.2 *Network synchronization*

Within a synchronized IDN, different methods of providing timing between exchanges may be used. It shall therefore be possible to synchronize the local exchange clock by one of the different methods of synchronization that will be provided within an IDN/ISDN. Plesiochronous operation should also be possible.

The clock of the local or combined exchange shall be responsible for maintaining the synchronization in the part of the network associated with that exchange.

The frequency accuracies of the clocks in local or combined exchanges of various sizes, clocks at subscriber premises, at digital PABXs, in digital concentrators, at muldexes, etc., require further study.

Synchronized national networks may be provided with exchange clocks not having the frequency accuracy required for international interworking. However, when these synchronized networks within national boundaries are required to interwork internationally as part of the international IDN, it will be necessary to provide means to operate these national networks to the internationally recommended value of frequency accuracy in Recommendation G.811.

2.3 *Slip*

The design objective controlled slip rate within a synchronized network controlled by the exchange should be zero provided that input jitter and wander remain within the limits given in this Recommendation.

The design objective controlled slip rate at a digital exchange in plesiochronous operation (or operating to another synchronized region) shall be not more than one slip in 70 days in any 64 kbit/s channel, provided that input jitter and wander remain within the limits given in this Recommendation.

The operational performance requirements for the rate of octet slips on an international connection or corresponding bearer channel are covered in Recommendation G.822.

The occurrence of a controlled slip should not cause loss of frame alignment.

Note – A synchronized region is defined as a geographic entity normally synchronized to a single source and operating plesiochronously with other synchronised regions. It may be a continent, country, part of a country or countries.

2.4 *Synchronization requirements when interworking with a digital satellite system*

On a provisional basis the following should apply:

The transfer from the timing of the terrestrial digital network to the timing of the satellite system, if required (plesiochronous operation), will not be performed by the digital exchange. The earth station will be equipped with buffer memories of suitable size to compensate for the time delay variations due to shifts of the satellite from its ideal position (and due to any other phenomena with similar effects) and to meet the slip performance requirements established in CCITT Recommendation G.822.

3 Connections through an exchange

3.1 *General*

The characteristics of the connections detailed in this section refer to an established connection when it is made available to the users.

An exchange must be able to provide originating, terminating and internal exchange connections between input and output interfaces for telephony and other services as required. It may also provide transit connections.

- A connection (if any) between an incoming and an outgoing circuit at interfaces to other exchanges/networks is called a *transit* connection.
- A connection between channel(s) of a calling subscriber line at an interface to subscribers and an outgoing circuit at an interface to other exchange/networks is called an *originating* connection.
- A connection between an incoming circuit at an interface to other exchange/networks and channel(s) of a called subscriber line at an interface to subscriber is called a *terminating* connection.
- A connection between channels of two subscriber lines at interfaces to subscribers is called an *internal* connection.

An exchange must be able to provide bidirectional connections between input and output interfaces for telephony and other services as required.

Also uni-directional connections may be required.

3.2 *Basic exchange connections*

3.2.1 *General*

Four types of exchange connection have been identified to show the basic forms of connection and their associated information flows that a digital local or combined exchange may be required to handle in an ISDN. They have been based on originating/terminating connections established via Interface U/V1 to/from locations external to the exchange. Calls may be set up in either direction, i.e. subscriber to network or network to subscriber.

These diagrams are functional and not intended to represent any particular implementation. They illustrate the options which may be available for handling a given information type within a digital local or combined exchange. Although this approach leads to some duplication between the individual diagrams when considered from the connection point of view, the approach is a logical basis for the further consideration of the more detailed issues arising from the impact of the ISDN on a digital local or combined exchange.

It is not intended to imply that every digital local or combined exchange should necessarily have the capability to handle all these types of connection.

Other types of connection and variants of these basic reference connections may be feasible in an ISDN and are the subject of further study.

The signalling and control aspects of these connections are covered in §§ 4 and 5 of this Recommendation.

3.2.2 *Explanatory information on the exchange connection diagrams*

The following information is to clarify the functions associated with the blocks shown on the Types I-IV exchange connection diagrams described in §§ 3.2.3 to 3.2.6.

3.2.2.1 *Functional blocks*

3.2.2.1.1 *Layer 1 functions*

This functional block includes:

- digital line/exchange termination interface functions.

3.2.2.1.2 *Layer 2 functions*

This functional block includes:

- layer 2 D-channel protocol handling.

3.2.2.1.3 *64 kbit/s circuit switch*

This functional block includes:

- 64 kbit/s switching stage(s).

3.2.2.1.4 *s-information handling and exchange control functions*

This functional block may include:

- layer 3 D-channel protocol for *s* information;
- functions related to circuit switched connection control;
- signalling functions for common channel signalling;
- signalling interfaces with "*p*-information handling function", for calls via circuit switched connections;
- functions related to packet switched connections;
- signalling interface with "packet switching interworking function", for calls that will be offered to subscribers via circuit switched connections.

3.2.2.1.5 *Packet switching interworking function*

This functional block may include:

- signalling interface with "*p*-information handling function" and "*s*-information handling and exchange control function" allowing call packets to be routed to/from the appropriate subscriber terminals;
- control functions for packet switched connections;
- routing functions;
- functions such as compatibility checking;
- some or all of the functions associated with packet switching (e.g. internal packet calls).

3.2.2.1.6 *p-information handling function*

This functional block may include:

- layer 3 D-channel protocol for *p* information;
- packet level multiplexing for outgoing calls;
- packet level demultiplexing for incoming calls;
- signalling interface with the "*s*-information handling function" and subscriber terminals via layer 1 and 2 functional block.

In the case where the packet switching inter-working function is not present in the local exchange, the local exchange contains the minimum functions necessary to enable it to communicate with the packet switching interworking function. The protocols to carry out this minimum function require further study.

3.2.2.2 *Key*

Information flows
- ________ information other than separate signalling
- – – – – separate signalling(s)

- p_1 = packet data information different from customer originated *p* information;
- s_1, s_2, s_3, s_4, s_5 = signalling information different from the *s* information associated with customer terminals;
- packet switching interworking functions may be provided at other exchanges in an ISDN or at the point of access to a separate packet switched network.

3.2.3 *Type I exchange connection (Figure 1/Q.513)*

This connection is used to transport telephony and associated voice services (information Type v_1).

It consists of a bidirectional connection between a digital subscriber access and an access port to a circuit switched analogue or digital network capable of handling voice services.

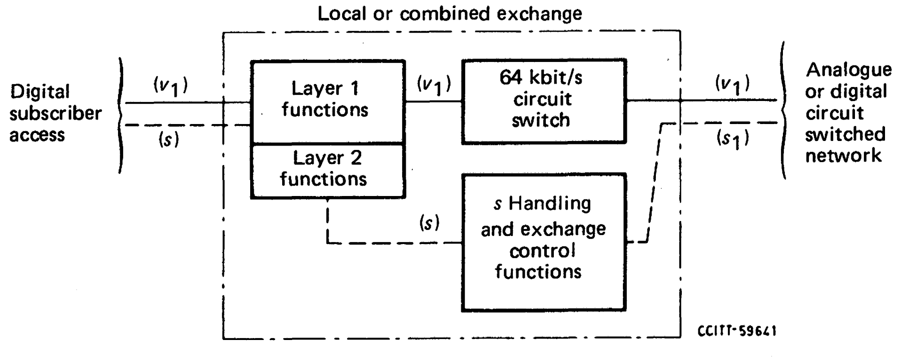


FIGURE 1/Q.513

Type I exchange connection (information type v_1)

3.2.4 *Type II exchange connection (Figure 2/Q.513)*

This connection is used to transport circuit switched data services (circuit switched *d* type information, at 64 kbit/s or rate adapted to 64 kbit/s).

It consists of a bidirectional transparent connection between an information channel on a digital subscriber access and an access port to a circuit switched digital network capable of carrying circuit switched data.

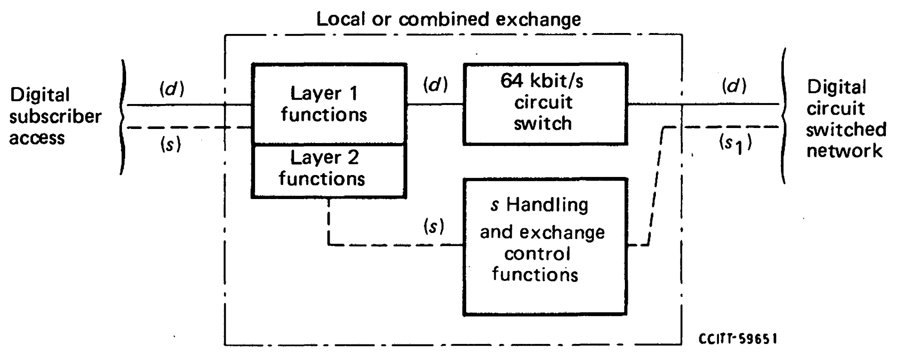


FIGURE 2/Q.513

Type II exchange connection (circuit switched *d* information)

3.2.5 *Type III exchange connection (Figure 3/Q.513)*

This is a circuit switched connection used to transport packetized data information.

It consists of a bidirectional transparent circuit switched connection between an information channel on a digital subscriber access and an access port to either:

a) a circuit switched digital network which has an access to the required packet switching interworking function, or,

b) a packet switching interworking function incorporated in the exchange itself.

This involves the setting-up of a circuit switched connection between subscriber and the point of access to the packet switching interworking function followed by an interchange of information between subscriber and packet switching interworking functions over this connection in accordance with packet transfer procedures.

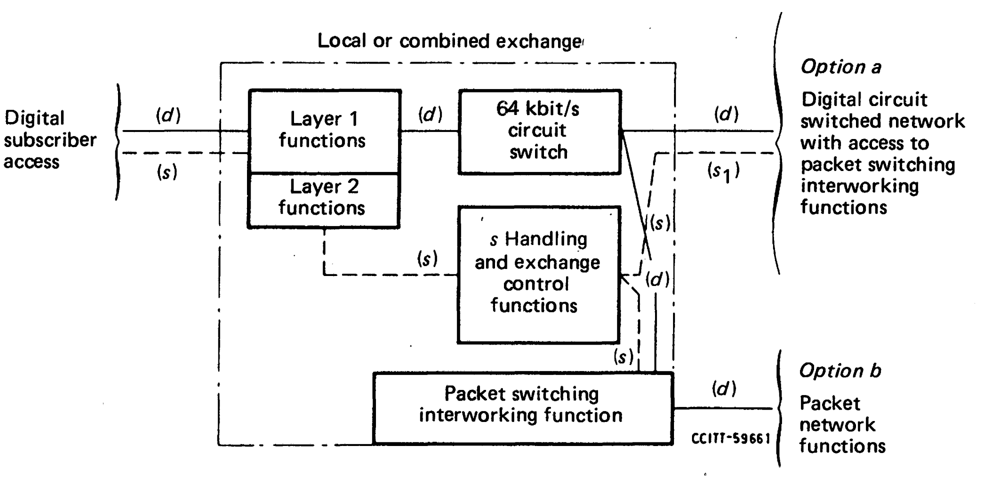


FIGURE 3/Q.513

Type III exchange connection (packet switched *d* information)

3.2.6 *Type IV exchange connection (Figure 4/Q.513)*

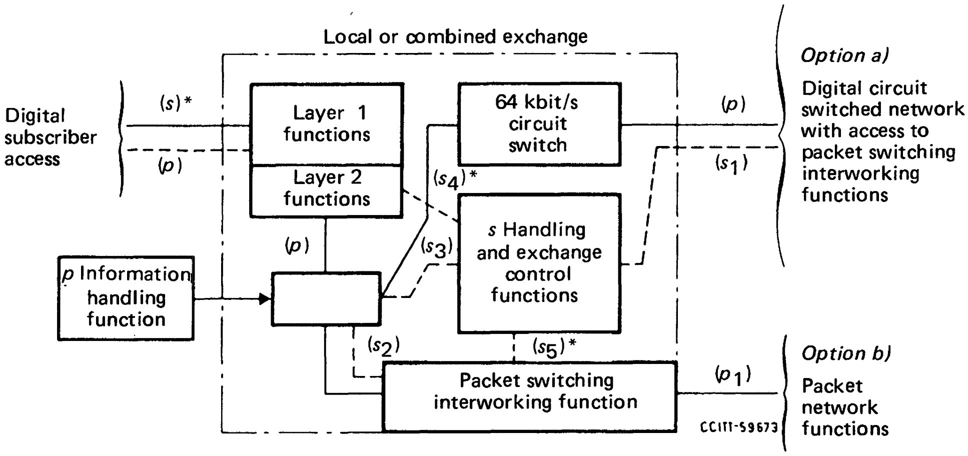
This connection is used to transport message type information, for example *p* or *t* (see § 2.2.1.2, Recommendation Q.512).

It consists of a message/packet type connection via a D channel on a digital subscriber access to an access port to either:

a) a circuit switched digital network which has an access to the required packet switching interworking function, or

b) a packet switching interworking function incorporated in the exchange itself.

It may or may not include a connection through the exchange circuit switching function.



* s, s_4 and s_5 are only applicable when all signalling required is not contained in the p information.

FIGURE 4/Q.513

Type IV exchange connection (*p* information)

3.3 *Bit rate of a connection through an exchange*

3.3.1 *Basic bit rate for circuit switched connections*

The exchange should be able to make circuit switched connections between channel timeslots with the basic bit rate of 64 kbit/s. The channel timeslots to be connected are contained in primary or higher order frame structures appearing at the digital interfaces of the exchange or derived from analogue channels appearing at the analogue interfaces, or from individual digital subscriber line interfaces.

Switching at rates other than 64 kbit/s is for further study.

3.3.2 *Basic bit rate for message/packet switched connections Type IV*

The bit rate of a message/packet connection Type IV will depend on a number of factors including the bit rate of the subscriber terminal equipment, the bit rate of the D channel and the bit rate capacity of the connection to the appropriate network.

3.4 *Services offered at bit rates less than 64 kbit/s*

Services requiring less than 64 kbit/s for a connection should be switched as 64 kbit/s connections.

3.5 *Services offered at bit rates requiring more than 64 kbit/s*

3.5.1 *General*

Services requiring more than 64 kbit/s for a connection are offered as a multiple of 64 kbit/s connections. They are called multi-slot connections and referred to as $n \times 64$ kbit/s connections.

It should be noted that an $n \times 64$ kbit/s connection can seriously affect the blocking probability of an exchange and the network, particularly if all n slots are routed in a defined order in the same multiplex. The ability to handle multi-slot traffic will be influenced by the traffic loading of the exchange at any instant and the number of circuits available on the required route.

All aspects of the provision of a multi-slot service, both switched and semi-permanent (see § 3.6.3), are therefore the subject of further study.

3.5.2 *Transit n × 64 kbit/s connections*

The interim requirements for a multi-slot service should be satisfied by the establishment of a number of separate semi-permanent connections, each of which would be set up to preserve the sequence with the other slots forming the multi-slot connection. A restriction on the maximum value of *n* or on the percentage of multi-slot connections carried by a digital exchange is not appropriate until further studies are complete. The *n* slots forming a semi-permanent multi-slot connection shall all appear in the same multiplex (defined in Interface A or B) incoming to the exchange and shall be switched all on the same outgoing multiplex. The channel timeslots received at the output of the exchange may occur in the same frame or the individual timeslots may occur in successive frames.

Note – As this paragraph refers to possible allocation of functions in the IDN, further study is needed.

3.5.3 *Originating, terminating and internal connections n × 64 kbit/s connections*

These require further study.

3.6 *Mode of establishment*

3.6.1 *Circuit switched connections*

Circuit switched connections are set up at any time on demand in response to signalling information received from subscribers, other exchanges or other networks.

3.6.2 *Message/packet switched connections, Type IV*

These connections are set up on demand subject to any D channel priority/flow control restrictions that may be applicable.

3.6.3 *Semi-permanent connections*

The exchange should have the capability of establishing semi-permanent connections which pass through the exchange switching network.

Other features of semi-permanent connections, e.g. grade of service, the need for an out-slot signalling channel associated with the connection, etc., are for further study.

3.7 *Bit sequence independence*

A limitation should not be imposed by the exchange on the number of consecutive binary ones or zeros or any other binary pattern within the 64 kbit/s paths through the exchange.

3.8 *Bit integrity*

Bit integrity is said to be maintained when the binary values of bits in an octet at the input of an exchange are exactly reproduced at the output.

Bit integrity will be maintained if required to support 64 kbit/s non-telephony services.

Note – It is understood that to meet this requirement, digital processing devices such as A/μ law converters, echo suppressors and digital pads must be disabled for non-telephony calls requiring bit integrity. The means of disabling these devices has yet to be determined (see also § 7.3).

3.9 *Bit patterns generated by the exchange in idle channel timeslots*

At interfaces A and B, the following patterns are recommended for the idle condition, where the left-most digit is the polarity digit.

01111111 for 1544 kbit/s systems

01010100 for 2048 and 8448 kbit/s systems.

At other interfaces the bit pattern generated in idle channel timeslots is for further study.

The patterns should not be used as an indication of the idle or barred conditions of a channel since this information should be derived from the control or signalling functions.

3.10 *Error performance*

The design objective long-term mean Bit Error Ratio (BER) for a single pass of a 64 kbit/s circuit switched connection through an exchange between the digital transmission/switching interfaces should be 1 in 10^9 or better. This corresponds to 99.5% error-free minutes assuming that the occurrence of errors has a Poisson distribution.

3.11 *In-call rearrangement*

In-call rearrangement is the rearrangement by the exchange of the established connections across the switchblock in a more efficient manner.

When it is provided, it is essential that the Recommendations for error performance, quality of service, etc., be met.

3.12 *Transmission performance characteristics*

For transit telephony connections, Recommendation Q.507 applies. For internal connections, Recommendation Q.517 applies. Originating and terminating connections are under study.

4 **Signalling and D and E channel handling**

4.1 *General*

The exchange should be capable of interworking with other exchanges using signalling systems indicated in Recommendation Q.7, and with user equipment on digital access lines (e.g. terminals and PABXs) using the signalling procedures in Recommendations I.430, I.431, Q.920 (I.441), Q.930 (I.451), Q.701, Q.702 and Q.703.

Interworking with user terminals or analogue subscriber access lines should be accomplished using nationally recommended signalling procedures.

64 kbit/s signalling channels entering the exchange via a multiplex structure may be connected through the exchange as semi-permanent channels.

4.2 *Signalling associated with exchange connections Types I-IV*

4.2.1 *General*

Details of the exchange connections Types I-IV are given in § 3.2.

For internal and originating connections, the call set up signalling information will be received from the subscriber.

For terminating and transit connections, the call set up signalling information will be received from the appropriate network or separate signalling network.

Note – Receipt of call set up signalling information may be affected by the involvement of supplementary services.

4.2.2 *Basic connections including Type I exchange connection*

The exchange should carry out the functions defined in the following signalling systems:

4.2.2.1 *On the subscribers side*

a) analogue line signalling systems as defined nationally; and
b) the defined digital subscriber access signalling system(s) if digital subscriber accesses are provided (see Recommendations I.430, Q.920, Q.930, Q.701, Q.702 and Q.703).

4.2.2.2 *On the trunk side*

One or more of the signalling systems are defined in CCITT Recommendation Q.7.

4.2.3 *Type II exchange connection*

For further study.

4.2.4 *Type III exchange connection*

For further study.

4.2.5 *Type IV exchange connection*

On the subscriber side

The signalling associated with the messages/packets may be:

a) contained in the individual message/packet, or

b) transported separately as *s* information (see Recommendations I.430, Q.920 and Q.930).

On the trunk side

The signalling associated with the messages/packets may be:

a) contained in the individual message/packet (p_1), or

b) transported separately (s_1 information), in accordance with one or more of the signalling systems defined in Recommendation Q.7.

A local exchange which supports such services must contain a function that is capable of either interpreting them and routing appropriately, or of sending them directly to an appropriate interworking function.

4.3 *Digital subscriber access — D and E channel and protocol handling layers 1, 2 and 3*

The following text refers to handling the D-channel protocol on the exchange side of the Interfaces U and V1.

The functions associated with handling the D-channel protocol are defined in the parts of Recommendations I.430, Q.920 and Q.930 relating to call establishment for subscribers connected to the U or V1 interfaces. Exchange functions for D-channel signalling procedures for users connected via a primary rate multiple access are also given in I.430, Q.920 and Q.930.

Signalling procedures for use on the E channel of a primary rate multiplex access are similar to those defined in Q.930, but use the message transfer part of signalling system No. 7 defined in Recommendations Q.701, Q.702 and Q.703. The E channel is defined in Recommendation I.412.

4.4 *User-to-user signalling*

The exchange may receive signals from the user (e.g. from a PABX) for transport across the network. It must be capable of receiving this information, verifying its acceptability, and if the service is permitted to the requesting user, send it via the inter-exchange signalling or other network to the distant exchange. Similarly the exchange may receive information from the signalling network for transmission to the subscriber. This capability may not be provided on all types of connection.

Where user-to-user signalling involves network inter-exchange facilities, it may be necessary for the originating local exchange to process this signalling information before sending it to the network, to ensure that it is compatible with signalling, charging and flow control requirements of the originating exchange and network.

5 Control functions associated with call handling

5.1 *Basic control functions*

The requirements for the basic control functions are implicit in the requirements recommended for the other functions of the exchange. However recommendation of a number of new requirements for the control functions associated with the handling of digital subscriber lines and the use of a digital local exchange within an ISDN, may be necessary.

5.2 *Exchange connections Types I-IV, general control aspects*

5.2.1 *Type I*

These connections will be set up between the accesses associated with network addresses specified in response to the signalling information received. Voice-associated facilities, e.g. tones, should be provided where appropriate and telephony supplementary services may be invoked if provided.

5.2.2 *Types II and III*

Such connections will be set up between the accesses associated with network addresses specified in response to the signalling messages received. Compatibility checking may be provided before the connection is completely established (see § 5.3.1 a)). Voice associated facilities (e.g. tones, pads) will be disabled in order to provide a transparent digital path, (the means of doing this is for further study). Data supplementary services may be invoked if provided.

5.2.3 *Type IV*

These connections will be of the message/packet type (e.g. virtual circuit). The "*p*-information handling function" and "packet switching interworking function" shown in Figure 4/Q.513 will implement procedures for control of the logical links on the D channel (e.g. flow control, error control) (see also § 3.2.2.1).

5.3 *Control functions associated with calls over a digital subscriber access via Interfaces U and V1*

5.3.1 *Control of circuit switched calls Types I, II and III*

In response to *s*-information carried on the D channel and network signalling messages, the exchange must have the following capabilities.

a) *Setting up a call*

The exchange must receive address information (overlap sending or en bloc), establish the desired path (digital only or mixed) and send further (e.g. SS No. 7) signalling, if necessary (e.g. address, calling line identity, service indicator) into the network.

The call set up procedure may include steps to verify compatibility based on the record in the exchange of the services permitted for the subscriber. The degree of compatibility checking provided by the exchange requires further study.

b) *During a call*

In addition to the basic functions of maintaining a call record, supervising the call, charging for the call, etc., the exchange must be able to handle in-call service/facility requests. These include for example transfer of a call to another terminal or conferencing.

If it is required that a terminal be moved from one location to another on the same access during a call, the exchange must be able to hold the call while the transfer is made and to re-establish communication on request by the user (including carrying out any compatibility checks). The exchange may limit the time allowed for moving a terminal. In addition, the user must send a signal to the exchange indicating that terminal movement is about to take place. Signalling procedures for terminal movement are given in Recommendation Q.930.

c) *Clearing a call*

The exchange will need to initiate call clearing on receipt of a clear request signal from the terminal or network.

d) *Without a call path*

The exchange may be required to handle signalling information without establishment of a call path (subscriber – network transactions).

5.3.2 *Control of message/packet calls over the D channel, Type IV*

Any messages carrying *p*- or *t*-information on the D channel must be handled by the exchange in accordance with the applicable Recommendation for services (e.g. Recommendation X.25) requested by the user. It is not necessary that every digital local or combined exchange in an ISDN should be able to carry out all the possible functions associated with handling this information. It is possible for example that the exchange may route such traffic to another node which has the appropriate handling facilities.

6 Control functions associated with maintenance and automatic supervision

For further study.

7 Ancillary functions

7.1 *Connection of ancillary equipment*

Ancillary equipment may be connected in the following way:

i) Serially. This may require more than one connection through the exchange. Examples of serially connected equipment include:
   - echo control devices,
   - encoding law converters,
   - manual board access equipment (for operator controlled traffic).

ii) As terminal connected equipment usually requiring one connection through the exchange. Examples of such equipment include:
   - recorded announcements,
   - manual board terminations,
   - speech codecs,
   - data terminal facilities,
   - test equipment (such as a test call sender),
   - tone generators,
   - signalling receivers.

The interface between the exchange and the items of equipment listed above may be left to the national designers. However, the use of internationally standardized interfaces is preferred.

Note – In some cases it may be necessary to establish more than one connection to one timeslot at the same time.

7.2 *Digitally generated tones and frequencies*

When tones and frequencies are digitally generated the following minimum requirements apply on a provisional basis.

7.2.1 *Service tones*

Digitally generated tones should meet the recommended limits specified in Recommendation Q.35 when decoded.

7.2.2 *Signalling frequencies*

Digitally generated signalling frequencies should be such that they can be detected after decoding by any analogue receivers designed to CCITT Recommendations.

7.3 *Echo control devices*

The exchange should be able to be equipped with echo control devices (echo suppressors/echo cancellers conforming to CCITT Recommendations G.164 and G.165 respectively). When required the exchange should be able to control such devices to meet the requirements of CCITT Recommendation Q.115. The means of control by the exchange is for further study.

(*Note* – It is recognized that there is a need for an internationally agreed method of disabling and enabling echo control devices for the purposes of making end-to-end circuit transmission maintenance measurements, e.g. as recommended in CCITT Recommendation V.25.)

PERFORMANCE AND AVAILABILITY DESIGN OBJECTIVES

1 General

This Recommendation applies to digital local and combined local/transit exchanges for telephony in Integrated Digital Networks (IDN) and mixed (analogue/digital) networks. It will form the basis for digital switching in Integrated Services Digital Networks (ISDN) when other services are integrated with telephony. Performance objectives for functions required to furnish ISDN services are not included and are a subject for further study. The field of application of this Recommendation is found in draft Recommendation Q.511.

These performance and availability design objectives relate to the technical capabilities of exchange designs. They are intended to assure that exchanges operating in their own environment will be capable, of supporting the recommended network grades of service covered in the E.500 series of Recommendations when engineered and provisioned to do so, at all points in their growth cycle up to and including their maximum computed capacity.

These reference loads and performance and availability objectives are primarily intended to guide the design of exchanges. The performance parameters may also be used by Administrations or RPOAs in evaluating a specific exchange design or for comparing different exchange designs. *These parameters and values are not intended for use as operational or grade of service requirements.*

2 Performance design objectives

2.1 *Reference loads*

The given reference loads are traffic load conditions under which the performance design objectives stated in §§ 2.2 to 2.6 are to be met. Administrations or operating Agencies may specify hypothetical exchange models for use in computing exchange capacity. These hypothetical models should characterize the sets of traffic parameters and services that are considered to be typical in the intended application of the exchange, and should include the traffic mix (originating-internal, originating-outgoing, incoming-terminating, transit, abandoned, busy, non answer, etc.), the mix of service classes (residential, business, PABX, coin, etc.), the types and volume of supplementary services (call waiting, call forwarding, etc.) and any other pertinent characteristics.

2.1.1 *Load on incoming interexchange circuits*

a) *Reference load A*

– 0.7 Erlang average occupancy on all incoming circuits

$$\text{Call attempts/h} = \frac{0.7 \times \text{number of incoming circuits}}{\text{Average holding time in hours}}$$

Note – Ineffective call attempts must be included in reference call attempts.

b) *Reference load B*

– 0.8 Erlang average occupancy on all incoming circuits

with 1.2 times the call attempts/hr for reference load A.

2.1.2 *Load on subscriber lines (originating traffic)*

Characteristics of traffic offered to local exchanges vary widely depending upon factors such as the proportions of residence and business lines that are served. The following table provides reference load characteristics for four model exchanges, designated W, X, Y and Z, which are representative of some possible local exchange applications.

Administrations or RPOAs may elect to use other models and/or loads that are more suitable for their intended application.

a) *Reference load A*

TABLE 1/Q.514

	Exchange type	Average occupancy	With average BHCA
Analogue and/or digital subscriber lines (Basic telephony)	W X Y Z	0.03 E 0.06 E 0.10 E 0.17 E	1.2 2.4 4 6.8
Digital subscriber lines with ISDN features	for future study		

b) *Reference load B*

Reference load B is defined as a traffic increase over reference load A of:

+25% in Erlangs,

with +35% in BHCA.

2.2 *Inadequately handled call attempts*

Inadequately handled call attempts are attempts which are blocked or excessively delayed[1)] within the exchange.

It is recommended that the probability of inadequately handling a call not exceed the values in Table 2/Q.514.

TABLE 2/Q.514

Type of connection	Reference load A	Reference load B
Internal Originating Terminating Transit	See note	See note

Note – Values for the probability of inadequately handling call attempts will have to be established so as to assure that network grade of service requirements can be met.

The requirement for multislot connections and/or ISDN services require further study.

The definition of objectives under failure conditions requires further study.

1) For further study.

2.3 *Delay probability*

In the delay tables appearing in the following paragraphs:

§ 2.3.1 incoming response delay

§ 2.3.2 dial tone sending delay

§ 2.3.4 through connection delay for internal and terminating connections

§ 2.3.7 ring tripping delay

§ 2.3.9 exchange signal transfer delay

§ 2.3.10 answer sending delay,

it is understood that delay timing begins after completion of signal verification and does not include line-dependent delays for recognition of induced voltage conditions and line transients.

In the following the term "mean value" is understood as the expected value in the probabilistic sense.

2.3.1 *Incoming response delay – transit and terminating incoming traffic connections*

The incoming response delay is a characteristic that is applicable where channel associated signalling is used. It is defined as the interval from the instant an incoming circuit seizure signal is recognizable until a proceed-to-send signal is sent backwards by the exchange.

The values in Table 3/Q.514 are recommended.

TABLE 3/Q.514

	Reference load A	Reference load B
Mean value	$\leqslant$ 300 ms	$\leqslant$ 400 ms
0.95 probability of not exceeding	400 ms	600 ms

Note – Different call set-up procedures are used with common channel signalling operation and a requirement covering incoming response delay as defined above is not relevant.

2.3.2 *Dial tone sending delay*

The dial tone sending delay is defined as the interval from the instant when the off-hook condition is recognizable at the subscriber line interface of the exchange until the exchange begins applying dial tone to the line. The dial tone sending delay interval is assumed to correspond to the period during which the exchange is unable to receive any call address information from the subscriber.

The values in Table 4/Q.514 are recommended.

TABLE 4/Q.514

	Reference load A	Reference load B
Mean value	$\leqslant$ 400 ms	$\leqslant$ 800 ms
0.95 probability of not exceeding	600 ms	1000 ms

Note – The above values are understood to apply when a continuous tone, i.e., without a cadence, is used and do not include delays caused by functions such as line tests, which may be used in national networks.

2.3.3 *Exchange call set up delay – transit and originating outgoing traffic connections*

Call set up delay of an exchange is defined as the interval from the instant when the digits required for setting-up a call are available for processing in the exchange, or the address information required for call set-up is received at the incoming signalling data transmission control of the exchange, to the instant when the seizing signal has been sent to the subsequent exchange or the corresponding address information is sent from the outgoing signalling data transmission control.

The values in Tables 5 and 6/Q.514 are recommended.

2.3.3.1 *For transit traffic connections*

TABLE 5/Q.514

	Reference load A	Reference load B
Mean value	$\leqslant$ 250 ms	$\leqslant$ 400 ms
0.95 probability of not exceeding	300 ms	600 ms

Note – Since the exchange will provide connections between circuits that may use either channel associated or common channel signalling systems in various combinations, the above requirement applies to all possible combinations. For connections involving the same common channel signalling system, the requirements of that signalling system recommendation should apply.

2.3.3.2 *For originating outgoing traffic connections*

TABLE 6/Q.514

	Reference load A	Reference load B
Mean value	$\leqslant$ 300 ms	$\leqslant$ 500 ms
0.95 probability of not exceeding	400 ms	800 ms

2.3.4 *Through-connection delay*

Through-connection delay is the interval from the instant at which the information required for setting-up a through connection in an exchange is available for processing in the exchange, to the instant that the switching network through connection is established and available for carrying traffic between the incoming and outgoing exchange terminations. For certain interconnection cases this interval will commence upon the completion of digit sending.

The exchange through-connection delay does not include an interoffice continuity check if provided but does include a cross office check if one occurs during the defined interval.

When the through-connection in an exchange is not established during the exchange call set-up interval, the through-connection delay may then contribute to the network call set up delay.

The values in Table 7/Q.514 are recommended.

2.3.4.1 *For transit and originating outgoing traffic connections*

TABLE 7/Q.514

	Reference load A		Reference load B	
	Without ancillary equipment	With ancillary equipment	Without ancillary equipment	With ancillary equipment
Mean value	≤ 250 ms	≤ 350 ms	≤ 400 ms	≤ 500 ms
0.95 probability of not exceeding	300 ms	500 ms	600 ms	600 ms

More stringent values than these shown in this table may be appropriate in some national networks.

When the through connection is established as soon as the last digit of the address information required for through connection is received, then the requirements for call set up delay apply.

The requirements for multi-slot connections require further study.

2.3.4.2 *For internal and terminating traffic connections*

For internal and terminating traffic connections, through connection delay is the interval from the instant at which the called subscriber off-hook condition (answer) is recognizable at the subscriber line interface of the exchange until the through connection is established and available for carrying traffic or a consequent signal is sent backwards by the exchange.

The maximum values applying to this parameter are included with those for ringing signal sending delay in § 2.3.5.

The requirements for multi-slot connections require further study.

2.3.5 *Ringing signal sending delay — for internal and terminating traffic connections*

Ringing signal sending delay is defined as the interval from the instant when the last digit of the called number is available for processing in the exchange until the start of ringing signal on the proper subscriber line.

The sum of the values for ringing signal sending delay and through connection delay for internal and terminating traffic connections should not exceed the figures given in the Table. In addition, two further conditions are imposed:

a) it is recommended that the value of the ringing signal sending delay not exceed 90% of the relevant figure in Table 8/Q.514, and

b) it is recommended that the value of the through connection delay should not exceed 35% of the value given in Table 8/Q.514.

2.3.6 *Ringing tone sending delay — terminating traffic connections*

Ringing tone sending delay is defined as the interval from the instant when the last digit is available for processing in the exchange until the ringing tone is sent backwards to the calling subscriber.

For terminating calls (assuming that ringing tone is applied at the terminating exchange) and for internal calls the same values as those for ringing signal sending delay (§ 2.3.5) are recommended.

TABLE 8/Q.514

Sum of ringing signal sending delay and through connection delay	Reference load A	Reference load B
Mean value	≤ 650 ms	≤ 1000 ms
0.95 probability of not exceeding	900 ms	1600 ms

Note – The above values assume that "immediate" ringing is applied and do not include delays caused by functions such as line tests, which may be used in national networks.

2.3.7 *Ring tripping delay – terminating traffic connections*

Ringing tripping delay is defined as the interval from the instant when the called subscriber off-hook condition is recognizable at the subscriber line interface until the ringing signal at the same interface is suppressed.

The values in Table 9/Q.514 are recommended for internal and for terminating traffic connections.

TABLE 9/Q.514

	Reference load A	Reference load B
Mean value	≤ 100 ms	≤ 150 ms
0.95 probability of not exceeding	150 ms	200 ms

2.3.8 *Exchange call release delay*

Exchange call release delay is the interval from the instant at which the last information required for releasing a call in an e1change is available for processing in the e1change to the instant that the switching network through connection is no longer available for carrying traffic and the disconnection signal is sent to the subsequent e1change, if applicable. This interval does not include the time taken to detect the release signal, which might become significant during certain failure conditions, e.g. transmission system failures.

The values in Tables 10 and 11/Q.514 are recommended.

2.3.8.1 *For transit traffic connections*

TABLE 10/Q.514

	Reference load A	Reference load B
Mean value	≤ 250 ms	≤ 400 ms
0.95 probability of not exceeding	300 ms	600 ms

For common channel signalling the relevant signalling system specification should apply.

2.3.8.2 *For originating, terminating and internal traffic connections*

TABLE 11/Q.514

	Reference load A	Reference load B
Mean value	⩽ 250 ms	⩽ 400 ms
0.95 probability of not exceeding	300 ms	700 ms

2.3.9 *Exchange signal transfer delay – transit traffic connections*

The exchange signal transfer delay is the time taken for the exchange to transfer a signal, no other exchange action being required.

For common channel signalling this delay is measured from the instant when the last bit of the signal unit leaves the incoming signalling data link to the instant when the last bit of the signal unit enters the outgoing signalling data link for the first time. It also includes the queuing delay in the absence of disturbances but not the additional queuing delay caused by retransmission.

The parameters in the appropriate common channel signalling system recommendations apply.

For channel associated signalling, the signal transfer delay is the interval from the instant when the incoming signal is recognizable to the instant when the corresponding outgoing signal has been transmitted. More stringent values are recommended for the *answer signal transfer delay* where connections involve inband line signalling. The objective of these requirements is to minimize the possible interruption of the transmission path, for any significant time during the initial voice response by the called party.

The values in Table 12/Q.514 are recommended.

TABLE 12/Q.514

	Reference load A		Reference load B	
	Answer signal [a)]	Other signals	Answer signal [a)]	Other signals
Mean value	⩽ 50 ms	⩽ 100 ms	⩽ 50 ms	⩽ 150 ms
0.95 probability of not exceeding	100 ms	150 ms	100 ms	300 ms

[a)] Applicable where in-band line signalling may be encountered in the national part of a built-up connection.

2.3.10 *Answer sending delay – terminating traffic connections*

Answer sending delay is the interval from the instant when the called subscriber off-hook condition is recognizable at the subscriber line interface of the exchange until the answer signal is sent back to the preceding exchange.

The values in Table 13/Q.514 are recommended.

TABLE 13/Q.514

	Reference load A	Reference load B
Mean value	$\leq$ 250 ms	$\leq$ 350 ms
0.95 probability of not exceeding	350 ms	700 ms

2.4 *Call processing performance objectives*

2.4.1 *64 kbit/s switched connections*

2.4.1.1 *Premature release*

The probability that an exchange malfunction will result in the premature release of an established connection in any one minute interval should be:

$$P \leq 2 \times 10^{-5}$$

2.4.1.2 *Release failure*

The probability that an exchange malfunction will prevent the required release of a connection should be:

$$P \leq 2 \times 10^{-5}$$

2.4.1.3 *Incorrect charging or accounting*

The probability of a call attempt receiving incorrect charging or accounting treatment due to an exchange malfunction should be:

$$P \leq 10^{-4}$$

2.4.1.4 *Misrouting*

The probability of a call attempt being misrouted following receipt by the exchange of a valid address should be:

$$P \leq 10^{-4}$$

2.4.1.5 *No tone*

The probability of a call attempt encountering no tone following receipt of a valid address by the exchange should be:

$$P \leq 10^{-4}$$

2.4.1.6 *Other failures*

The probability of the exchange causing a call failure for any other reason not identified specifically above should be:

$$P \leq 10^{-4}$$

2.4.2 *64 kbit/s semi-permanent connections*

This requires further study taking into consideration:

- need to recognize an interruption;
- probability of an interruption;
- requirements for re-establishment of interrupted connection;
- any other unique requirements.

2.4.3 *$n \times 64$ kbit/s switched connections*

To be recommended if/when specific services are defined.

2.4.4 *$n \times 64$ kbit/s semi-permanent connections*

To be recommended if/when specific services are defined.

2.5 *Transmission performance*

2.5.1 *64 kbit/s switched connections*

The probability of a connection being established with an unacceptable transmission quality across the exchange should be:

$$P\,(\text{Unacceptable transmission}) \leqslant 10^{-5}$$

The transmission quality across the exchange is said to be unacceptable when the bit error ratio is above alarm condition.

Note – The alarm condition has yet to be defined.

2.5.2 *64 kbit/s semi-permanent connections*

To be recommended.

2.5.3 *$n \times 64$ kbit/s switched connections*

To be recommended if/when specific services are defined.

2.5.4 *$n \times 64$ kbit/s semi-permanent connections*

To be recommended if/when specific services are defined.

2.6 *Slip rate*

2.6.1 *Normal conditions*

The slip rate under normal conditions is covered in Recommendation Q.513.

2.6.2 *Temporary loss of timing control*

The slip rate resulting from temporary loss of timing control is the subject of further study taking into account the requirements of Recommendation G.822.

2.6.3 *Abnormal conditions at the exchange input*

The slip rate in case of abnormal conditions (wide phase deviations, etc.) at the exchange input is the subject of further study taking into account the requirements of Recommendation G.823.

3 Exchange performance under overload conditions

(For further study.)

4 Availability design objectives

4.1 *General*

Availability is one aspect of the overall quality of service of an exchange.

Availability objectives are important factors to be considered in the design of a switching system and may also be used by administrations to judge the performance of a system design and to compare the performance of different system designs.

Availability may be estimated by using the ratio of the accumulated time during which the exchange (or a part of it) is capable of proper operation to a time period of statistically significant duration called the mission time.

$$\text{Availability (A)} = \frac{\text{accumulated up-time}}{\text{mission time}} = \frac{\text{accumulated up-time}}{\text{accumulated up-time + accumulated down-time}}$$

Sometimes it is more convenient to use the term unavailability (instead of availability) which is defined as:

$$\text{Unavailability (U)} = 1 - \text{A}.$$

The terms used in this section, when they already exist, are in accordance with CCITT Recommendation G.106.

4.2 *Causes of unavailability*

This Recommendation deals with availability as observed from the exchange termination point of view. Both planned and unplanned outages need to be considered, and both types need to be minimized. Unplanned outages reflect on the inherent reliability of the exchange and are therefore considered separately from planned outages in this Recommendation.

Unplanned unavailability counts all failures that cause unavailability. Thus hardware failure, software malfunctions and unintentional outages resulting from craftperson activity are to be counted.

4.3 *Intrinsic and operational unavailability*

Intrinsic unavailability is the unavailability of an exchange (or part of it) due to exchange (or unit) failure itself, excluding the logistic delay time (e.g. travel times, unavailability of spare units, etc.) and planned outages.

Operational unavailability is the unavailability of an exchange (or part of it) due to exchange (or unit) failure itself, including the logistic delay time (e.g. travel times, unavailability of spare units, etc.).

4.4 *Planned outages*

Planned outages are those intentionally induced to facilitate exchange growth or hardware and/or software modifications. The impact of these activities on service depends on their duration, the time of day they are introduced and on the particular system design.

4.5 *Total and partial unavailability*

Exchange unavailability may be either total or partial. Total unavailability affects all terminations, and consequently, all traffic that is offered during the outage is equally affected. A partial outage has an effect only on some terminations.

From the point of view of one termination on an exchange (e.g. a subscriber line termination) the numerical value of mean accumulated downtime (and hence the unavailability) for a specified period of time should not depend on the exchange size or its traffic handling capacity. Similarly, from the point of view of a group of terminations of size n, the mean accumulated downtime for a specified period of time, *in case they are simultaneously unavailable*, should not depend on exchange size. However, for two groups of terminals of differing size n and m such that n is greater than m ($n >$ m), the mean accumulated downtime (and hence the unavailability) for n will be less than the mean accumulated downtime (MADT) or the unavailability for m,

Thus:

$$\mathrm{MADT}(n) < \mathrm{MADT}(m) \text{ where } n > m$$

and

$$\mathrm{U}(n) < \mathrm{U}(m)$$

The lower limit of m is one termination, and it can be specified as having a mean value of T minutes per year.

4.6 *Statistical basis*

Any estimation of unavailability is of necessity a statistical quantity, because outages are presumed to occur randomly and they are of random duration. Therefore, availability measurements are significant when made over a statistically significant number of exchanges. It follows then, that a single exchange may exceed the unavailability objectives. Further, to be statistically significant the mission time must be adequate in order to have sufficient collected data. The accuracy of the result is dependent on the amount of collected data.

4.7 *Relevant failure events*

Different types of failure events may occur in an exchange. In order to evaluate the unavailability of an exchange (or part of it) only those events having an adverse effect on the exchange's ability to process calls as required should be taken into account. A failure event which is short in duration and results only in call delay rather than in a call denial can be disregarded.

4.8 *Availability independence*

The design objectives for the unavailability of a single termination or any group of terminations of size n are independent of exchange size or internal structure.

4.9 *Intrinsic downtime and unavailability objectives*

The recommended measure for use in determining *intrinsic unavailability* is mean accumulated intrinsic down time (MAIDT) for individual or groups of terminations, for a given mission time, typically one year.

For one termination:

$$\text{MAIDT (1)} \leqslant 30 \text{ minutes per year.}$$

For an exchange termination group of size n:

$$\mathrm{MAIDT}(n) < \mathrm{MAIDT}(m) \text{ where } n > m.$$

This reflects the consequences (e.g. traffic congestion, social annoyance, etc.), of the simultaneous outage of a large number of terminations.

The above expression is a statement of principle and means that units serving larger group sizes shall have lower MAIDT.

4.10 *Operational unavailability objectives*

4.10.1 *Logistic delay time*

Due to differing national conditions, logistic delay times may vary from country to country and therefore may not be subject to international Recommendation.

Nevertheless, for design guidance, an indication of the Administration's logistic delays is considered desirable to establish overall operational performance objectives. It is left for the operating Administration to determine how it should be accounted for in the determination of operational unavailability.

4.10.2 *Planned outages*

Planned outages are to be minimized to the greatest extent practicable. They should be scheduled so as to have least impact on service practicable.

4.11 *Initial exchange availability performance*

A system rarely meets all long-term design objectives when first placed into service. The objectives contained in this Recommendation may therefore not be fulfilled for a limited period of time after the newly designed switched system has been put into service; this period of time should be minimized to the greatest extent practicable.

5 Hardware reliability objectives

A bound on the rate of hardware failures is recommended. It includes all types of hardware failures and the failures counted are independent of whether or not there is a resulting service degradation.

An acceptable hardware failure rate for an exchange is a function of the exchange size and the types of terminations.

The following formula can be used to verify that the maximum failure rate does not exceed the Administration's requirements:

$$F_{max} = C_0 + \sum_{i=1}^{n} C_i T_i$$

where:

F_{max}	the maximum acceptable number of hardware failures per unit of time;
T_i	the number of terminations of type i;
n	the number of distinct types of terminations;
C_0	to be determined taking into account all failures which are independent of exchange size;
C_i	coefficients for terminations of type i, reflecting the number of failures associated with individual terminations of that type. Different hardware used with different types of terminations may result in different values for C_i.

Recommendation Q.515

EXCHANGE MEASUREMENTS

1 General

This Recommendation applies to digital local and combined local/transit exchanges for telephony in Integrated Digital Networks (IDN) and mixed (analogue/digital) networks. It will form the basis for digital switching in Integrated Digital Networks (ISDN) when other services are integrated with telephony. The field of application of this Recommendation is found in draft Recommendation Q.511.

This Recommendation includes measurements for digital transit (local and combined local/transit) exchanges that are necessary for provisioning and operating exchanges so as to satisfy grade of service objectives covered in the E.500 series of Recommendations. These measurements are typically performed during specified periods and intervals after which the results are sent to designated local and/or remote exchange terminals or operation and maintenance centres (OMC) or any other appropriate data handling centre. In some cases, data may be utilized in its original form whereas in other cases data may need to be processed to determine when pre-set thresholds are exceeded and/or to recognize an abnormal condition when it occurs. In this Recommendation, no particular system design requirement is implied. Different designs may have more or less data accumulated and processed within the exchange or by an external system.

Different types and sizes of exchanges may require different sets of measurements. Also, different Administrations may have different requirements for measurements depending on policies, procedures or national network considerations. An Administration may thus find it desirable in some applications to measure items that are not covered by this Recommendation whereas in other applications some measurements may not be desired.

Exchange measurements are required for both national and international service. Requirements for international service take into consideration the following CCITT Recommendations:

- Recommendations E.401 to E.427: International telephone network management and checking of service quality;
- Recommendations E.230 to E.277: Operational provisions relating to charging and accounting in the international telephone service.

The aspects of traffic engineering are given in Recommendations E.500 to E.543. Recommendations on traffic meaurements for SPC exchanges are provided by Recommendation E.502.

Note – For the terms and definitions of teletraffic used in this Recommendation, see *Yellow Book*, Volume II.3, Supplement No. 7.

2 Measurement processes

2.1 *General*

The activities involved in exchange measurements can be split in four processes as represented by Figure 1/Q.515.

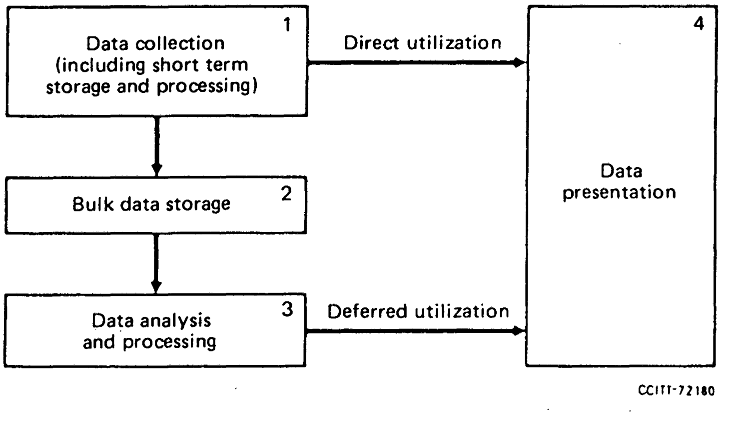


FIGURE 1/Q.515

Measurement processes

On choice of each individual national Administration, the above four processes can be fully or partially integrated into the exchanges.

It is nevertheless recommended that:

a) *data collection* be fully integrated into the exchange for all types of data;

b) *data presentation* be integrated into the exchange and/or at the O&M centre at least for the measurements required by O&M personnel.

Presentation of data required for planning and administration activities could be performed at the O&M personnel premises or in other locations which could be more centralized and generally takes place at a deferred time.

2.2 *Data collection*

Three different activities of data collection can be identified:

- event registration;
- traffic registration (traffic intensity and/or volume of traffic);
- call records registration.

The data generated by event registration and traffic registration are suitable for direct utilization (immediate presentation).

Call records can only be utilized after off-line analysis. Processing of call records can generate any type of data, including the event registration and traffic registration.

2.3 *Bulk data storage, analysis and processing*

Data storage for collected data can be required for accumulation of a massive data base suitable for subsequent analysis and processing.

These data can be held in the exchange for processing at the exchange location or transferred to administrative and engineering centres.

2.4 *Data presentation*

It is the function through which the collected data are becoming readable. Features related to the data presentation are:

a) location of presentation;

b) time frame of presentation. It is dependent on the nature of the data and their utilization. The activities of maintenance and network management require immediate presentation;

c) physical support of the displayed data and relevant format. These aspects are mainly related to the type of data and are to be left to individual implementations.

3 **Types of measurement data**

Measurement data primarily consists of counts of various events and the traffic intensity on various resources. For certain measurement data, sampling, or time averaging techniques may provide an acceptably accurate result. In some cases, externally generated test calls may provide the most practical method of obtaining the data. In other cases, call records, such as detailed charging records, may be used.

3.1 *Event counts*

Events, for example incoming seizures, call attempts encountering busy, and call attempts to specified destination codes should be countable. Some event counts may be accumulated over the whole exchange whereas others may be accumulated only over a subset such as an inter-exchange circuit group. In some cases, event counts may be accumulated several ways.

3.2 *Traffic intensity*

Traffic intensity on a pool of resources is the traffic volume divided by the duration of observation. It is thus equal to the average number of busy resources. As in the case of event counts, traffic intensity data may be for the whole exchange or for various subsets.

3.3 *Call records*

Call records contain data used by the exchange for the setting up of calls. The data may include the identity and classification of the originating line or incoming circuit, the dialled number, the call routing and disposition, and possibly the time of occurrence of certain events during the entire call period.

Call records can be generated and outputted by the exchange to allow the establishment of a data base suitable for off-line processing to determine traffic values and characteristics. A statistical sample of the total number of call records may be sufficient for this purpose.

4 **Measurement administration**

Exchanges should provide capabilities for operating personnel to establish measurement schedules and direct the output routing of measurement results. It should be possible to have a number of measurements simultaneously active with different schedules and output routings. The number of measurement types running concurrently may be limited to conserve exchange storage and processing resources. Criteria for measurement and recording of traffic may be found in Recommendation E.500 and other related E-Series Recommendations.

4.1 *Scheduling*

4.1.1 *Recording periods*

A recording period is the time interval during which a measurement is performed. Measurements can be activated either on-demand or according to a time schedule.

Different measurement periods may be schedulable for different days of the week. For example, a measurement may be scheduled for 0900 to 1800 on Monday through Friday and 0900 to 1200 on Saturday. The measurements for an entire week may be programmed and the weekly cycle may be repeated until a new command will stop it.

4.1.2 *Result accumulation periods*

A recording period contains one or more result accumulation periods. The beginning and ending of the recording period must correspond to the beginning and ending of result accumulation periods.

The measurement result outputs are to be made available at the end of each result accumulation period and shall refer to that period.

More than one result accumulation period may be required for an individual measurement.

4.2 *Data output criteria*

4.2.1 *On schedule*

Measurement data output typically occurs shortly after the end of each result accumulation period specified by the measurement schedule. Alternatively, the exchange may store the data in its memory for limited periods, e.g. in the event of contention for output resources.

4.2.2 *On demand*

(For further study.)

4.2.3 *On exception*

The exchange should be able to provide measurement data when specified criteria are met, for example, when the rate of incoming call attempts exceeds a particular value.

4.3 *Data output routing*

4.3.1 *To a local or remote terminal*

Measurement data should be able to be routed for printing or display on designated terminals which are either directly connected to the exchange or remotely connected via dedicated or switched circuits.

4.3.2 *To an external processing centre*

Measurement data should be routable to external locations such as OMC that provide data collection and analysis functions for multiple exchanges.

4.3.3 *To local storage media*

An Administration may require exchanges to store measurement data in bulk memories such as magnetic tapes for later processing and analysis. This could be an alternative to sending the data to an OMC.

5 **Application of measurements**

5.1 *Planning and engineering*

Measurement data is essential for planning efficient telecommunication networks that meet specified grade-of-service standards. Analysis of data accumulated over a period of time provides information needed to forecast future demand and to plan and engineer extensions to the network.

5.2 *Operation and maintenance*

Operation and maintenance functions are supported by the following types of measurement data:

i) performance data pertaining to call handling irregularities and delays;

ii) availability data for the exchange, its subsystems, and its connecting subscriber lines and inter-exchange circuits;

iii) load on various components of the exchange.

The above data may be used to evaluate exchange and network performance and to plan rearrangements to improve the service provided by the existing network equipment.

5.3 *Network management*

Data for network management includes certain traffic and performance measurements and status indications. These are used to detect abnormalities in the network and to automatically enable, or allow manual operation of, network management controls. In some cases, the data must be analysed to determine whether specified thresholds are being exceeded. Since the effectiveness of network management actions depends upon their responsiveness to changing conditions in the network as a whole, it may be appropriate to perform this analysis by a data processing system serving one or more exchanges and display the results at a network management centre. Network management functions are covered in Recommendations E.410 through E.413 and Q.516.

5.4 *Accounting in international service*

Accounting in international service needs to be mutually agreed between Administrations; Recommendations E.230 to E.277 apply.

5.5 *Subdivision of revenue*

Subdivision of revenue is a matter of agreement between RPOAs of the same country. Requirements in this area are a national matter.

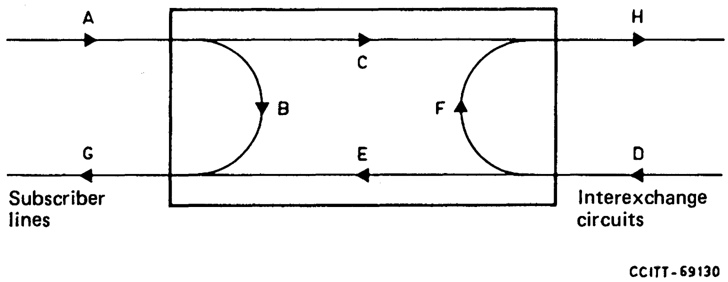
5.6 *Tariff and marketing studies*

The studies are intended to identify subscriber needs and trends. Requirements in this area are a national matter.

6 Traffic measurements

6.1 *General*

From the point of view of the exchange the traffic can be categorized as shown in Figure 2/Q.515.



A Originating traffic
B Internal traffic
C Originating outgoing traffic
D Incoming traffic
E Incoming terminating traffic
F Transit traffic
G Terminating traffic
H Outgoing traffic

FIGURE 2/Q.515

Exchange traffic categories

6.2 *Interexchange circuit groups*

The measurements apply to individual circuit groups. All circuit groups should be measurable. For traffic intensity, it may be desirable to measure all circuit groups simultaneously. Information for estimating the average number of circuits in service during the result accumulation period should be provided in addition to the traffic data for each circuit group.

6.2.1 *Incoming traffic*

Incoming traffic is understood to be:

– the traffic on incoming circuit group,

– the incoming traffic on both-way circuit groups.

The following parameters should be measured:

a) traffic intensity,

b) number of seizures.

6.2.2 *Outgoing traffic*

Outgoing traffic is understood to be:

– the traffic on outgoing circuit groups,

– the outgoing traffic on both-way circuit groups.

The following parameters should be measured:

a) traffic intensity,

b) number of seizures,

c) number of call attempts overflowing from the group,

d) answered call attempts.

6.3 *Auxiliary circuit groups*

Auxiliary circuits provide functions such as multifrequency signalling, tones, announcements, and access to operators. Grouping of auxiliary circuits may vary with system implementation characteristics. Groups in this section refer to system independent functional groups. Some systems may allow calls to wait for an auxiliary circuit if one is not immediately available.

The measurements indicated below are intended to provide information for the dimensioning of auxiliary circuits. They should be provided for each group which may require dimensioning. Measurements may be activated for any specified list of auxiliary circuit groups. Information for estimating the average number of circuits in service during the result accumulation period should be provided in addition to the traffic data for each circuit group:

a) traffic intensity,

b) number of seizures,

c) number of bids not served.

6.4 *Subscriber line groups*

These measurements are applicable to groups of subscriber lines that share switching network access paths. The lines served by a particular line concentration unit of a local exchange would be an example of such a group. In systems where traffic levels on such line groups could result in failure to meet grade of service objectives, appropriate measurements for load balancing purposes should be provided.

6.5 *Destination codes*

These measurements are used to assess the probability of success on calls to various destinations and may be used in deciding on any network management actions considered necessary. The number of destination codes specified for measurement at any one time may be limited. For any specified destination code, the following parameters should be measured:

a) number of call attempts,

b) number of call attempts resulting in an outgoing seizure,

c) number of answered calls.

Parameter a) would typically be most applicable to network planning whereas b) and c) would be applicable to network management. Intensity measurements for specified destination codes may be required by some Administrations or RPOAs for traffic engineering purposes.

6.6 *Control equipment*

These measurements are highly system dependent and therefore no specific recommendations can be made. However, it is essential that systems will have provisions for determining the utilization of control equipment, such as processors, for dimensioning, planning, and grade of service monitoring of the exchange.

6.7 *Total exchange*

The following measurements are applicable to the total traffic of an exchange. Owing to the variability of signalling methods and switching system designs, some variation of the measurements for the following traffic categories might be appropriate. For example, Administrations may require more detailed, but system dependent counts to allow them to conduct a meaningful call failure analysis. Furthermore, the traffic categories to which any measurement relates may vary from that shown in the following list, depending on system design, since, for example, there may be certain causes of failure which affect all traffic categories.

Figure 2/Q.515 and 3/Q.515 illustrate the traffic categories and call disposition events referenced in the following sub-sections.

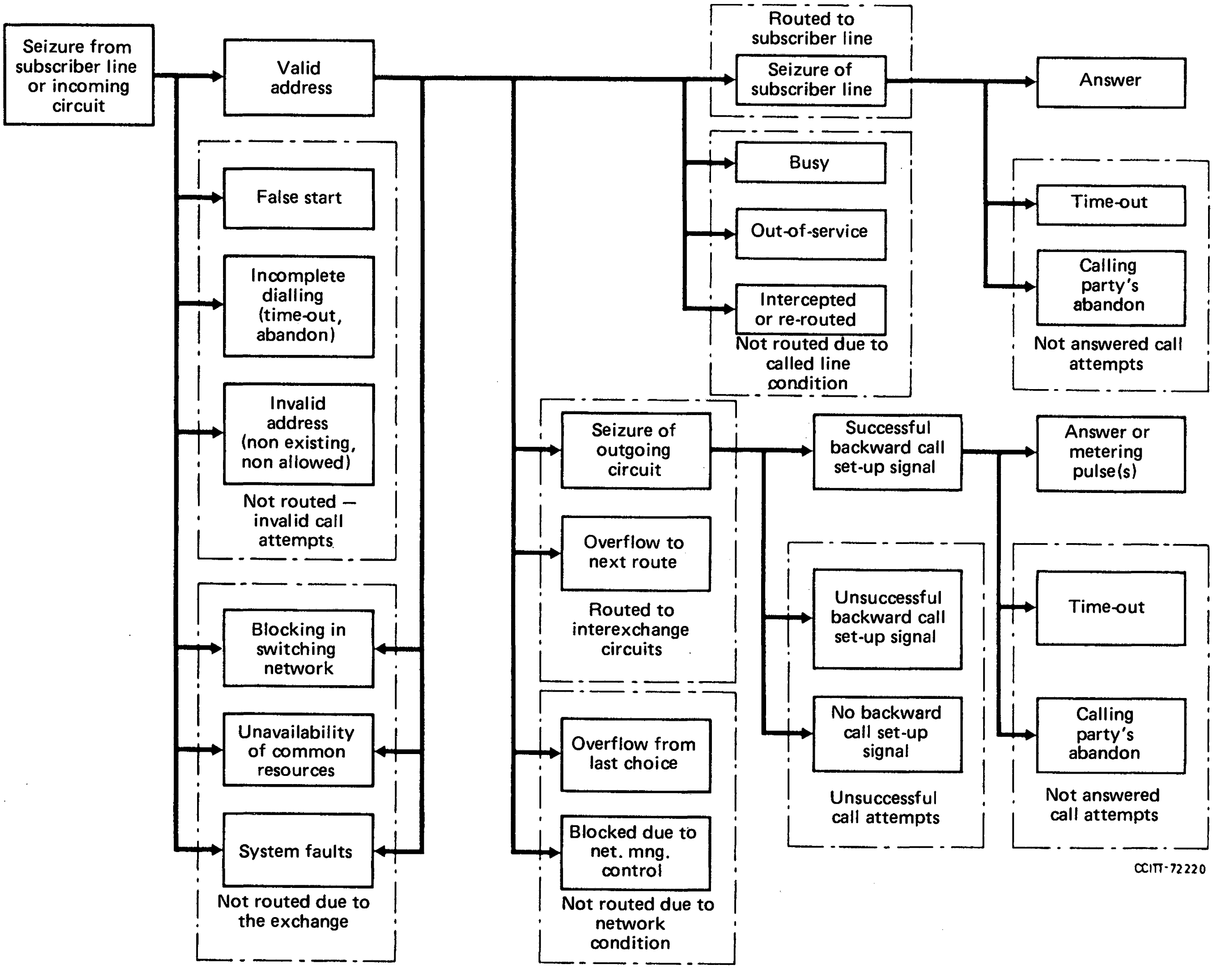


FIGURE 3/Q.515

Call events reference diagram

6.7.1 *Originating traffic*

a) Originating call attempts.

b) Invalid call attempts, for example:
   – no dialling,
   – incomplete dialling,
   – invalid number dialled.

c) Call attempts not routed due to the exchange, for example, due to:
   – blocking through the switching network,
   – unavailability of common resources,
   – system faults.

d) Internal call attempts.

6.7.2 *Incoming traffic*

a) Incoming seizures.

b) Invalid call attempts, for example:
   – incomplete dialling,
   – invalid number dialled.

c) Call attempts not routed due to the exchange, for example, due to:
   – blocking through the switching network,
   – unavailability of system resources,
   – system faults.

d) Transit call attempts.

6.7.3 *Terminating traffic*

a) Call attempts routed to subscriber lines.
b) Call attempts not routed due to line condition.

6.7.4 *Outgoing traffic*

a) Outgoing call attempts routed to an interexchange circuit.
b) Call attempts not routed due to network condition.
c) Unsuccessful call attempts.

6.7.5 *Service utilization*

The exchange should be able to measure the utilization of each type of basic and supplementary service it provides. The mix of services and the corresponding exchange measurements depends upon switching system capabilities and Administration policies.

7 Exchange performance and availability measurements

7.1 *Performance measurements*

For monitoring the exchange grade of service, a certain number of parameters should be observed. They may include the measurements given in Recommendation E.543 for delay grade of service monitoring. However, other processing delays (see relevant paragraphs of Recommendation Q.514) may be observed for complete monitoring of the exchange grade of service.

Measuring processing delays on a per call or statistical basis could be burdensome to the exchange. Moreover, some processing delays may not be measurable with an acceptable time accuracy and others may not be easily measured by the exchange itself.

Operating procedures of Administrations will impose constraints on the accuracy of the measurements for grade of service monitoring purposes. When such accuracy requirements allow, it may be possible to measure processing delays on a sample or test call basis. Requirements in this area are therefore a national matter.

7.2 *Availability measurements*

The exchange should record the beginning and ending time of all detected instances during which service is unavailable to one or more exchange terminations. The recorded information should permit the determination of the number and identity of terminations affected, if possible.

8 Data for network management

Procedures for network management are specified in Recommendations E.410 through E.413. Those procedures make use of data from exchanges to determine overall network performance and, when required, appropriate control actions. Much of the data required for network management is also needed for other operation and maintenance functions. However, effective network management requires control actions to be executed quickly in response to changing network and traffic conditions. Therefore, exchanges that Administrations have designated to provide network management functions must be able to provide traffic and status data to other exchanges and network management centres on a pre-arranged basis or when triggered by a specific event, such as an overload condition. The network management functions provided by any specific exchange will depend upon factors such as its size, position in the network, and Administration policies.

Data for network management includes measurement items specified within this Recommendation in the following sections:

§ 6.2 Inter-exchange circuit groups.

§ 6.3 Auxiliary circuit groups.

§ 6.5 Destination codes.

§ 6.6 Control equipment.

Data on the following is also applicable:

- equipment status,
- signalling system status,
- network management controls in effect.

Analysis of the above data and status information to activate controls or exception indicators may be provided as an exchange function. However, it is desirable to implement network management techniques centrally on a regional or national basis, in order to take account of conditions over a large number of exchanges and transmission systems. Factors such as overall network size, signalling and switching systems in use and Administration policies have a bearing on the implementation of this analysis function which is, therefore, not subject to CCITT Recommendation.

Recommendation Q.516

OPERATIONS AND MAINTENANCE FUNCTIONS

1 General

This Recommendation applies to digital local and combined local/transit exchanges for telephony in Integrated Digital Networks (IDN) and mixed (analogue/digital) networks. It will form the basis for digital switching in Integrated Services Digital Networks (ISDN) when other services are integrated with telephony. The field of application of this Recommendation is found in Recommendation Q.511.

The exchange and/or any associated Operations and Maintenance Systems/Centres shall have the capabilities needed to allow the exchange to be operated and administered efficiently while providing service in accordance with an Administration's performance requirements.

A detailed list of operation and maintenance functions to be performed at input/output terminals using CCITT Man-Machine-Language (MML) appears in Recommendation Z.331.

2 Operations functions

2.1 *Exchange modifications and growth*

The exchange should be capable of having hardware and/or software added or changes made without causing a significant impact on service (see Recommendations Q.514, §§ 4.4, 4.10.2, Planned outages).

2.2 *Service provisioning and records*

There should be efficient means of establishing service, testing, discontinuing service and maintaining accurate records for:

- subscriber lines and services,
- interexchange circuits.

2.3 *Translation and routing information*

There should be efficient means of establishing, testing and changing call processing information, such as translation and routing information.

2.4 *Resource utilization*

There should be efficient means of measuring performance and traffic flows and to arrange equipment configurations as required to insure efficient use of system resources and to provide a good grade of service to all subscribers (e.g. load balancing).

3 Maintenance functions

3.1 *Status and other information*

The exchange shall provide information to maintenance personnel so that they can quickly ascertain:

- equipment/system status,
- critical load levels,
- trouble conditions,
- network management controls in effect.

3.2 *Inputs and outputs*

The exchange shall be able to transmit and receive maintenance information and respond to commands from on-site and if appropriate, from remote maintenance centre(s) or systems over the recommended interface(s) (§ 2.3.1, Recommendation Q.512).

The exchange shall use CCITT MML at its input/output terminals as covered in the Z.300 series of Recommendations.

3.3 *Physical design*

The exchange shall have a good physical design that provides:

- adequate space for maintenance activities,
- conformance with environmental requirements,
- uniform equipment identification (conforming with the Administration's requirements),
- a limited number of uniform power up/down procedures for all component parts of the exchange.

3.4 *Routine testing*

The exchange shall have facilities for performing or directing routine test activities on its component parts and possibly with interfacing equipment or systems.

3.5 *Trouble localization*

The exchange shall have adequate facilities for diagnosing and locating faults within the exchange.

3.6 *Fault and alarm detection and response*

The exchange shall interact with transmission systems as required to detect fault and alarms and take appropriate actions.

3.6.1 *At interfaces A, B, V2, V3, V4 and V5*

3.6.1.1 *Fault detection*

The following fault conditions should be detected:

- failure of local power supply (if practicable),
- loss of incoming signal,

  Note – The detection of this fault condition is required only when the fault does not result in an indication of loss of frame alignment.
- loss of frame alignment (Recommendations G.732, G.733 G.744 and G.746),
- excessive error ratio.

The criteria for activating and deactivating the indication of the fault condition are given in Recommendations G.732 and G.744.

3.6.1.2 *Alarm detection*

The following alarm indications should be detected:

- Alarm indication (remote alarm) received from the remote end.
- AIS (Alarm Indication Signal) for 2048 and 8448 kbit/s systems. The equivalent binary content of the Alarm Indication Signal (AIS) is a continuous stream of "1"s at 2048 or 8448 kbit/s.

The strategy for detecting the presence of the AIS should be such that the AIS is detectable even in the presence of an error ratio of 1 in 10^3. However, a signal with all bits except the frame alignment bit in the 1 state should not be mistaken as an AIS.

3.6.1.3 *Consequent actions*

3.6.1.3.1 *Generation of alarm signals for action within the exchange*

- The service alarm indication should be generated to signify that the service is no longer available (see Table 1/Q.516).
- The prompt maintenance alarm indication should be generated to signify that performance is below acceptable standards and that immediate maintenance attention is required locally (see Table 1/Q.516).

3.6.1.3.2 *Generation of alarms transmitted by the exchange*

- Alarm signals sent "upstream" towards the exchange interface.

  The relevant alarm bits for the remote alarm indication, as recommended in G.732, G.733, G.744 and G.746, should be effected as soon as possible (see Table 1/Q.516).
- Alarm signals sent "downstream" towards the switching function. Alarm Indication Signal applied in all received time-slots containing speech, data and/or signalling should be applied as soon as possible and not later than 2 ms after the detection of the fault condition (see Table 1/Q.516).

Note – The terms "upstream" and "downstream" are defined in Recommendation G.704.

3.6.1.3.3 *Removal of alarm indications*

When all fault conditions have been cleared and Alarm Indication Signal is no longer received, the Alarm Indication Signal and remote alarm indication should be removed within the same respective time limits as specified in § 3.6.1.3.4 after the conditions have cleared.

3.6.1.3.4 *Alarm processing*

The following items are required to ensure that equipment is not removed from service due to short breaks in transmission (e.g. due to noise or transient fault) and to ensure that maintenance action does not result where no direct maintenance action is required.

- The persistence of service alarm and of the prompt maintenance alarm indications may be verified for 100 ms before action is taken.
- When the AIS is detected, the prompt maintenance alarm indication, associated with loss of frame alignment and excessive error rate in the frame alignment pattern, should be inhibited.
- When the fault conditions cease, the service alarm and prompt maintenance alarm indications, if given, should be removed. Again, the persistence of this change in condition may be verified for 100 ms before action is taken.
- It is possible that some systems could suffer from frequent transient faults resulting in an unacceptable quality of service. For this reason, if a persistence check is provided, fault rate monitoring should also be provided for each digital transmission system. This monitoring will result in permanent removal from service of digital transmission system which are frequently removed from the service or frequently produce transient alarm conditions. The threshold for removal from service needs study. When this action is taken the service alarm indication and the prompt maintenance alarm indication shall be given.

Note to 3.6.1 – The utilization of these indications will depend upon the switching and signalling arrangements provided nationally. Separate indications for some of the fault conditions listed may be provided nationally if required.

TABLE 1/Q.516

Fault conditions and alarms detected by exchange terminal functions and consequent actions

Fault conditions and alarms detected (see § 3.6.1)	Consequent actions (see § 3.6.1)			
	Service alarm indication generated	Prompt maintenance alarm indication generated	Alarm indication to remote end generated	AIS towards the switching stages
Failure of power supply	Yes	Yes	Yes, if practicable	Yes, if practicable
Loss of incoming signal	Yes	Yes	Yes	Yes
Loss of frame alignment	Yes	Yes	Yes	Yes
Excessive error ratio	Yes	Yes	Yes	Yes
Alarm indication received from remote end	G.732 + G.744: Yes G.733 + G.746: optional	G.733 + G.746: Yes		
AIS received	Yes		Yes	Yes

Note – A *Yes* in the table signifies that an action should be taken. An open space in the table signifies that the relevant action should *not* be taken, if this condition is the only one present. If more than one fault condition or alarm is simultaneously present, action should be taken if for at least one of the conditions a *Yes* is shown, except in the case of AIS received for which § 3.6.1 applies.

3.6.2 *At Interface V1*

a) Fault detection b) Alarm detection c) Consequent actions	To be specified

3.6.3 *At Interface Z1*

a) Fault detection b) Alarm detection c) Consequent actions	To be specified

3.6.4 *Transmission systems*

Faults and alarms which cannot be directly detected by the exchange terminal function but which are detected by transmission equipment (e.g. group pilot failure) should be accepted by the exchange as needed to take appropriate action.

3.6.5 *Signalling function*

3.6.5.1 *Channel associated signalling (2048 and 8448 kbit/s systems)*

3.6.5.1.1 *Fault detection*

The exchange signalling function should detect the following fault conditions for each multiplex carrying a 64-kbit/s signalling channel:

- failure of local power supply (if practicable),
- loss of 64 kbit/s incoming signal,

  Note – The detection of this fault condition is required only when the fault does not result in an indication of loss of multi-frame alignment.
- loss of multi-frame alignment.

The criteria for activating and deactivating the indication of the fault condition are given in Recommendations G.732 and G.744.

3.6.5.1.2 *Alarm detection*

The exchange signalling function should detect the alarm indication (remote alarm) received from the remote end.

3.6.5.1.3 *Consequent actions*

3.6.5.1.3.1 *Generation of alarm signals for action within the exchange*

- The Service Alarm indication should be generated by the exchange signalling function to signify that the service is no longer available (see Table 2/Q.516).
- The prompt maintenance alarm indication should be generated to signify that performance is below acceptable standards and that immediate maintenance attention is required locally. (see Table 2/Q.516).

3.6.5.1.3.2 *Alarm transmitted by the exchange*

An alarm indication (remote alarm) should be applied "upstream" towards the transmission/switching interface as soon as possible (see Table 2/Q.516). The relevant alarm bit for the remote alarm indication is given in Recommendation G.732.

3.6.5.1.3.3 *Removal of alarm indication*

When all fault conditions have been cleared and AIS is no longer received, the remote alarm indication should be removed as soon as possible.

3.6.5.1.3.4 *Alarm processing*

Same as in § 3.6.1.

TABLE 2/Q.516

Fault conditions and alarms detected by the exchange signalling function and consequent actions

Fault conditions and alarms detected (see § 3.6.5)	Consequent actions (see § 3.6.5)		
	Service alarm indication generated	Prompt maintenance alarm indication generated	Alarm indication to remote end generated
Failure of power supply	Yes	Yes	Yes, if practicable
Loss of 64 kbit/s incoming signal	Yes	Yes	Yes
Loss of multi-frame alignment	Yes	Yes	Yes
Alarm indication received from remote end	Yes		

Note – A *Yes* in the table signifies that an action should be taken. An open space in the table signifies that the relevant action should *not* be taken, if this condition is the only one present. If more than one fault condition or alarm is simultaneously present, action should be taken if for at least one of the conditions a *Yes* is shown.

3.6.5.2 *Channel associated signalling (1544 kbit/s)*

Requires further study.

3.6.5.3 *Common channel signalling*

Requirements specified in relevant Recommendations apply.

3.6.6 *Fault and alarm detection and consequent actions – other functions of the exchange*

3.6.6.1 *Faulty circuits*

The exchange should not switch any new calls to a detected faulty circuit.

The exchange should remove from service all circuits found to be permanently faulty as detailed in §§ 3.6.1, 3.6.4 and 3.6.5.

3.6.6.2 *Master clock distribution*

The absence of timing information distributed from a master clock located at the exchange or received from an external master clock shall be recognized and a prompt maintenance alarm shall be given.

Changeover to an alternate timing source shall be operated so as to fulfil the requirements of §§ 2.6.2 and 2.6.3 of Recommendation Q.514.

3.6.6.3 *Internal timing distribution*

The distribution of timing information to the major elements of the exchange shall be supervised as required. A service alarm shall be given when a failure is detected. A maintenance alarm shall be given if it is appropriate.

Note – Remote elements may have to be taken into consideration.

3.7 *Supervision or testing of interface function*

The exchange shall have the capability of verifying the proper operation of the interface functions, including the fault detection and supervision functions.

Routine tests, statistical tests, manual activities and/or other means may be used to verify proper operation of these functions.

Information shall be given to the far end exchange when new calls cannot be established on the circuits on which routine tests are being initiated. Established calls, including semi-permanent connections, must not be interrupted. During the tests, the generation of alarms at the far end exchange due to the removal of circuits from service should be avoided, if possible.

3.7.1 *ET functions – Interfaces A, B, V2, V3, V4, V5*

The verification of the proper operation of exchange terminal functions can be performed by the means of statistical observations or by testing. Testing may be manual or automatic.

3.7.2 *ET functions – Interfaces E and Z2*

i) Failures of codecs (except those covered in ii) below) should be recognized by the exchange using the criteria defined in Recommendation G.732.

ii) Supervision or testing of codecs of one or a small number of channels may be accomplished according to i) above or by inter-office transmission measurement and testing on circuits between exchanges or by statistical measurements.

3.7.3 *ET functions – Interface V1*

To be specified.

3.8 *Supervision or testing of signalling functions*

In addition to fault detection required in § 3.6.3 the following applies.

3.8.1 *Channel associated signalling*

The exchange should be able to verify the proper operation of the signalling functions by generating and responding to test calls or by a statistical observation.

3.8.2 *Common channel signalling*

The exchange should be able to verify the proper operation of the signalling functions as required by common channel signalling recommendations.

3.9 *Supervision or testing of exchange performance*

3.9.1 *Exchange error performance*

A means of determining that the operational bit error ratio requirement is being met should be provided.

3.9.2 *Through-connection supervision*

The exchange should provide adequate supervision of the cross office path continuity.

3.9.3 *Switched connections*

The requirements of § 2.5.1 of Q.514 are considered to be sufficient in order to guarantee the cross office path continuity. The method by which this is performed may be on per call basis, continuously, statistically or by other means.

3.9.4 *Semi-permanent connections*

Semi-permanent connections may require special supervision procedures.

3.9.5 *n × 64 kbit/s connections*

This item requires further study for both switched and semi-permanent connections.

3.10 *Supervision or testing of digital facilities performance*

The exchange shall have the capability of monitoring digital link performance to detect when bit error ratio and loss of framing thresholds exceed operational objectives. The exchange will then take subsequent action to give appropriate trouble indications or alarms and perform other appropriate actions, such as removing circuits from service.

3.11 *Supervision or testing of analogue facilities performance*

3.11.1 *Interexchange circuit continuity check*

The exchange should be capable of performing circuit continuity checks in accordance with appropriate signalling system recommendations. Circuits failing circuit continuity checks should be removed from service and repair procedures initiated as required.

3.11.2 *Interexchange transmission measurement and testing on circuits between exchanges*

The exchange may also be equipped within itself or give access to external equipment to perform other transmission tests on circuits. Faulty circuits should be removed from service and repair procedures initiated as required.

4 **Subscriber line maintenance and testing**

4.1 *Analogue subscriber lines*

For further study.

4.2 *Digital subscriber lines*

For further study.

5 **Network management functions**

5.1 *General*

Network management is the function of supervising the performance of a network and taking action to control the flow of traffic, when necessary, to promote the maximum utilization of network capacity.

These functions have application in exchanges within the IDN, and may or may not have application in national networks during the transition period to IDN.

The implementation of network management features and functions in national networks and in specific exchanges will be at the option of Administrations or RPOA's. Likewise the choice of which controls and features to use will be the option of each Administration or RPOA.

5.1.1 *Network management objectives*

Information on network management objectives can be obtained from Recommendation E.410, and from the CCITT "Handbook on Service Quality, Network Maintenance and Management" ITU, Geneva 1984.

5.1.2 *The application of network management in exchanges*

The decision whether or not to provide network management capabilities in local or combined local/transit exchanges will be based on the following considerations:

- the features necessary to provide essential services in emergency situations, where other means are not available;
- the economics of adopting a specific network management functional arrangement.

The costs and benefits of the following must be considered:

- the network management organization, its equipment and selected functions;
- the reduction of exchange processing capacity due to the additional load imposed by network management (if appropriate);
- possible additional holding time of equipment in some switching and signalling systems where open numbering is used, if and when certain network management controls are applied.

Other factors to be considered are:

- the size, capabilities, and technology of the exchange(s), and its role in the network;
- the architecture and size of the network;
- alternative approaches such as providing redundancy and special routing methods;
- the evolution towards IDN, and interworking of SPC with non-SPC exchanges in the interim period;
- the degrees of automatic and manual features to be implemented, and the rate of introduction of various network management features.

5.2 *Network management elements in an exchange*

The basic elements of a network management system to be provided by an exchange or by network management centres are:

- information on which network management decisions can be made,
- the capability to activate/deactivate controls resulting from decisions made in the exchange, or at a network management centre,
- feedback of status in response to control actions.

Descriptions of the functions required to support these elements are given in §§ 5.3 and 5.4.

5.3 *Information provided by an exchange for network management purposes*

5.3.1 *General*

The term "information" is used here as meaning all messages, signals or data in any form, used or provided by the exchange or network management centre.

5.3.2 *Sources of information*

The information provided by an exchange for network management will be based on the status, availability and performance of:

- circuit groups,
- exchange processes,
- common channel signalling link sets,
- other exchanges with direct links to this exchange,
- destination exchanges.

Details of network management measurements are given in Recommendation Q.515.

5.3.3 *Processing of network management information in an exchange*

Information collected at an exchange for network management purposes may or may not require some form of sorting and assembly (processing) before being used for network management.

Where processing is required this may be done by the exchange processor, or by a data processing system serving one or more exchanges, or by a network management centre.

5.3.4 *Transmittal of information*

Network management information may be sent as required on a near real-time basis:

- within the originating exchange,
- to distant exchanges,
- between the exchange and a network management centre.

Information may be carried over a dedicated telemetry or data facility, over a common channel signalling network, or over other telephony network facilities as appropriate.

For each mode of transmittal the appropriate interface and protocol requirements where covered by CCITT Recommendations should be satisfied.

Information may be sent automatically on a pre-arranged basis, or when triggered by an event such as an overload situation. Alternatively information may be sent in response to an external request from a network management centre.

5.3.5 *Presentation of information*

Indications of network management controls in effect in an exchange shall be presented on visual indicators and/or printing-type or video display unit terminals for purposes of advising on-site personnel.

Similar displays and/or indicators may also be provided in a co-located and/or distant network management centre.

5.4 *Exchange controls for network management*

5.4.1 *General*

Network management controls may be classified as expansive, or protective depending on the action produced when they are applied. Some controls may fall into both categories.

Definitions of these categories of control and their application are given in the E.400 series of Recommendations, and in the "Handbook on Service Quality, Network Maintenance and Management".

5.4.2 *Activation and deactivation of controls*

Network management controls in exchanges may be activated as a result of decisions made by one of the following methods:

- pre-established logic in an exchange responding to pre-set levels (or thresholds) being exceeded. For example overloads of traffic, excessive processing delays, or blocking;
- by manual, semi- or fully-automatic over-rides by external request;
- other methods appropriate to specific exchange configurations or technology.

Controls will usually be activated or deactivated in steps (stages) that are intended to avoid surge effects in the network that could be caused by too much control being added or removed too quickly.

A low-level threshold may be required to remove controls as appropriate, when conditions have stabilized.

5.4.3 *Network management controls*

The following is a list of typical network management controls to be considered for implementation in a given exchange.

5.4.3.1 *Code blocking control (protective)*

This control bars or restricts routing to a specific destination code. Code blocking can be done on a country code, an area code, an exchange identifying code and, in some cases, on an individual line number. The last is the most selective control available.

5.4.3.2 *Cancellation of alternative routing (protective)*

There are several variations of this control. One is to prevent traffic from the selected route overflowing onto the next alternate route. Another is to prevent overflow traffic from all sources from accessing a specific route.

5.4.3.3 *Restriction of direct routing (protective)*

This control limits the amount of direct routed traffic accessing a route.

5.4.3.4 *Skip route (expansive and/or protective)*

This control allows traffic to bypass a specific route and advance instead to the next route in its normal routing pattern.

5.4.3.5 *Temporary alternative routing (expansive)*

This control redirects traffic from congested routes to routes not normally available which have idle capacity at the time. This can be done for subscriber, and/or operator originated traffic.

5.4.3.6 *Circuit directionalization (protective/expansive)*

This control changes both-way operated circuits to one-way operated circuits. At the end of the circuit for which access to the route is inhibited this is a protective action, whereas at the other end of the circuit (where access is still available) it is an expansive action.

5.4.3.7 *Circuit turndown/busying (protective)*

This control removes one-way and/or both-way operated circuits from service.

5.4.3.8 *Operator controls (Traffic operator actions) (protective)*

These controls reduce the number of attempts to a particular destination or provide special handling instructions for emergency calls during serious congestion or failure.

5.4.3.9 *Recorded announcements (protective)*

These are announcements which give special instructions to operators and subscribers, such as to defer their call to a later time, during congestion, failures, or other abnormal events.

5.4.3.10 *Circuit reservation (protective)*

This control reserves the last few idle circuits in a circuit group for a particular type of traffic such as, for example, direct routed traffic or operator originated traffic.

5.4.3.11 *Switching system controls (protective)*

These are internally provided automatic controls that are part of the exchange design. They improve switching performance during overloads by:

– inhibiting second trials;
– inhibiting low-priority tasks;
– reducing the acceptance of new calls based on the availability of major components, or other load reduction actions;
– informing connected exchanges that protective controls should be activated.

5.4.4 *Range and application of controls*

It is desirable that these controls be activated to affect a variable percentage of traffic (for example, 25%, 50%, 75% or 100%). Alternatively the number of call attempts routed in a particular period may be controlled (for example 10 calls per minute). It may also be desirable to apply controls on a destination code basis.

Many of the controls specified above can be activated by manual or automatic means. When automatic activation is provided, however, an ability for manual override must also be provided.

Recommendation Q.517

TRANSMISSION CHARACTERISTICS

1 Introduction

1.1 *General*

This Recommendation applies to digital local exchanges[1] for telephony in Integrated Digital Networks (IDN) and mixed analogue/digital networks. The field of application of this Recommendation is found in Recommendation Q.511.

The signals taken into consideration are passed through the following interfaces as described in § 2 of Recommendation Q.512 and in Figure 1/Q.517.

- Interface A is for primary PCM multiplex signals at 2048 kbit/s or 1544 kbit/s.
- Interface B is for secondary PCM multiplex signals at 8448 kbit/s or 6312 kbit/s.
- Interface C comprises both 4-wire and 2-wire analogue trunk interfaces. Interfaces C1 and C2 represent possible applications of interface C in Figure 1/Q.512.
- Interface V is for digital subscriber line access.
- Interface Z is for analogue subscriber line access.

In accordance with § 2 of Recommendation Q.512, Z interfaces other than Z1 are not subject to CCITT Recommendations.

Interfaces V and Z may appear remote from the exchange through the use of digital transmission facilities. When this occurs, there should be no impact on transmission parameters other than delay. Transmission parameters associated with interface Z include the effects of the equipment provided for interfacing the analogue subscriber line to the digital switching network of the exchange.

It is necessary to ensure that representative feeding currents are flowing during the measurements of all of these transmission parameters. These feeding currents can contribute to noise, distortion, crosstalk, variation of gain with input level, etc. Therefore, appropriate allowances for this must be made. In some cases, where indicated, the permissible limits quoted include these allowances.

In the present Recommendation, values given for transmission characteristics relate to complete paths connecting input and output analogue interfaces. It is envisaged that, as a result of further studies, a later revised Recommendation will give the characteristics in a different form, relating to the path from an exchange test point to an analogue interface and vice versa; the overall characteristics for connections involving two interfaces will be obtainable by suitably combining these values.

In the future, other interfaces may be defined, and at that time, this Recommendation will be extended to include those interfaces.

At this time this Recommendation considers analogue signals which are encoded in accordance with Recommendation G.711. Other coding laws may be defined in the future and this Recommendation will need to take them into account.

[1] For "combined" digital exchanges it will be necessary to consider also Recommendation Q.507 in parallel.

The transmission characteristics for connections involving a 64 kbit/s channel time-slot at the recommended digital interfaces are still under study and therefore are not yet included in this Recommendation.

The principles of Recommendation G.142 and the limits of Recommendation G.712 have been used as a basis for establishing the transmission characteristics for analogue/analogue voice frequency connections specified in §§ 2 and 3 of this Recommendation. The limit values are not necessarily identical with those specified for equipment, since in the case of a connection through the exchange, additional allowances generally have been made for cabling (see § 2). The principles of Recommendation G.714 have been used for the analogue/digital test connections referred to in §§ 2 and 3.

The values given are to be considered as either "design" or "performance objectives" according to the explanations of the terms given in Recommendation G.102 (Transmission performance objectives and recommendations) and the particular context.

1.2 *Definitions*

1.2.1 *Exchange test points and exchange input and output*

1.2.1.1 **exchange test points**

The exchange test points, shown in Figure 1/Q.517, are defined for specification purposes. They may not actually exist in an exchange.

They are located such that end-to-end performance can be determined by suitably combining performances between each interface and the exchange test points.

1.2.1.2 **exchange input and output**

The exchange input and output for a connection through a digital local exchange are located at the interfaces identified in § 1.1 and shown in Figure 1/Q.517.

The exact position of each of these points depends on national practice, and it is not necessary for the CCITT to define it. Only the authority responsible for each digital exchange can fix the position of these points in each case.

1.2.2 *Relative levels*

1.2.2.1 *Exchange test points*

The nominal relative level at the input and output exchange test points is assigned the value 0 dBr.

1.2.2.2 *Analogue interfaces*

The nominal relative level at the exchange input point is designated L_i.

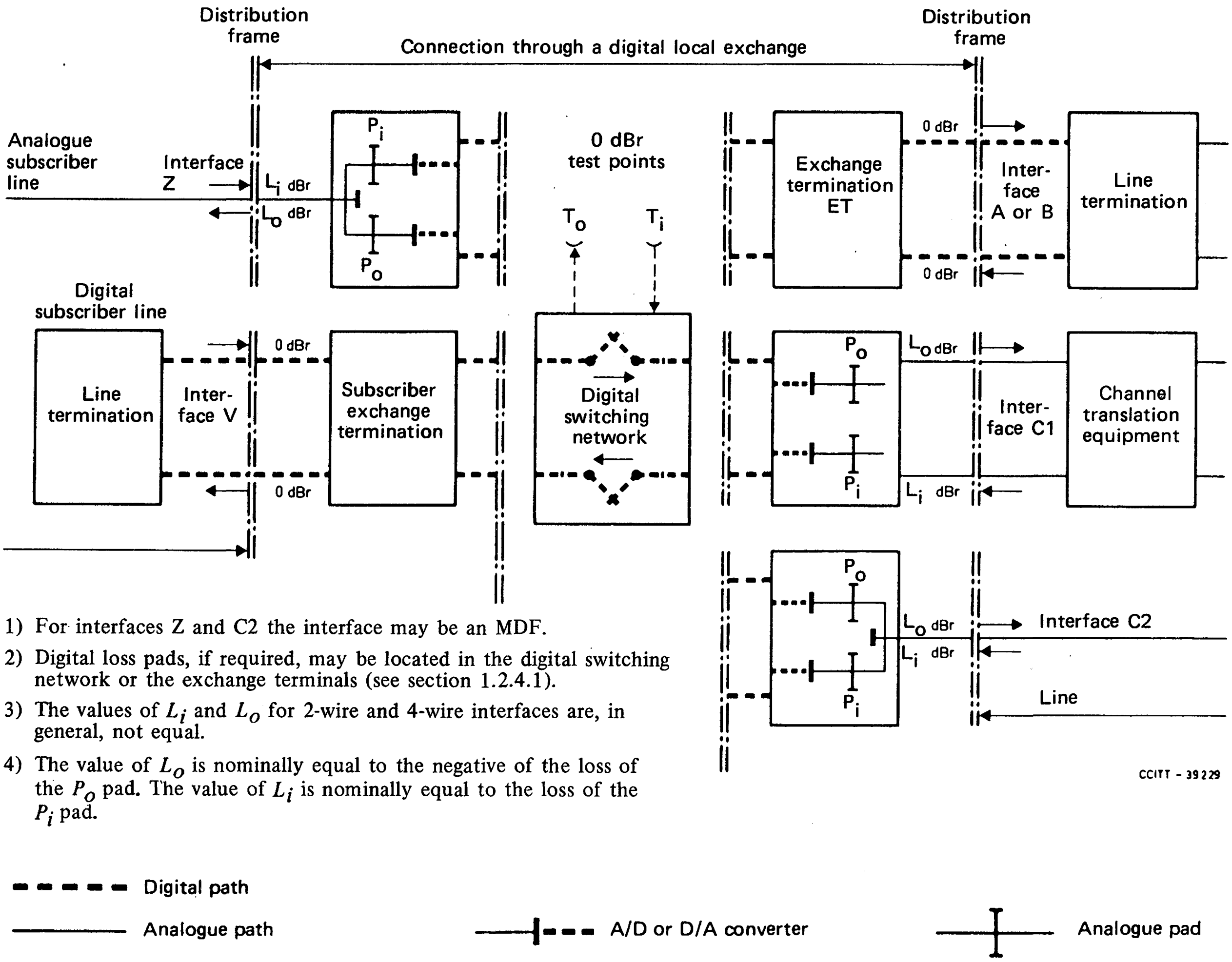
The nominal relative level at the exchange output point is designated L_o.

1.2.2.3 *Digital interfaces*

The relative level to be associated with a point in a digital path carrying a digital bit stream generated by a coder lined-up in accordance with the principles of Recommendation G.101 is determined by the value of the digital loss or gain between the output of the coder and the point considered. If there is no such loss or gain the relative levels at the exchange input and output points (i.e. digital interfaces V, A and B) are by convention said to be 0 dBr. For further information, see Recommendation G.101, § 5.3.2.

Note – The digital level may be established using measuring equipment in accordance with Recommendation O.133.

Relative level has no meaning for digital bit streams that are not derived from real or simulated analogue sources.



1) For interfaces Z and C2 the interface may be an MDF.

2) Digital loss pads, if required, may be located in the digital switching network or the exchange terminals (see section 1.2.4.1).

3) The values of L_i and L_o for 2-wire and 4-wire interfaces are, in general, not equal.

4) The value of L_o is nominally equal to the negative of the loss of the P_o pad. The value of L_i is nominally equal to the loss of the P_i pad.

FIGURE 1/Q.517

Transmission levels and test points at a digital local exchange

1.2.3 *Measurement conditions*

1.2.3.1 *Reference frequency*

The nominal reference frequency, on which values of relative level, transmission loss, attenuation/frequency distortion, etc. are based, is 1000 Hz. For measurements performed with analogue sine-wave oscillators, a frequency of 1004 to 1020 Hz should be used.

To avoid level errors produced as a result of the use of test frequencies which are sub-multiples of the PCM sampling rate, the choice of test frequencies should accord with Supplement No. 35 of Fascicle IV.4 of the CCITT *Yellow Book.* In addition, it is considered that the use of other integer sub-multiples of the sampling rate should be avoided. In particular, where a nominal frequency of 1000 Hz is indicated, the actual frequency should be chosen in the range 1004-1020 Hz as appropriate. Within this range, frequencies above 1010 Hz may permit faster measurement by avoiding fluctuations due to the "stroboscopic effect".

1.2.3.2 *Impedance*

Unless otherwise specified, measurements at analogue interfaces shall be made under nominally matched conditions, i.e. the interface is terminated with the nominal exchange impedance.

1.2.3.3 *Test levels at analogue interfaces*

At the reference frequency, test levels are defined in terms of the apparent power relative to 1 mW. At frequencies different from the reference frequency, test levels are defined as having the same voltage as the test level at the reference frequency. Measurements are based on the use of a test generator with a frequency-independent e.m.f. and which has an impedance equal to the nominal impedance.

1.2.4 *Transmission loss*

1.2.4.1 **nominal transmission loss**

A connection through the exchange (see Figure 1/Q.517) is established by connecting in both directions an input located at one interface to an output located at another interface.

The nominal transmission loss for a connection through an exchange is equal to the difference of the relative levels at the input and the output:

$$NL = (L_i - L_o) \text{ dB}$$

The nominal transmission loss between the input at an analogue interface and the exchange test point is defined as:

$$NL_i = L_i$$

The nominal transmission loss between the exchange test point and the output of an analogue interface is defined as:

$$NL_o = -L_o$$

This is equal to the nominal "composite loss" (see definition in *Yellow Book*, Fascicle X.1) at the reference frequency. See also Supplement No. 9 in Fascicle VI.1 of the CCITT *Red Book*.

Note 1 – The nominal transmission loss, *NL*, may be implemented by an analogue loss pad. It may also be implemented by a digital loss pad. In the latter case, the digital loss pad may be on the incoming side of the digital switching network, or on the outgoing side of the digital switching network or both.

As a general principle the use of digital loss pads should be avoided because bit integrity is lost for digital services and additional transmission impairments are introduced for analogue services.

However, it is recognized that during the transition stage to a completely digital network, existing national transmission plans may require digital pads to be inserted for speech.

In addition, connections in a future ISDN used for voice can be expected to contain other devices which destroy bit integrity of the 64 kbit/s path (e.g. code converters, digital echo control devices, digital speech interpolation apparatus, or all-zero-suppressors) provision must be made to render all such devices inoperative when necessary (see Recommendation Q.513, § 3.7).

Note 2 – The nominal transmission loss of the exchange may be different in the two directions.

1.2.5 **attenuation/frequency distortion**

The attenuation/frequency distortion (loss distortion) is the logarithmic ratio of output voltage at the reference frequency (nominally 1000 Hz), U(1000 Hz), divided by its value at frequency f, $U(f)$:

$$LD = 20 \log \left| \frac{U(1000 \text{ Hz})}{U(f)} \right|$$

See Supplement No. 9 in Fascicle VI.1 of the CCITT *Red Book*.

2 Characteristics of interfaces

The interfaces taken into account are those of Figure 1/Q.512. For voice-frequency interfaces (C and Z), the electrical parameters refer to the appropriate distribution frame (DF), on the assumption that the length of the cabling between the DF and the actual exchange does not exceed 100 m (exchange cables).

2.1 *Interface Z*

The interface Z provides for the connection of analogue subscriber lines and will carry signals such as speech, voice-band analogue data and multi-frequency push button signals, etc. In addition the interface Z must provide for DC feeding the subscriber set and ordinary functions such as DC signalling, ringing, metering, etc., where appropriate. Since the interface Z terminates the subscriber line, it is necessary to control the impedance and unbalance about earth.

2.1.1 *Impedance of 2-wire voice frequency ports*

2.1.1.1 *Nominal value*

The principal criteria governing the choice of the nominal value of the exchange impedance are:

- to terminate the analogue subscriber line of a digital PBX to ensure that the PBX will have an adequate stability margin;
- to ensure an adequate sidetone performance for telephone sets particularly for those on short lines.

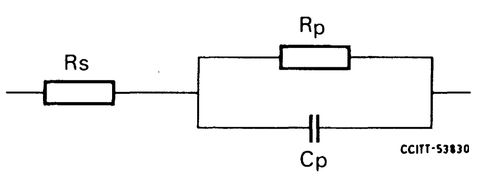
If these criteria are met then the impedance will also be suitable for subscriber lines fitted with voice-band modems.

As a general rule a complex impedance with a capacitive reactance is necessary to achieve satisfactory values of stability, echo and side tone. For additional information, see Supplement No. 10, Fascicle VI.1 of the CCITT *Red Book*.

In order to minimize the diversity of types of exchange impedances, a preferred configuration is given below, but at present no unique values can be recommended. However, to provide guidance for other Administrations, examples of nominal values chosen by some Administrations are given in Table 1/Q.517.

TABLE 1/Q.517

Test networks for exchange impedances being considered



	Rs (ohms)	*Rp (ohms)*	*Cp (farads)*
NTT	600	infinity	1 μ
Austria, FRG	220	820	115 *n*
AT&T	900	infinity	2.16 μ
BT	300	1000	220 *n*

Note 1 – The test network and the component values represent a configuration that exhibits the required impedance. It need not necessarily correspond to any actual network provided in the exchange termination.

Note 2 – The range of component values reflects the fact that there are substantial differences in the sensitivity and sidetone performance of the various telephone instruments throughout the world. In general the combination of short lines and sensitive telephone sets might be rather common in the future due to increased use of remote concentration. In order to control sidetone performance, Administrations need to take into account telephone set parameters. Not only the parameters of existing telephone sets should be considered but also what parameters are desirable for the future to allow improvement in sidetone performance to be achieved.

Note 3 – It may be necessary to group the subscriber lines of a particular exchange into classes, each requiring a different input impedance of the Z interface. This point requires further study.

2.1.1.2 *Return loss*

For actual values of exchange impedances, tolerances need to be specified. For this purpose the return loss of the impedance presented by a 2-wire port against the nominal impedance should comply with certain limits which depend on the particular conditions of the subscriber network considered.

In consequence of the varying national conditions, it is only possible to recommend a minimum requirement. The values given in Figure 2/Q.517 should be met.

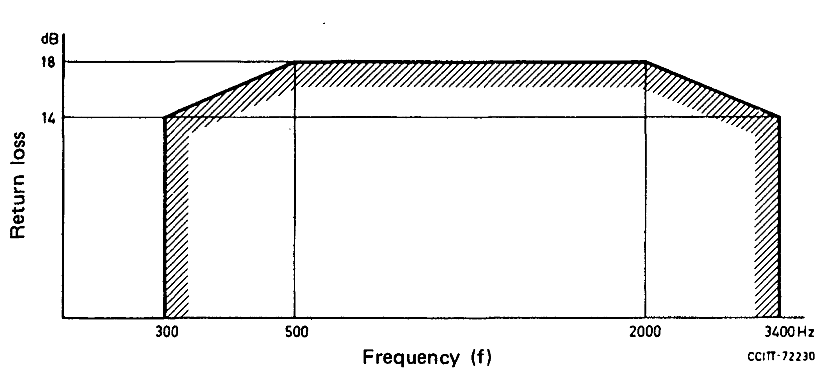


FIGURE 2/Q.517

Minimum values of return loss against nominal impedance

Some Administrations need to specify higher values. Examples of limit values for the return loss, currently adopted by some Administrations, are given in Table 2/Q.517 for guidance. For further information, see also Supplement No. 9 in Fascicle VI.1 of the CCITT *Red Book*.

TABLE 2/Q.517

Return loss examples

FRG	14 dB at 300 Hz, rising (log *f* scale) to 18 dB at 500 Hz remaining at 18 dB to 2000 Hz and then falling (log *f* scale) to 14 dB at 3400 Hz.
NTT	22 dB: 300-3400 Hz.
BT	18 dB: 200-800 Hz; 20 dB: 800-2000 Hz; 24 dB: 2000-4000 Hz.
AT&T	20 dB: 200-500 Hz; 26 dB: 500-3400 Hz.
Austria	14.5 dB at 300 Hz, rising (log *f* scale) to 18 dB at 500 Hz remaining at 18 dB to 2500 Hz and then falling (log *f* scale) to 14.5 dB at 3400 Hz.

Note – The 12 dB spread in values stems from the differences in telephone set sensitivities. For example, adopting the strategy of a low feeding current for some classes of exchange line will cause a regulated set to adopt its most sensitive value. Thus, in particular, on a short line, the exchange impedance must provide all the sidetone reduction that is ordinarily provided by a long line.

Test method for exchange impedance

The test method may be based on conventional return loss measuring set techniques. Measurements should be carried out with the four-wire loop broken.

2.1.1.3 *Impedance unbalance about earth*

The value for the longitudinal conversion loss (LCL) (defined in Recommendation G.117, § 4.1.3) should exceed the minimum values of Figure 3/Q.517 which is in accordance with Recommendation K.10 with the equipment under test in normal speech condition.

Test method

LCL should be measured in accordance with the principles given in Recommendation O.121, §§ 2.1 and 3. Figure 4/Q.517 shows an example for the basic measuring arrangement for digital local exchanges (interface Z).

Measurements of the longitudinal and transversal voltages should preferably be performed by means of a selective level meter.

2.1.1.4 *Longitudinal interference threshold level*

With Z interfaces of electronic design, transmission performance can be degraded by non-linear operation when such interfaces are connected to subscriber lines exposed to longitudinal potentials of sufficiently high magnitude. (Such magnitudes could be below that necessary to cause permanent damage or to operate protective devices at the Z interface.) The longitudinal potentials would typically arise from mains-frequency or electric traction sources, but could also include radio-frequency interference. These aspects require further study.

As defined in Recommendation G.117, Section 4.4 the threshold level for longitudinal interference causing misoperation should not be less than X volts.

Note 1 – The value of X for sinusoidal interference over frequency ranges to be specified, and details of the appropriate measuring arrangements are under study. As a matter of importance, priority could be given to the frequency range from 16 2/3 Hz to 300 Hz.

Note 2 – Consideration should also be given to those remote subscriber metering systems using longitudinal voltages in this frequency range during voice frequency transmission.

Note 3 – Misoperation is defined as failure to satisfy the performance requirements of Recommendation Q.517.

2.1.2 *Values of relative levels*

2.1.2.1 *Basic nominal values*

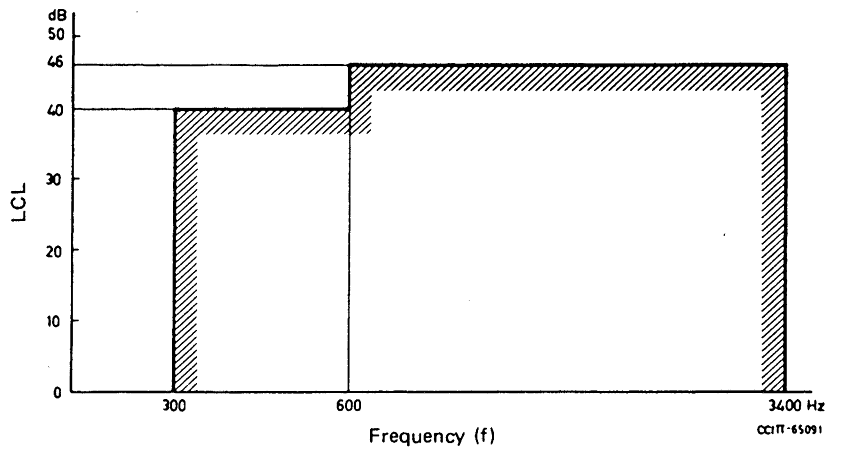
2.1.2.1.1 The input relative level should be chosen in the range:

$$L_i = -0.5 \text{ to } +1 \text{ dBr}$$

Note 1 – Recommendation G.101, item 5.3.2 indicates that if the nominal corrected send reference equivalent "referred to a point of 0 dBr of a PCM encoder is not less than 3.5 dB then the peak power of the speech will be suitably controlled". It follows that, for instance, the value $L_i = -0.5$ dBr (lower limit of range for L_i) is suited to a corrected send reference equivalent of the local system (= subscriber set plus subscriber line) of $\geqslant$ 4 dB.

Note 2 – The values given above are in conformity with current national practices and with the existing text of Recommendation G.101. However, the latter is itself partly based on a very old investigation (which Study Group XII has been asked to review) of the relationship between reference equivalents and speech levels. This may, in the near future, lead to amending the basis of objectives, so that it may be useful to allow wider design margins.

2.1.2.1.2 The configuration of national extensions is not the same in all Administrations, and therefore, the value (or values) of output relative level will not necessarily be the same.

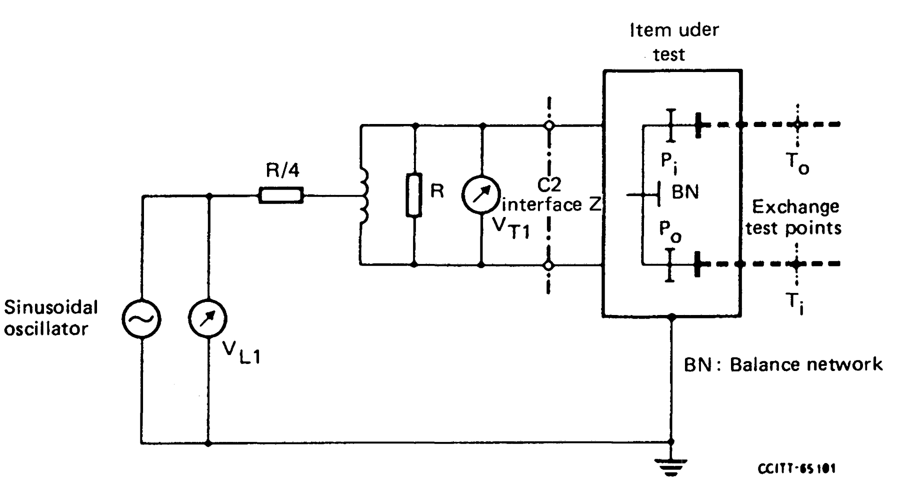


Note 1 – Some Administrations may adopt other values and in some cases wider bandwidths depending upon the actual conditions in their telephone network.

Note 2 – A limit may also be required for the transverse conversion loss (TCL) (as defined in Recommendation G.117, § 4.1.2) if the exchange termination is not reciprocal with respect to the transverse and longitudinal paths. A suitable limit would be 40 dB to ensure an adequate near-end crosstalk attenuation between interfaces.

FIGURE 3/Q.517

Minimum values of LCL measured in the arrangement shown in Figure 4/Q.517



R should be in the range of 600-900 Ω.

$$\text{Longitudinal convertion loss (LCL)} = 20 \log_{10} \left| \frac{V_{L1}}{V_{T1}} \right| \text{ dB}$$

Note 1 – Special care must be taken in those applications using active hybrids.

Note 2 – The exchange test point, T_i, must be driven by a PCM signal corresponding to the decoder output value number 0 for the μ-law or decoder output value number 1 for the A-law.

FIGURE 4/Q.517

Arrangement for measuring LCL

In order to limit the range of values which may need to be provided by digital local exchange designers, it is recommended that Administrations select the value (or values) or output relative level within the range:

$$L_o = -8.5 \text{ to } 0 \text{ dBr}$$

This range is intended to cover all classes of calls.

The output relative level has to be such that taking into account the particular value of relative level at the input of the connection through the exchange, the requirements of Recommendation G.121, § 6 (Incorporation of PCM digital processes in national extensions) are fully satisfied. (This text is referred to in Recommendtion G.111 in respect of international connections.)

2.1.2.2 *Consideration of short or long subscriber lines*

In order to compensate for the loss of short or long subscriber lines, an Administration may choose values of the relative levels derived from the basic values as follows:

$$L'_i = L_i + x \text{ dB}$$

$$L'_o = L_o - x \text{ dB}$$

The value of x is within national competence (e.g. $x = 3$ dB for short subscriber lines).

By choosing values of L'_i and L'_o as indicated, the loss difference is unchanged with respect to the conditions given in § 2.1.2.1.

The use of values $x < 0$ requires careful selection of balance networks; values of $x < -3$ dB are not recommended.

2.1.2.3 *Tolerances of relative levels*

The difference between the actual relative level and the nominal relative level should lie within the following limits. (These terms are defined in Recommendation G.101, § 5.3.2.)

a) input relative level: -0.3 to $+0.7$ dB,

b) output relative level: -0.7 to $+0.3$ dB.

These differences may arise from design tolerances, adjustment increments, or time variation.

Note – It is assumed that for the equipment ports the adjustment is made in accordance with Recommendation G.712, § 16. The asymmetry of the tolerance at the DF takes the existence of cabling between the DF and the exchange equipment into account.

2.1.2.4 *Difference in transmission loss*

Recommendation G.121, § 6.3 deals with the "difference in transmission loss between the two directions of transmission". For the national extension this is the value "loss (t-b) – loss (a-t)", (see the text in the cited Recommendation for guidance). This difference is limited to $\pm$ 4 dB. In terms of the pad values P_i and P_o, this corresponds to a difference $P_o - P_i = 3$ to 11 dB. However, to make allowance for additional asymmetry of loss in the rest of the national network, only part of this difference can be used by the local exchange.

2.1.3 *Echo and stability*

The Terminal Balance Return Loss (*TBRL*) as defined in § 2.1.3.1 is introduced in order to characterize the exchange performance required to comply with the network performance objective of Recommendation G.122 with respect to echo. The *TBRL* applies to switching equipment in normal speaking condition only as used in a connection through a digital exchange.

The parameter "Stability Loss" as defined in Recommendation G.122 applies to the worst terminating conditions encountered at interface Z in normal operation.

2.1.3.1 *Terminal Balance Return Loss (TBRL)*

The term Terminal Balance Return Loss (*TBRL*) is used as an aid to characterize the impedance balancing property of the 2-wire port.

The expression for *TBRL* is:

$$TBRL = 20 \log \left| \frac{Z_o + Z_b}{2\,Z_o} \cdot \frac{Z_t + Z_o}{Z_t - Z_b} \right|$$

where

Z_o = input impedance of the 2-wire port;

Z_b = impedance of the balance network of the 2-wire port;

Z_t = impedance of the echo test network.

The echo test network should be representative of the impedance conditions to be expected from a population of subscriber lines with the telephone sets off-hook, as determined by the national transmission plan.

The *TBRL* is related to the (T_i to T_o) loss as follows:

$$TBRL = (T_i \text{ to } T_o) \text{ loss} - (P_i + P_o)$$

TBRL can thus be determined by measurement of (T_i to T_o) loss = a, provided the sum ($P_i + P_o$) is known. This can be derived in several ways:

a) P_i and P_o are assigned their nominal values.

b) P_i and P_o are measured (under matched load conditions).

c) The loss a is measured with the Z interface open- and short-circuited, a_{oo} resp. a_o. Then:

$$(P_i + P_o) \approx (a_{oo} + a_o)/2$$

For a more accurate measurement of the frequency response of the *TBRL*, methods b) or c) can be used.

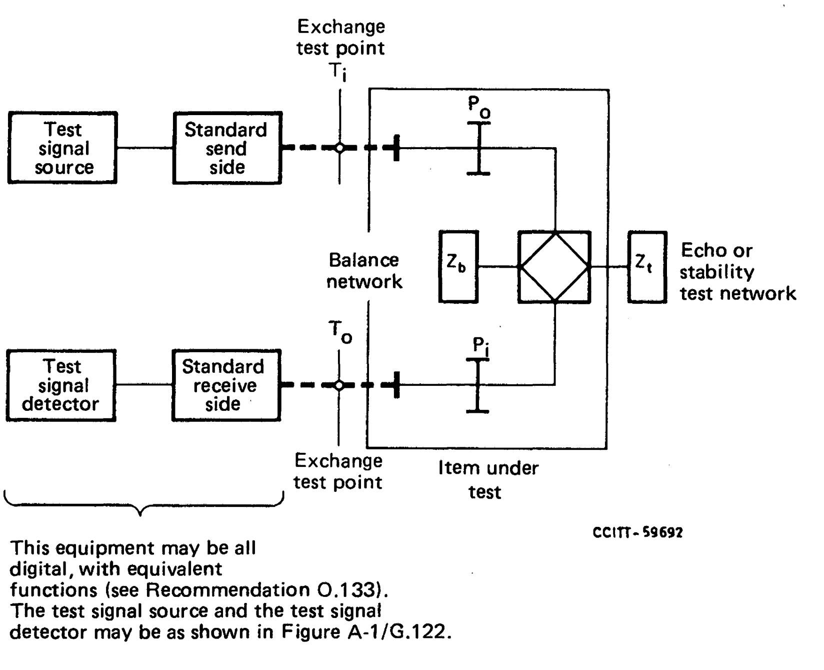


FIGURE 5/Q.517

Arrangement for measuring (T_i to T_o) loss

Some Administrations consider that equivalent results can be obtained using either a weighted spectrum signal or a sinusoidal signal, as indicated in Figure 5/Q.517. For the weighted spectrum signal, the *TBRL* should provisionally be greater than 22 dB. For sinusoidal signals the *TBRL* should be at least greater than the limits shown in Figure 6/Q.517. Some administrations may wish to adopt more stringent limits than those shown in Figure 6/Q.517.

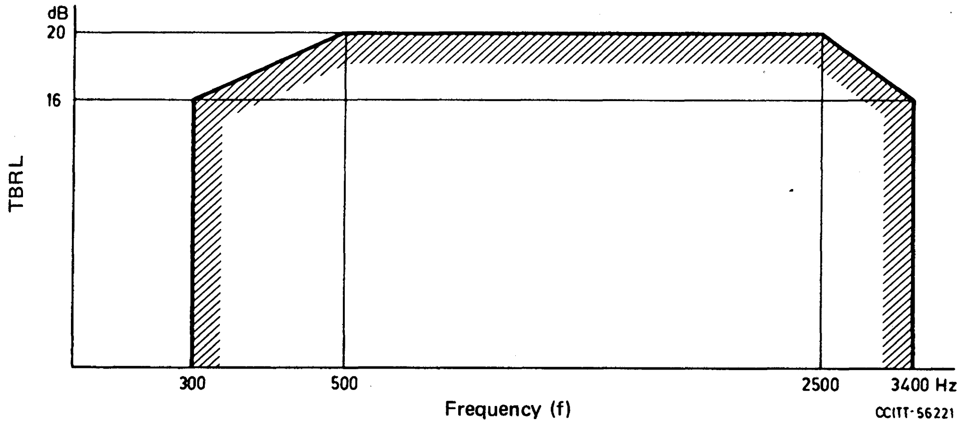


FIGURE 6/Q.517

Limits for *TBRL*

Figure 7/Q.517 gives examples of echo test networks currently being considered by some administrations. These examples may provide guidance for other administrations in order to minimize the diversity of types of echo test networks.

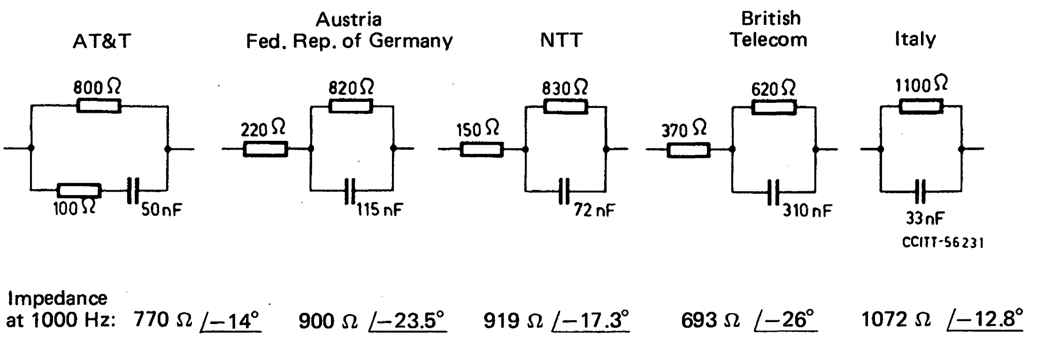


FIGURE 7/Q.517

Examples of echo test networks planned to be used by some Administrations (applicable to unloaded subscriber lines)

Note – Some Administrations may need to adopt several echo test networks to cover the range of various subscriber line length and types of subscriber lines.

2.1.3.2 *Stability Loss*

The Stability Loss should be measured between T_i and T_o (Figure 5/Q.517) by terminating the Z interface with stability test networks representing the "worst terminating condition encountered in normal operation". Some administrations may find that open circuit and short circuit terminations are sufficiently representative of worst case conditions. Other administrations may need to specify, for example, an inductive termination to represent that worst case condition.

With worst case terminating conditions on the Z interface.

Stability Loss = T_i to T_o loss $\geqslant x$, where x is under study for sinusoidal signals at all frequencies between 200 Hz and 3600 Hz. The need for requirements outside this frequency band is also under study.

In the case where the digital local exchange is connected to the international chain using only 4-wire digital switching and transmission, the local exchange provides the total stability loss of the national extension[2]. The attenuation measured between T_i and T_o should be not less than 6 dB at all frequencies between 200 Hz and 3600 Hz. This permits the national extension to meet the stability requirement of Recommendations G.121 and G.122.

Note – It is suggested that a digital PBX as well as a digital remote unit connected to the digital local exchange by a digital transmission system should also meet the echo and stability requirement of § 2.1.3.

3 Voice-frequency (VF) parameters of a connection between two Z interfaces of the same exchange

3.1 *General*

This section of Q.517 refers to measurements at 2-wire points at a DF, i.e. including the exchange cabling (cf. § 2). This necessitates appropriate considerations for each parameter.

In measuring transmission parameters with 2-wire ports involved, it is necessary to interrupt the opposite direction of transmission in order to avoid disturbing effects due to reflections at hybrids.

Separate transmission performance requirements for paths between an analogue input and an exchange test point as well as between an exchange test point and an analogue output are under study.

3.2 *Transmission loss through the exchange*

3.2.1 *Nominal value of transmission loss*

The nominal transmission loss corresponds to the difference of the nominal relative levels at the interfaces used for the connection through the exchange (cf. § 2.1.2). In accordance with the definition of relative levels (cf. § 1.2.2.2) the value of nominal loss is valid at 1000 Hz (1004 to 1020 Hz).

3.2.2 *Difference in transmission loss between the two directions*

The difference in actual transmission loss at the reference frequency between the two directions of transmission should not exceed 1 dB. The value of 1 dB is provisional.

3.2.3 *Short-term variation of loss with time*

When a sine-wave signal at a level of −10 dBm0 at the reference frequency is applied to any Z interface input, the level measured at the corresponding Z interface output should not vary from the value at the beginning of the interval by more than ± 0.2 dB during any 10-minute interval of typical operation.

Note – The specification for the short-term stability is of a provisional nature.

3.2.4 *Attenuation/frequency distortion*

The attenuation/frequency distortion of any connection between two subscriber lines should lie within the limits of Figure 8/Q.517. The input power level is −10 dBm0. The results are referred to the output at the reference frequency defined in § 3.2.1.

The attenuation/frequency distortion can be measured in two ways with regard to the terminating impedances. Using the nominal exchange impedances as defined in § 2.1.1.1, the measurement closely represents the attenuation/frequency distortion the exchange will introduce in a real connection. An alternative method is to measure with a low-impedance generator and a high-impedance level meter.

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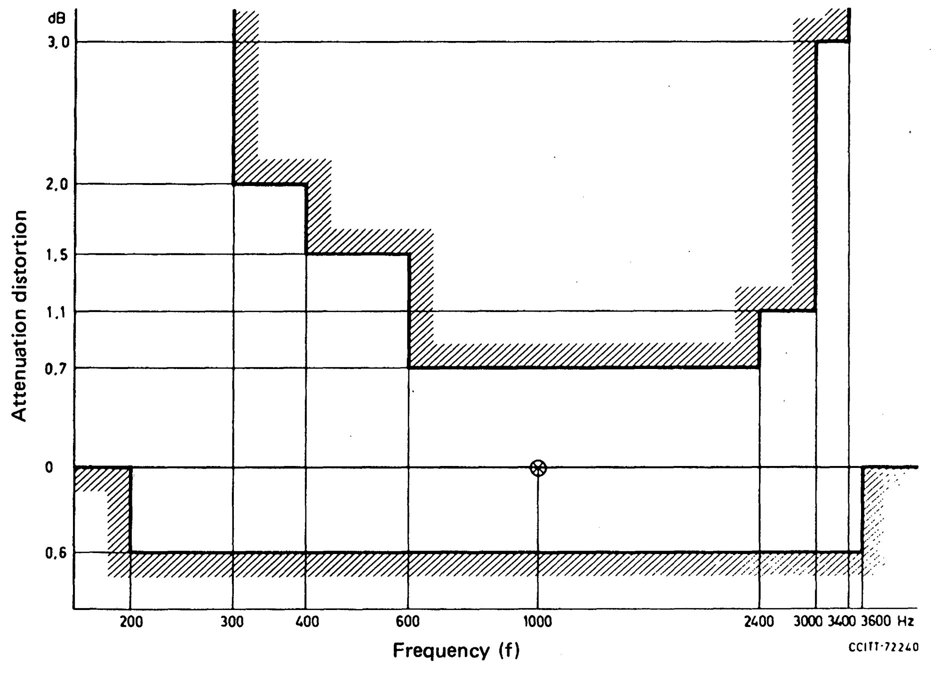
[2] This may include the precautions of Recommendation Q.32 if necessary.

In general, the results from the two methods will differ slightly unless the return losses of the exchange input and output impedances against the nominal are extremely high (40 dB for 0.1 dB accuracy). However, in many cases, the difference in measured distortion resembles the distortion of a very short subscriber cable and therefore is of no practical importance. Hence, either method may be used.



Note 1 – The reference frequency of 1000 Hz is chosen because this frequency is used for adjustment in accordance with Recommendations G.711, § 4, and G.712, § 15.

Note 2 – The mask takes into account the existence of a feeding bridge and a hybrid in each subscriber terminating set.

FIGURE 8/Q.517

Attenuation/frequency distortion limits

3.2.5 *Variation of gain with input level*

Two alternative methods are recommended.

a) *Method 1*

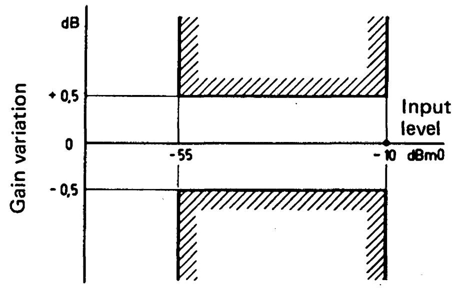
With a band limited noise signal, as defined in Recommendation O.131, applied to the input of any channel at a level between -55 dBm0 and -10 dBm0, the gain variation of that channel, relative to the gain at an input level of -10 dBm0, should lie within the limits of the mask of Figure 9a/Q.517. The measurement should be limited to the frequency band 350-550 Hz in accordance with the filter characteristic defined in Recommendation O.131, § 3.2.1.

Furthermore, with a sine-wave signal in the frequency range 700-1100 Hz applied to the input of any channel at a level between -10 dBm0 and $+3$ dBm0, the gain variation of that channel relative to the gain at an input level of -10 dBm0, should lie within the limits of the mask of Figure 9b/Q.517. The measurement should be made selectively.

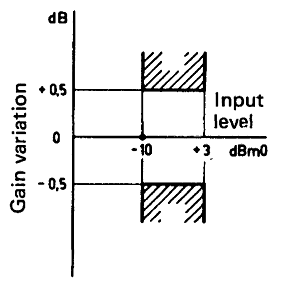
Note – The impact of attenuation-frequency distortion on the measurement accuracy is under study.

b) *Method 2*

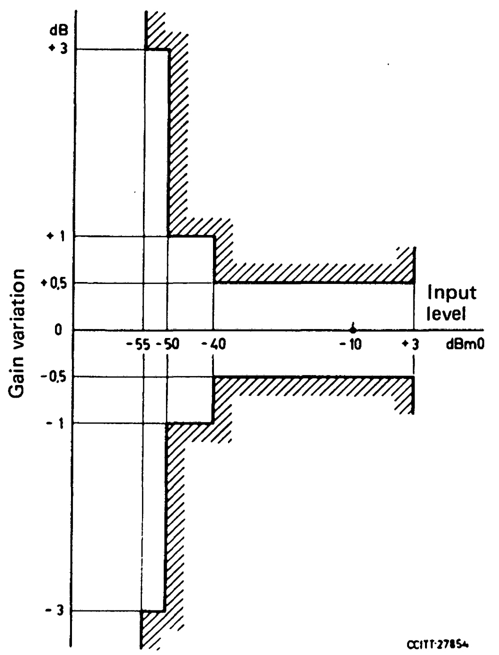
With a sine-wave signal in the frequency range 700-1100 Hz (excluding submultiples of 8 kHz) applied to the input port of any channel at a level between −55 dBm0 and +3 dBm0, the gain variation of that channel relative to the gain at an input level of −10 dBm0, should lie within the limits of the mask of Figure 9c/Q.517. The measurement should be made selectively.



a) Method 1: White noise test signal



b) Method 1: Sinusoidal test signal



c) Method 2: Sinusoidal test signal

FIGURE 9/Q.517

Variation of gain with input level

3.3 *Group delay through the exchange*

"Group delay" is defined in the *Yellow Book*, Fascicle X.1.

3.3.1 *Absolute group delay*

"Absolute group delay" is the group delay at that frequency where it has its smallest value in the frequency range from 500 Hz to 2800 Hz.

The sum of the separately measured absolute group delays for passing in each direction through an exchange should meet the requirements given in Table 3/Q.517, where the term "mean value" is understood as the expected value in the statistical sense.

The absolute group delay includes delay due to electronic devices such as frame aligners and time stages of the switching matrix but does not include delays due to ancillary functions, such as echo suppression or echo cancellation.

TABLE 3/Q.517

Absolute group delays through an exchange

Interconnection Z to Z	Mean value	0.95 probability of not exceeding
Analogue subscriber A to analogue subscriber B plus analogue subscriber B to analogue subscriber A	< 3000 μs	3850 μs

Note 1 – These values for the absolute group delays are applicable under reference load A conditions as defined in Recommendation Q.514, § 2.1.

Note 2 – These values do not include the propagation delay associated with transmission across the link between the main part and any remotely located parts of a digital local exchange.

3.3.2 *Group delay distortion with frequency*

Taking the absolute group delay (cf. § 3.3.1) as reference, the group delay distortion for a single direction of transmission should lie within the limits shown in the template of Figure 10/Q.517. Group delay distortion with frequency is measured in accordance with Recommendation O.81.

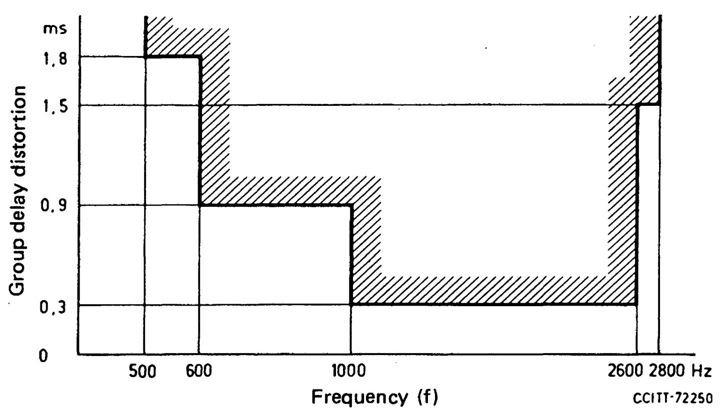


FIGURE 10/Q.517

Group delay distortion limits with frequency

3.3.3 *Input level*

The requirements of §§ 3.3.1 and 3.3.2 should be met at an input level of -10 dBm0.

3.4 *Noise and crosstalk*

3.4.1 *Idle channel noise*

3.4.1.1 *General*

For the specification of noise, the fact must be taken into account that the exchange equipment can provide only a finite rejection of the noise superimposed on the main power supply voltage (e.g. -48 or -60 V) which is used for feeding the subscriber sets. The specification of the power supply noise and of the rejection ratio is under study.

Information about the subject of the noise on the DC power supply is given in Supplement No. 13 to the G-Series Recommendations (*Orange Book*, Volume III-3).

3.4.1.2 *Weighted noise*

It is necessary to consider two components of noise. One of these, e.g. noise arising from the encoding process, is dependent upon output relative level. The other, e.g. power supply noise, is independent of output relative level. The first component is limited by Recommendation G.712, § 4.1 to -65 dBm0p; the other component is assumed by Recommendation G.123, Annex A to be 200 pWp.

The total psophometric power allowed at an exchange 2-wire Z interface with a relative output level of L_o dB may be approximated by the formula:

$$P_{TN} = P_{AN} + 10 \left(\frac{90 + L_{IN} + L_o}{10}\right) \text{pWp}$$

respectively the total noise level

$$L_{TN} = 10 \log \left(\frac{P_{TN}}{1 \text{ pW}}\right) - 90 \text{ dBmp}$$

where:

P_{TN}: total weighted noise power for the local digital exchange;

P_{AN}: weighted noise power caused by analogue functions according to Recommendation G.123, Annex A for local exchanges, i.e. 200 pWp;

L_{IN}: idle channel noise (weighted) for PCM translating equipment according to Recommendation G.712, i.e. -65 dBm0p;

L_o: output relative level of a local digital exchange;

L_{TN}: total weighted noise level for the local digital exchange.

For example, with $L_o = -7$ dBr, the total weighted noise power $P_{TN} = 263$ pWp corresponding to $L_{TN} = -66$ dBmp.

It should be noted that the above noise values for digital local exchanges are based on an output relative level of -7 dBr. In cases where essentially higher output relative levels are used, e.g. for intra-office calls, the noise contribution of the PCM process will increase proportionally.

3.4.1.3 *Unweighted noise*

This noise will be more dependent on the noise on the power supply and on the rejection ratio.

Note – The need for and value of this parameter are both under study. Recommendations Q.45, § 5.1 and G.123, § 3 must also be considered.

3.4.1.4 *Single frequency noise*

The level of any single frequency (in particular the sampling frequency and its multiples) measured selectively, should not exceed −50 dBm0.

Note – The frequency range for this parameter is under study.

3.4.1.5 *Impulsive noise*

It will be necessary to place limits on impulsive noise arising from sources within the exchange; these limits are under study. Pending the results of this study, Recommendation Q.45, § 5.2 may give some guidance on the subject of controlling impulsive noises with low frequency content.

Note 1 – The sources of impulsive noise are often associated with signalling functions (or in some cases the power supply) and may produce either transverse or longitudinal voltage at Z interfaces.

Note 2 – The disturbances to be considered are those to speech or modem data at audio frequencies, and also those causing bit errors on parallel digital subscriber lines carried in the same cable. This latter case, involving impulsive noise with high frequency content, is not presently covered by the measurement procedure of Recommendation Q.45.

3.4.2 *Crosstalk*

In a local digital exchange the signal to crosstalk ratio measured between any two connections through the exchange should be at least 67 dB at 1100 Hz. This measurement should be made with an input signal level of 0 dBm0.

This limit of 67 dB should apply to the most unfavourable case which results because of the spatial or temporal relationship between those two connections.

For measurement an auxiliary signal (i.e. a low level activating signal) should be injected into the disturbed connection: for example a pseudo-random noise signal as specified in Recommendation O.131 at a level of −60 to −50 dBm0 is suitable. It is necessary to use a frequency selective detector when performing this measurement.

Note – Further study is required concerning the effects of the activating signal. Further study is also required to determine if more stringent limits or measurements at additional frequencies should be specified.

When a white noise signal shaped in accordance with Recommendation G.227 at a level of 0 dBm0 is applied to up to four input ports, the level of the crosstalk received at the output port of any other connection should not exceed −60 dBm0p. Uncorrelated noise should be used when more than one input port is energized.

3.5 *Distortion*

3.5.1 *Total distortion, including quantizing distortion*

Two alternative methods are recommended.

a) *Method 1*

With a noise signal corresponding to Recommendation O.131 applied to the input port of a connection, the ratio of signal-to-total distortion power measured at the output port should lie above the limits shown in Figure 11/Q.517.

Note – The limits and the method of taking into account the effects of attenuation/frequency distortion and noise weighting are under study.

Under study

FIGURE 11/Q.517

Limits for signal-to-total distortion ratio as a function of input level (Method 1)

b) *Method 2*

With a sine-wave signal at a nominal frequency of 820 Hz or preferably 1020 Hz (see Recommendation O.132) applied to the input port of a connection, the ratio of signal-to-total distortion power measured with the proper noise weighting (see Table 4 of Recommendation G.223), should exceed the value given by the formula:

$$\frac{S}{N_T} = L_S + L_o - 10 \cdot \log_{10} \left[10^{\left(\frac{L_S + L_o - S/N}{10}\right)} + 10^{\left(\frac{L_N}{10}\right)} \right]$$

where

$\frac{S}{N_T}$: modified signal-to-total distortion ratio for digital local exchanges;

L_S : signal level of the measuring signal in dBm0;

L_o : output relative level of the local exchange in dBr;

$\frac{S}{N}$: signal-to-total distortion ratio for PCM-channel translating equipment in Recommendation G.712;

L_N : -67 dBmp = weighted noise caused by analogue functions according to Recommendation G.123, Annex A.

These limits include appropriate allowance for the noise contributed by feeding currents.

As an example, the limits of Figure 12/Q.517 apply for an output relative level of $L_o = -7.0$ dBr.

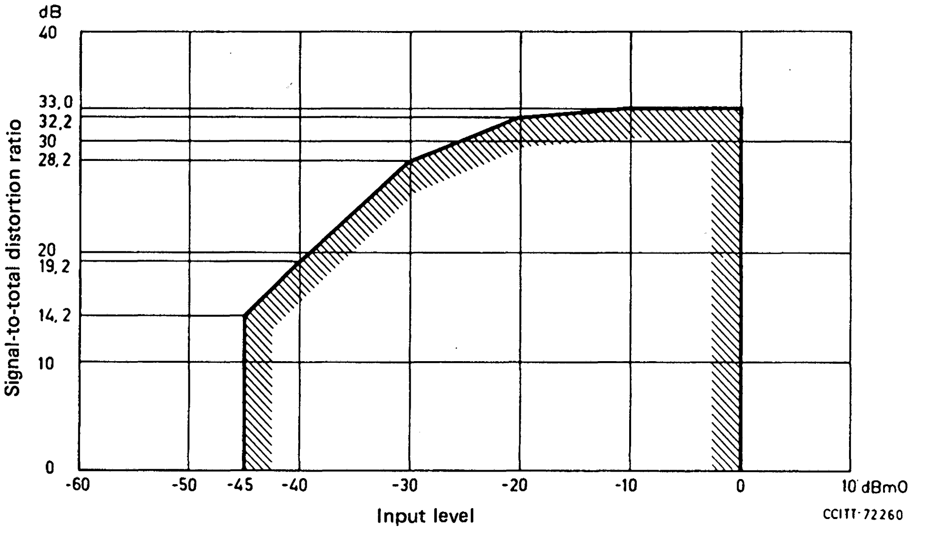


FIGURE 12/Q.517

Limits for signal-to-total distortion ratio as a function of input level for $L_O = -7.0$ dBr (Method 2)

3.5.2 *Intermodulation*

1) Two sine-wave signals of different frequencies f_1 and f_2 not harmonically related, in the range 300-3400 Hz and of equal levels in the range −4 to −21 dBm0, applied simultaneously to the input port of a channel should not produce any $2f_1 - f_2$ intermodulation product having a level greater than −35 dB relative to the level of one of the two input signals.

2) A signal having a level of −9 dBm0 at any frequency in the range 300-3400 Hz and a signal of 50 Hz at a level of −23 dBm0 applied simultaneously to the input port should not produce any intermodulation product of a level exceeding −49 dBm0.

Note – These requirements, are in practice, always met if the requirements according to §§ 3.5.1 and 3.2.5 are met.

3.5.3 *Spurious in-band signals at the output ports*

With a sine-wave signal in the frequency range 700-1100 Hz (excluding submultiples of 8 kHz) and at a level of 0 dBm0 applied to the input port of a connection, the output level at any frequency other than the frequency of the applied signal, measured selectively in the frequency band 300-3400 Hz, should be less than −40 dBm0.

3.6 *Discrimination against out-of-band signals*

3.6.1 *Discrimination against out-of-band signals at the input port*

1) With any sine-wave signal above 4.6 kHz applied to the input port of the connection at a suitable level, the level of any image frequency produced at the output port of the connection should, as a minimum requirement, be at least 25 dB below the level of the test signal. The upper limit of the frequency range should be chosen such that, in a given application, possible disturbances of the input filter are adequately covered.

   Note – It has been found that a suitable test level is −25 dBm0.

2) Under the most adverse conditions encountered in a national network, the PCM channel should not contribute more than 100 pW0p of additional noise in the band 0-4 kHz at the output port, as a result of the presence of out-of-band signals at the input port.

Note 1 – The discrimination required depends on the performance of FDM channel equipments and telephone instruments in national networks and individual Administrations should carefully consider the requirements they should specify, taking into account the comments above and the requirement of 2) above. In all cases at least the minimum requirement of 1) above should be met.

Note 2 – Attention is drawn to the importance of the attenuation characteristic in the range 3400 to 4600 Hz. Although other attenuation charateristics can satisfy the requirements 1) and 2) above, the filter template of Figure 13/Q.517 gives adequate protection against the out-of-band signals.

Note 3 – An additional requirement for 2-wire interfaces may be needed in order to suppress frequency at 16 2/3 Hz and 50 or 60 Hz (e.g. fundamental waves of interference from power lines and electrical railways) and is under study in conjunction with § 2.1.1.4, Longitudinal interference threshold level.

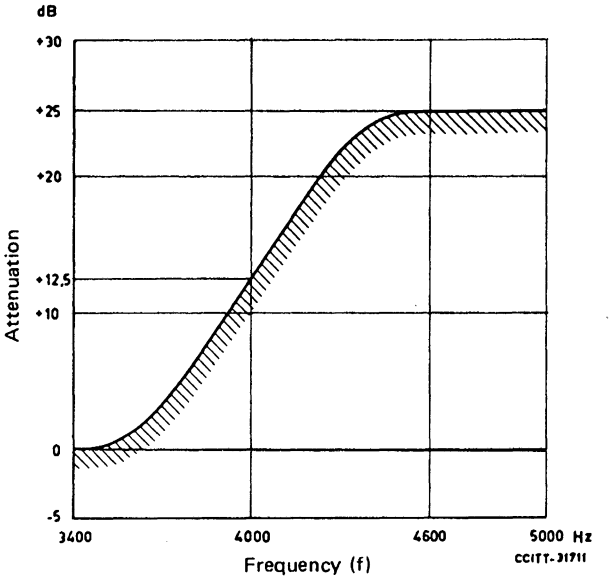
3.6.2 *Spurious out-of-band signals at the output port*

1) With any sine-wave signal in the range 300-3400 Hz at a level of 0 dBm0 applied to the input port of a connection, the level of spurious out-of-band image signals measured selectively at the output port should be lower than −25 dBm0.

2) The spurious out-of-band signals should not give rise to unacceptable interference in equipment connected to the output port. In particular, the intelligible or unintelligible crosstalk in a connected FDM channel should not exceed a level of −65 dBm0 as a consequence of the spurious out-of-band signals at the output port.

Note 1 – The discrimination required depends on the performance of FDM channel equipment and telephone instruments in national networks and individual Administrations should carefully consider the requirements they should specify, taking into account the comments above and the requirement of 2) above. In all cases at least the minimum requirement of 1) above should be met.

Note 2 – Attention is drawn to the importance of the attenuation characteristic in the range 3400 to 4600 Hz. Although other attenuation characteristics can satisfy the requirements 1) and 2) above, the filter template of Figure 13/Q.517 gives adequate protection against the out-of-band signals.



Note – The curved portion of the graph conforms to the equation:

$$\text{Attenuation } X = 12.5 \left[1 - \sin \frac{\pi(4000 - f)}{1200}\right] \text{ dB}$$

for the range $3400 \leqslant f \leqslant 4600$ Hz.

FIGURE 13/Q.517

Attenuation relative to attenuation at 1000 Hz

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