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Voluntary Code of Practice for Design of Private Telecommunication Networks

Issue 1

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Normative Information

If you have any comments concerning the accuracy of the contents of this document, please write to:

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NICC Task Group 23

A Voluntary Code of Practice for the Design of Private Telecommunication Networks

Foreword

Oftel, via the Network Interoperability Consultation Committee, requested that the Code of Practice for the design, development and evolution of Private Telecommunication Networks be reviewed as to whether or not there is an ongoing need for such a document. A representative group of interested parties met to discuss the matter and concluded that there is sufficient support from the industry to provide the effort to undertake a revision of the Code of Practice.

The Terms of Reference of the Task Group are:

I) To decide whether to simply update the Code of Practice starting with the present document, or whether it is more appropriate to write a completely new document using sections from the old document if appropriate.

ii) To decide on the breadth and depth of the subject matter to be covered in the revised document referring to work within the wider European forum as appropriate.

iii) To agree a format and style for the revised document and appoint a member of the Task Group to be responsible for the integration of the final document.

iv) To identify the required content of the document.

v) To produce the finished product for presentation to the NICC.

Subsequently, the NICC decided that this Code of Practice and the Recommended standard for the National Transmission Plan for Public Networks NPDS7(94)4 would be integrated.

The Task Group was convened under the PSTS Interest Group and included representatives from :

- Office of Telecommunications
- Telecommunications systems suppliers
- Telecommunications managers / Users
- PTOs
- BABT

It is anticipated that, from time to time, this Code of Practice will be further revised in light of developments.

Although the recommendations are couched in terms of call routing apparatus and similar types of systems they are equally applicable to any circumstance where voice and/or data services are provided by a private or corporate network.

Another Code of Practice may be drafted that provides guidance on the ASSESSMENT of the performance of private or corporate networks by non-technical persons.

IT IS A REGULATORY REQUIREMENT THAT A TELECOMMUNICATIONS NETWORK IS RUN UNDER A LICENCE GRANTED BY THE SECRETARY OF STATE IN ACCORDANCE WITH THE TELECOMMUNICATIONS ACT 1984. A PRIVATE TELECOMMUNICATIONS NETWORK MAY BE RUN UNDER A CLASS LICENCE OR AN INDIVIDUAL LICENCE THAT INCLUDES A CONDITION RELATING TO THE USE OF APPARATUS APPROVED UNDER SECTION 22 OF THE TELECOMMUNICATIONS ACT 1984 OR STATUTORY INSTRUMENT 1992/2423, 1994/3129 OR 1995/144 AS APPROPRIATE.

Contents

1. SCOPE

This voluntary Code of Practice recommends those factors and technical limits that should be considered for the design, development and evolution of private telecommunication networks(PTN) in order that they may provide a high probability of satisfactory communications for the user for calls to and from a public switched network(PSN).
The requirements are applicable to the following types of communication path:

i) those between private telecommunication network users and public switched telecommunication network users, and

ii) those that transit the private telecommunication network between interconnections with public networks.

This Code of Practice applies where the interconnection between a private network and a public network is via either analogue or digital wired circuits, 2- or 4-wire interfaces and where the public network services are of the circuit switched type.

> Note 1. Where the private telecommunication network uses digital access to the fixed public switched telecommunication network, public voice telephony calls are encoded according to the A-law (see ITU-T Rec. G.711).

This Code of Practice applies where PTNs utilise terrestrial or satellite based leased line services or switched VPN circuits provided by public telecommunications operators or self-provided circuits. Communications via international or European leased lines are included. as are communications with off-shore installations.

> Note 2. Whilst a VPN is part of a public network its performance will need to be considered within the design of a PTN in a similar manner to leased lines. The designer of a PTN will need to take the performance of a VPN into account in the same way as for leased lines. A PTN that accesses a VPN for “indirect” access to PSTN may need to negotiate with the VPN operator for a portion of the PTN performance allowance being made available for the VPN. Where VPN services are provided by the same infrastructure as a PSN a PTN would not normally be expected to make a performance allowance for it.

Where new technologies, that are not acknowledged in this Code of Practice, are introduced they should be evaluated for satisfactory performance. The performance of new technologies should be evaluated against the criteria in this Code. If the criteria in this Code are not appropriate for a new technology which gives satisfactory performance, then this Code will be reviewed.

The guidance is equally applicable to systems located in normal or “stressful” sites. However, where a site requires the PTN equipment to provide additional safety features, the result may be an increase in impairments.

This Code of Practice may be applied to single call routing or equivalent systems.

> Note 3. Centrex with leased line access is for further study.

2. DEFINITIONS, ABBREVIATIONS AND NOTATION

2.1. Definitions

Analogue, 2-wire exchange line means a line that enables a PTN to connect to a PSN over a circuit that provides a nominally 3 kHz transmission channel with DC access signalling and address signalling by either loop disconnect or MF methods.

Breakout is a term used to describe the function of an outgoing call from a PTN emerging at an exchange line on a switch different from the switch to which the originating terminal is connected.

Centrex line is a line provided by a PTO between a PSN and part of a closed user group bearing a service which may emulate the facilities of a stand-alone call routing system including the interconnection with the PSN.

Digital exchange line means a line that enables a PTN to connect to a PSN over circuits that provide channels in each direction at 64 kbit/s using 8-bit A-law digital encoding of voice-band signals in accordance with ITU Recommendation G.711 e.g. ISDN Primary and Basic Rate Interfaces and 2048 kbit/s Channel Associated Signalling, Digital Access Signalling System No 2 and Digital Private Network Signalling System No 1 interfaces.

Grade of Service is the probability that calls are lost owing to a lack of equipment or link capacity rather than equipment failure or an engaged terminating station. For example a GOS of 0.01 represents one call lost in 100 offered.

Jitter means short-term variations of the significant instants of a digital signal from their ideal positions in time.

Link means a point-to point transmission and/or signalling path between two separate items of apparatus, neither of which is part of a Public Telecommunication System.

Private Telecommunications Network means all telecommunication apparatus which is comprised within:

(a) a set of systems, which are all connected together either directly or by means of other systems or by leased lines; or

(b) any leased lines which are directly connected to any of the systems referred to in (a) above.

Leased line means a communication facility which is:

(i) provided by one or more public telecommunication systems,
(ii) for the conveyance of messages between points, all of which are points of connection between public telecommunication systems and other telecommunication systems,
(iii) such that all the messages transmitted at any of the points referred to in (ii) are received at every other such point, and
(iv) such that the points mentioned in (ii) are fixed by the way in which the facility is installed and cannot otherwise be selected by persons or apparatus sending messages by means of that facility.

Public Switched Network means a public telecommunications system by means of which two-way telecommunication services are provided whereby messages are switched incidentally to their conveyance.

Public Telecommunications System means a telecommunication system designated as a public telecommunication system by an Order under section 9 of the Telecommunications Act 1984.

Quantizing means a process in which a continuous range of values is divided into a number of adjacent intervals, and any value within a given interval is represented by a single predetermined value within the interval.

Quantizing Distortion means the distortion resulting from the process of quantizing samples within the working range.

Significant Instant of a Digital Signal means the instant at which a signal element commences in a discretely-timed signal.

Switch means apparatus forming a node of a PTN for the purpose of joining together from time to time links or other circuits that terminate on that apparatus.

Synchronisation means the process of adjusting the corresponding significant instants of signals to make them synchronous.

Terminal Apparatus means apparatus which may initially send or ultimately receive calls to or from a PSN but which may or may not be directly connected to a PSN.

Virtual private network is a network provided by a PTO for the interconnection of terminal equipment which forms part of a closed user group and in which interconnection between part of the same closed user group is performed under control of the user in accordance with a defined routing plan.

Wander means long-term variations of the significant instants of a digital signal from their ideal positions in time.

2.2. Abbreviations

ADPCM Adaptive Pulse Code Modulation

CCITT International Telegraph and Telephone Consultative Committee

CLI Calling Line Identification

CT2 2nd Generation Cordless Telephone

CVSD Continuously Variable Slope Delta

DC Direct Current

DDI Direct Dialling in

DECT Digital Enhanced Cordless Telecommunications

DISA Direct Inward System Access

ETR ETSI Technical Report

ETS European Telecommunications Standard

ETSI European Telecommunications Standards Institute

ISDN Integrated Services Digital Network

ITU International Telecommunications Union

JLR Junction Loudness Rating

LAN Local Area Network

NTP Network Termination Point

OLR Overall Loudness Rating

PCM Pulse code Modulation

PSN Public Switched Network

PTN Private Telecommunications Network

PTO Public Telecommunications Operator

qdu quantizing distortion units

RLR Receive Loudness Rating

SLR Send Loudness Rating

VPN Virtual Private Network

3. REFERENCES

BS 6305: 1992: Specifications for general requirements for apparatus for connection to the British Telecommunications Public Switched Telephone Network.

BS 6833: Apparatus using cordless attachments (excluding cellular radio apparatus) for connection to analogue interfaces of public switched telephone networks:-
Part 1 1987: Specification for general requirements.
Part 2 1987: Specification for cordless telephone apparatus using radio links.

ETR 250: Transmission and Multiplexing; Speech communication quality from mouth to ear for 3.1 kHz handset telephony across networks. July 1996

NPDS7(94)4: Recommended standard for the national transmission plan for public networks. Available from Oftel Library.

Recommendation E.500: Measurement and recording of traffic..

Recommendation G.122: Influence of national systems on stability, talker echo and listener echo in international connections.

Recommendation G.711: Pulse code modulation (PCM) of voice frequencies.

Recommendation G.721: 32 kbit/s adaptive differential pulse code modulation (ADPCM).

Recommendation G.792: Characteristics common to all trans-multiplexing equipment.

Recommendation P.76: Determination of loudness ratings; fundamental principles.

Recommendation G.811: Timing requirements at the outputs of primary reference

clocks suitable for plesiochronous operation of international digital links.

Recommendation G.823: The control of jitter and wander within digital networks which are based on the 2048 kbit/s hierarchy.

Guidance and Best Practice for the Avoidance of Dial Through Fraud published by BABT.

Code of practice on call answering and charging arising from the attachment of private equipment and systems to the public switched telephone network. Available from Oftel Library.

4. RESPONSIBILITIES

4.1. General

For a PTN to be designed in accordance with this Code of Practice it is necessary for those who are responsible for certain roles to carry them out as presented in 4.2 to 4.5.

4.2. PTN manager

Those responsible for the design and operation of PTN should prepare and maintain proper records from which PTN performance can be planned and assessed against this Code of Practice. Such records should include:

- details of all exchange lines at each location,
- details of all PTO leased lines having one end, or both ends, terminating on the PTN,
- lists of equipment at each location, including capacity, model numbers, software releases, etc.,
- a PTN plan showing all significant call paths together with the transmission performance planned for those paths,
- the numbering plan,
- the synchronisation plan,
- estimates of PTN traffic by source, destination and routing (updated by measurements when available),
- any commercial information needed for asset valuation and usage accounting purposes.

Approval requirements for terminal equipment have been substantially reduced in recent years and no longer necessarily include quality aspects. Therefore it cannot be assumed that the inclusion of approved equipment in a PTN will mean that it automatically meets the level of performance recommended in this Code.

> Note 1. Managers of private systems are reminded that they have the ultimate responsibility for compliance with regulatory requirements, e.g. licence conditions, applicable to the running of a PTN. Regulations applicable to trading, supply, works and services contracts would normally apply to operations such as equipment and systems supply, installation, commissioning and maintenance.

Note 2. European standards and British Standard Guides applicable to the design and planning of PTN installations are in preparation. When available they should be referenced.

4.3. System designer or integrator

Those responsible for the design and development of PTN should prepare, on behalf of the PTN manager, proper records and other documentation from which PTN performance can be assessed against this Code of Practice.

4.4. Equipment supplier

Those who supply apparatus and other functions for integration into PTN should provide sufficient information about their products to enable the performance and operation of PTN to be designed or developed to conform with this Code of Practice

4.5. Public telecommunications operator

Those who provide public telecommunication services and other network functions for use by PTN should provide sufficient information about their products and services, switched and leased lines, to enable the performance and operation of a PTN to be designed or developed to conform with this Code of Practice.

5. TRANSMISSION PERFORMANCE

5.1 General

Transmission performance on call paths between terminals and PSN interfaces and where appropriate between two PSN interfaces should comply with the appropriate transmission performance recommendations in 5.2 to 5.5. The background to the recommendations can be found in Annex F.

5.2. Transmission Levels

Note See Annex F.2.

5.2.1 PTN terminating call paths - telephony calls

5.2.1.1 Digital exchange lines

For digital exchange lines the PTN should be designed so that the SLRs and RLRs between NTPs and mouth and ear interfaces are within the range of values stated in Table 1.

Table 1: Loudness ratings for digital exchange lines

	Preferred value	Maximum Recommended Range	Limiting Range
SLR	7 dB	7 to 12.5 dB	7 to 16.5 dB
RLR	3 dB	3 to 8.5 dB	3 to 12.5 dB

5.2.1.2 Analogue 2-wire exchange lines

Regular exchange lines have a loss of up to 10 dB and are usually used for connection of simple terminals, however, analogue exchange line services at lower values of loss may be requested by the PTN customer in order that more extensive PTNs may be connected.
For analogue exchange lines the PTN should be designed so that the SLRs and RLRs between NTPs and mouth and ear interfaces are within the appropriate range of values stated in Table 2, 3 or 4, as appropriate.
Exchange lines with values of 8, 6 and 3 dB maximum loss are available.

Table 2: Loudness ratings for analogue 2-wire exchange lines with 8 dB maximum loss		
	Preferred Range	Limiting Range
SLR	0 to 3 dB	0 dB to 7 dB
RLR	- 8 to - 5 dB	- 8 to -1 dB

Table 3: Loudness ratings for analogue 2-wire exchange lines with 6 dB maximum loss		
	Preferred Range	Limiting Range
SLR	0 to 5 dB	0 dB to 9 dB
RLR	- 8 to - 3 dB	- 8 to 1 dB

Table 4: Loudness ratings for analogue 2-wire exchange lines with 3 dB maximum loss		
	Preferred Range	Limiting Range
SLR	0 to 8 dB	0 dB to 12 dB
RLR	- 8 to 0 dB	- 8 to 4 dB

Where the actual exchange line loss is less than the advertised maximum loss, SLR and RLR values greater than the minimum values in the given ranges should be used to reduce the probability of low OLR making calls seem too loud.

5.2.2 PTN terminating call paths - data calls

a) For that section of a call path within a PTN between analogue 2-wire exchange lines and apparatus that is approved for direct connection to an analogue 2-wire exchange line the appropriate ranges of SLR in 5.2.1 should be used instead as transmission loss.

b) For that section of a call path within a PTN between analogue 2-wire exchange lines and apparatus that is approved for direct connection to a digital exchange line the transmission loss should be in the range applicable to the maximum loss of the exchange line given in the appropriate Table 5, 6 or 7.

Table 5: Transmission loss for analogue 2-wire exchange lines with 8 dB maximum loss		
	Preferred range	Limiting range
Send path	-7 to -4 dB	-7 to 0 dB
Receive path	11 to 14 dB	11 to 18 dB

Table 6: Transmission loss for analogue 2-wire exchange lines with 6 dB maximum loss		
	Preferred range	Limiting range
Send path	-7 to -2 dB	-7 to 2 dB
Receive path	11 to 16 dB	11 to 20 dB

Table 7: Transmission loss for analogue 2-wire exchange lines with 3 dB maximum loss		
	Preferred range	Limiting range

Send path	-7 to 1 dB	-7 to 1 dB
Receive path	11 to 19 dB	11 to 21 dB

c) For that section of a call path within a PTN between digital exchange lines and apparatus that is approved for direct connection to an analogue 2-wire exchange line the transmission loss should be in the applicable range given in Table 8.

Table 8: Transmission loss for digital exchange lines		
	Preferred range	Limiting range
Send path	7 to 12.5 dB	7 to 16.5 dB
Receive path	-11 to -5.5 dB	-11 to -1.5 dB

d) For that section of a call path within a PTN between digital exchange lines and apparatus that is approved for direct connection to a digital exchange line the transmission loss should be 0 dB.

e) For that section of a call path within a PTN between exchange lines and apparatus that is not intended for direct connection to an exchange line the transmission loss should ensure that the power level limits in appropriate technical regulation (PD or TBR) for direct connection is not exceeded. Terminal apparatus characteristics obtained from the supplier should be used to derive the minimum transmission loss.

5.2.3 PTN transit calls - telephony and data calls

Call paths that transit a PTN between two (or more) PSN exchange line NTPs should be within the range of transmission loss values stated in Table 9.

Table 9: Transmission loss for PTN transit calls		
Exchange lines	Digital	Analogue 2-wire
Digital	0 to 3 dB	3.5 to 4.5 dB
Analogue 2-wire	3.5 to 4.5 dB	- 7 to +3 dB

5.3. Transmission Delay, Echo Loss and Stability

Note. See Annex F.3.

5.3.1 PTN terminating call paths - telephony and data calls

5.3.1.1 Transmission delay and echo path loss

The echo path delay/loss characteristics between digital and analogue 2-wire exchange lines NTPs and mouth and ear interfaces and between NTPs and 4-wire to 2-wire conversion points should be designed to be within the appropriate range of values given in Table 10.

Table 10: Echo path loss requirements appropriate to ranges of echo path delay		
Lower limit of echo path delay (round trip) range	Upper limit of echo path delay (round trip) range	Minimum echo path loss
0 ms	10 ms	16 dB
10 ms	15 ms	18 dB
15 ms	20 ms	20 dB
20 ms	25 ms	22 dB
25 ms	30 ms	24 dB

30 ms	40 ms	28 dB
40 ms	50 ms	30 dB
50 ms	70 ms	35 dB
70 ms	100 ms	40 dB
100 ms	150 ms	45 dB
150 ms	600 ms	50 dB

It is recommended that where echo control is provided in a PTN to benefit distant speakers, similar control is provided in the other direction of transmission to benefit the PTN speaker against the effects of echo, See Annex G.

Where echo control equipment is used it should be capable of responding to the disabling signals generated by voice-band data terminals, although some modems operating half duplex on very long delay circuits may require echo control. For echo suppressers this signal is a 2100 Hz tone and for echo chancellors a 2100 Hz tone with phase reversals.

Note 1. Where PTN echo path delay exceeds 10 ms, there is a risk that on international PSN calls the echo control measures provided by PSN will not be effective depending on the location of the PTN/NTP with respect to the PSN echo control device being used on the call. Values for delays in the UK PSN can be found in the document NPDS7(94)4 produced by the Network Performance Design Standards Group of PNO-IG.

Note 2. In assessing the echo path loss for a call path the following can be assumed:

a) The published value of loss for any leased line service should be used.
b) The balance return loss of a 4-wire to 2-wire conversion hybrid can normally be assumed to be 14 dB.
c) The Telephone Acoustic Loss for an analogue telephone should be assumed to be 16 dB and that of an approved digital telephone should be assumed to be 40 dB, unless information provided by the supplier states otherwise.

Note 3. An echo cancelling device having a nominal value of echo loss of at least 50 dB under single talk conditions can be used to achieve conformity with the echo path loss recommendation. A single echo cancelling device may control the echo on more than one echo path.

Note 4. Careful consideration should be given to network architecture and equipment selection to ensure that echo cancellor devices operate as required.

5.3.1.2 Stability

To ensure acceptable stability, the loss presented by the PTN between the receive and transmit circuits of a 4-wire analogue or digital interface with the PSN or PTO-provided 4-wire link, when calculated at equal relative levels for both directions of transmission, should not be less than 6 dB at any frequency in the band 0 to 4 kHz.

The sum of the losses around any closed 4-wire path in the PTN, i.e. 4-wire paths with terminated by 2-wire circuits at each end, should not be less than 6 dB at any frequency in the band 0 to 4 kHz. Account should be taken of all conditions presented at the interface encountered in normal operation. For planning purposes, terminations in the range of 200 to 1200 ohms should be assumed to be present at 2-wire PTN and PSN interfaces.

Note. The stability recommendations are consistent with ITU Recommendation G.122,

5.3.2 PTN transit calls - telephony and data calls

5.3.2.1 Transmission delay/echo loss

The NTP-to-NTP delay on PTN transit call paths should be less than 10 ms.

The provision and location of echo control devices should be considered by the PTN designer. Echo control devices could be provided by the PSN or one of the other networks in the overall call path.

> Note 1. Long round trip delays can necessitate large buffers in data terminals to accommodate the time it takes for a data stream or message to transit a call path.
>
> Note 2. These recommendations are made on the basis of current knowledge and understanding. These recommendations may need to be changed in the light of experience.

Where echo control equipment is used it should be capable of responding to the disabling signals generated by voice-band data terminals, although some modems operating half duplex on very long delay circuits may require echo control. For echo suppressers this signal is a 2100 Hz tone and for echo chancellors a 2100 Hz tone with phase reversals.

5.3.2.2 Stability

To ensure acceptable stability, the loss presented by the PTN between the receive and transmit circuits of a 4-wire analogue or digital interface with the PSN or PTO-provided 4-wire link, when calculated at equal relative levels for both directions of transmission, should not be less than 6 dB at any frequency in the band 0 to 4 kHz.

The sum of the losses around any closed 4-wire path in the PTN, i.e. 4-wire paths with terminated by 2-wire circuits at each end, should not be less than 6 dB at any frequency in the band 0 to 4 kHz. Account should be taken of all conditions presented at the interface encountered in normal operation. For planning purposes, terminations in the range of 200 to 1200 ohms should be assumed to be present at 2-wire PTN and PSN interfaces.

> Note. The stability recommendations are consistent with ITU Recommendation G.122,

5.4. Quantizing Distortion

> Note. See Annex F.4.

5.4.1 General

> Note. Study has shown that summation of qdu, particularly at high values, does not reflect a representative level of distortion. The ITU-T and ETSI are investigating this matter further. A proposal can be found in ETSI Technical Report 250.

5.4.2 PTN terminating call paths - telephony and data calls

a) Preferred Values

To achieve preferred levels of performance a PTN should not introduce distortion equivalent to more than 5 qdu in any call path carrying PSN traffic.

b) Limiting Values

At the limiting levels of performance a PTN should not introduce distortion equivalent to more than 10 qdu in any call path carrying PSN traffic.

Note. Values of qdu appropriate to various coding algorithms are given in Annex F.4

5.4.3 PTN transit call paths - telephony and data calls

To achieve preferred levels of performance a PTN should not introduce distortion equivalent to more than 1 qdu in any PTN transit call path carrying PSN traffic.

5.5. Jitter, Wander and Network Synchronisation

PTNs with digital transmission and switching should be designed so that their synchronisation is sufficiently accurate and levels of jitter are sufficiently low to support the services being carried. The synchronisation, including timing and any buffering capacity of equipment used in PTN should be designed to ensure that digital signals are not lost or repeated. See also Annex F.5

Note 1. Limits for jitter at hierarchical interfaces are defined in ITU-T G.823.

A synchronisation plan should be prepared for PTN to show the accuracy of clocks and the normal and alternative sources of timing at each location.

Note 2. For PSN connection it is advisable that synchronisation is traceable to a primary reference clock, complying with ITU-T G.811. This may be derived from a PTO source.

5.6. Application to PTNs

5.6.1 General

PTN planned in accordance with preferred values will provide a high probability of satisfactory performance. Difficulty may be experienced on some calls when call path performance characteristics approach the limiting values. However an acceptable level of satisfaction may be achieved where lower levels of PTN performance arise;

a) if it incorporates sufficient intelligence and stored data to identify the performance of the PSN portion of a call,

b) if users are conditioned to expect different levels of performance on calls and

c) if the proportion of calls that may be subject to a lower performance paths is limited to an average of less than 5% of all calls.

5.6.2 Interception of calls

Calls to and from a PSN that pass through a point of interception in the PTN should conform to the preferred values between the PSN/PTN interface and the point of interception and may conform with the limiting values for the ultimate call path. Interception decouples the first section of the call from the subsequent routing, and effectively conditions the user to the performance experienced on such calls.

5.6.3 Transfer and diversion of calls

Calls that are transferred, diverted or otherwise extended to a point other than their usual termination point should also conform to this Code of Practice. Calls transferred to an alternative terminating station in the PTN, after a voice communication, should be treated in the same way as intercepted calls.

Calls transferred or diverted to an alternative terminating station outside the PTN, either in another PTN or directly connected to a PSN, should conform to this Code of Practice.

5.6.4 Exceptional routing of calls

Normally, a PTN will be designed for optimum performance during normal business hours, if, for example, outside normal business hours call paths to night service extensions do not conform with the recommendations of this Code of Practice an acceptable level of satisfaction should be achieved provided that the proportion of such calls does not exceed 5% of relevant calls

5.6.5 Availability of Suitable Transmission Links

Normally, the links in a PTN will either be self provided or provided by a PTO as leased lines. In exceptional circumstance, such as the connection of a PTN to an off-shore oil installation, where the performance of available transmission systems is below that of systems in general national use, it may not be practicable or economic to plan to the preferred values, or even the limiting values, in this Code. Where possible, users of these links should be made aware of any peculiarities of the transmission quality so that they are suitably conditioned for satisfactory communication, possibly using interception as described in 5.6.2

5.6.6 Fault Conditions

PTN designed in accordance with this Code of Practice may be expected to function satisfactorily under normal fault-free conditions. It is recommended that PTN designers build in a degree of resilience in anticipation of possible faults, whether in PTN equipment or PTO-provided leased lines. The proportion of calls on which limiting values are exceeded due to alternative routing under fault conditions should not be greater than 10% of relevant calls.

5.6.7 Traffic Overload Conditions

PTN designed in accordance with the requirements of this Code of Practice may be expected to function satisfactorily under normal traffic conditions. It is recommended that PTN designers build-in a degree of resilience in anticipation of unforeseen peaks of traffic. The proportion of calls on which limiting values are exceeded due to alternative routing under overload conditions should not be greater than 5% of relevant calls.

5.6.8 Individual Call Paths Exceeding the Planning Limits

In some circumstances it may prove to be impractical technically, and unattractive economically, to design PTN so that all possible call paths conform with the preferred or limiting values specified in this Code of Practice.

The proportion of calls on which limiting values are exceeded under this clause should not be greater than 5% of relevant calls.

However call paths should be designed to be acceptable to the user.

6. SIGNALLING AND CALL CONTROL

6.1. General

Note. The PTN maybe connected to the PSN by the use of analogue or digital exchange line interfaces. The apparatus used must be approved for connection to the PSN and the type of exchange line interface being utilised. Calls to and from the PSN will experience the signalling and call control mechanisms related to the particular exchange line interfaces to which it is connected (establishing. answering, maintaining and clearing).

Irrespective of the methods of signalling or call control used within the PTN, or the point within the PTN at which calls originate or terminate, the signalling and call control mechanisms appearing at the PSN interface should comply with protocols used at that interface.

6.2. In-Band Tones

Call progress signals in the form of in-band supervisory tones returned to the PSN during the delivery of a call (prior to answer) to a PTN, should:

a) be subjectively equivalent in characteristics and meaning to tones used within the PSN. Note. PSN tones are described in "BS 6305 Annex C".

b) be at levels of not higher than -9 and not lower than -20 dBm0.

c) not be changed for another tone during the setting up or attempted setting up of the PSN call, except that a tone indicating call failure may be ceased after not less than 20 seconds from the commencement of the injection of the tone into the PSN by the PTN.

6.3. Delay to Call Progress Indication for Incoming DDI Calls

For satisfactory operations on incoming DDI calls to a PTN from a PSN, a call progress indication, e.g. a supervisory tone, or where appropriate signalling information in lieu of a call progress indication, should be returned to the PSN within 6 seconds of the receipt of the call routing information by the PTN.

6.4. Incoming Call Answer

Calls presented from the PSN to a PTN should be answered in a manner which gives an unambiguous indication to the calling party when call charging commences. The “Code of practice on call answering and charging arising from the attachment of private equipment and systems to the public switched telephone network” provides more detailed recommendations.

6.5. Incoming PSN calls diverted back to the PSN as an outgoing call

6.5.1 Where an incoming call from a PSN to a PTN is diverted and results in an outgoing call from the PTN to the PSN and the respective signalling and operational arrangements are incompatible, the original incoming call should be answered with a recorded announcement indicating the diversion and informing the caller that the call has been answered and is being forwarded at no additional cost to the caller. The transmission path should be switched through when the outgoing call routing information has been sent; to enable the caller to hear call progress information resulting from the second call.

6.5.2 Where an incoming call from a PSN to a PTN is diverted and results in an outgoing call from the PTN to the PSN and the respective signalling and operational arrangements are compatible, the original incoming call should not be answered; it should be forwarded without delay to the second called party.

Note. For example, In a DASS2 to DASS2 call diversion the CAUSE message received from the second call attempt could be returned to the originating leg of the call to cause call progress tone to be returned to the caller.

6.5.3 Where an incoming call arrives on an exchange line, that is addressed by a Directory Number known to certain callers only, is to be diverted to another, not necessarily published, Directory Number via the PTN (a PTN transit call) it should not be necessary to answer the call with a pre-recorded announcement stating that the call has been answered and is being forwarded at no additional cost to the caller.

6.6. Major Failures

Careful consideration should be given to the effect on service of major failures, such as loss of power or faulty apparatus. The PTN should incorporate arrangements to ensure proper release of calls in progress so that charging will cease, when a major failure occurs, and to minimise subsequent ineffective PTN and PSN calls by inhibiting circuits that are no longer available for service, so that suitable tones or announcements can be returned on any calls that cannot be connected.

6.7. Calling line identification

6.7.1 Where CLI information is received from a PSN it should be presented to suitable terminals, for example, for display to the called party.

6.7.2 Where a terminal that has its own individual PSN number, as with DDI, is capable of originating calls to Public Emergency Services such calls should be routed via a PSN, NTP on the same site so that calls to the emergency services will forward the appropriate CLI information.

6.7.3 Calls from terminals accessible via DDI that are routed via PSN, NTPs on sites other than their own should be arranged to forward a “CLI withheld” indication to called parties. The number sent as CLI information is determined by the PSN from the line identity.

Note. This may mean that separate groups of outgoing PSN lines are needed for “breakout” and on-site calls and is recommended because CLI information may be used for return calls.

6.7.4 PSN to PSN calls that transit a single PTN site or a multisite PTN should be set to send a “CLI withheld” indication.

Note. Since Oftel will not allow a PSN to forward a CLI that they have not been able to verify in the local PSN exchange a “CLI withheld” indication must be given on outgoing calls from sites that are accessible for breakout by terminals on other sites. A PSN can verify identities within its PSN directory numbering range only.

7. NUMBERING AND ADDRESSING

7.1. Numbering

The PTN numbering plan should allow for the assignment of an appropriate PTN number to the addressable entities in the PTN. Such entities can be:

- a terminal access to the PTN

- several terminal accesses to the PTN (hunt group)
- an internal entity in the PTN.

Note. Since a PTN operates independently of the PSN, its numbering plan is not constrained by the PSN numbering scheme.

7.2. DDI

Note 1. The DDI facility allows an addressable entity within the PTN, an extension for example, to have a PSN number in which some of the least
addressable entities usually also have a PTN number. In principle there does not have to be any relation between the PSN number and the PTN number, however it is often simpler for users if the least significant digits of both numbers are the same.

The DDI facility requires the assignment of numbers from the PSN numbering plan to entities within the PTN, therefore those planning the PTN should consult the PTO to ascertain the availability of PSN numbers for this purpose.

Note 2. Currently, the maximum length of numbers used in DDI numbering schemes is 10 digits, excluding the prefix '0', up to another 3 digits may be added in the future.

Note 3. A PTN having DDI service may have one group, or more than one group of DDI lines from a Public Exchange, depending on the number of DDI numbers required by the PTN and the trunking arrangements at the Public Exchange.
For example, a PTN with analogue DDI PSN lines with 400 DDI-extensions will normally be allocated four blocks of a hundred numbers each, each block corresponding to a group of DDI PSN lines. In this example, for an incoming call to the PTN, the PSN will select a line from the appropriate DDI line group for the call and send, as a minimum, the two least significant digits of the called PSN number so that the PTN can route the call to the called destination.
In the course of improving their networks PTO's may need to change the number allocated. In such cases due notice will be given.

7.3. Sub-addressing

In cases where the PTN numbering plan is not sufficient to uniquely identify an addressable entity, the PTN should be capable of transferring sub-address information as part of call establishment. Applications of sub-addressing include the selection of an application process in terminating equipment and selection of nodes on a LAN.

Note. Sub-addressing operates independently of CLI. Sub-addresses can have a maximum size of 40 digits.

7.4. lncoming calls to the PTN

The PTN should be capable of processing the number of digits received from the PSN.

Note. For a PTN with DDI, the number of digits received by the PTN on a on a particular DDI access may be as low as two or as high as four, or exceptionally as high as five or six. The actual number of digits is determined by the DDI arrangements for that access.

The PTN may receive a sub-address, as part of the called destination address, by use of the ISDN Sub-addressing supplementary service.
Depending on the capabilities of the PTN, it may be possible for the PSN to send CLI information to the PTN. This may be subject to arrangement with the PTO.

Where CLI is normally provided but not received (CLI "unavailable" or "withheld" indication received), its absence should not affect the routing of a call. CLI information may be absent because the call originates in a PSN that either does not support CLI or does not pass it on.

7.5. Outgoing calls from the PTN

The PTN should allow PSN numbers of up to 18 digits, excluding any prefix or suffix digits, to be dialled.

The current maximum number of routing digits that may be required to be dialled from the PTN is 18. Introduction of excessive pauses between consecutive digits by the PTN should be avoided.

Note 1. Where a call is established over PSNs operated by more than one PTO a further stage of in-band signalling may be required.

If the calling party provided a sub-address, this should be passed on to the PSN.

Note 2. Depending on the capabilities of the PTN, it may be possible for the PTN to send CLI information to the PSN on outgoing calls. This may be subject to arrangement with the PTO.
Such arrangements may define the nature of the CLI information to be sent to the PSN. For example, it is possible that the CLI number digits sent across a particular access to a PSN may be restricted to those allocated to a DDI facility defined at that access. However, the arrangements may allow **the** CLI number digits to be a national or international number which does not necessarily lie within the numbering range of the serving Public exchange.

CLI information should not be sent if the calling party has a PTN number but no corresponding PSN, DDI number.

Note 3. Since Oftel will not allow a PSN to forward a CLI that they have not been able to verify in the local PSN exchange a "CLI withheld" indication must be given on outgoing calls from sites that are accessible for breakout by terminals on other sites. A PSN can verify identities within its PSN directory numbering range only.

7.6. Emergency calls

It is a common expectation that the presence of dial tone on a telephone means that an emergency call can be made. The PTN should be planned to allow emergency calls from such telephones using a well displayed emergency call code that gives access to either an internal emergency call handling point or the Public Emergency Services.

Note. In their handling of emergency calls, PTOs endeavour to correlate the origin of a call with the authority responsible for dealing with that type of emergency in the location concerned. Those planning the PTN are advised to bear this in mind in the routing of such calls to ensure reasonable correspondence between the location of the PTN terminating

station from which the call originates with the location of the PSN interface at which the call is connected to the PSN.

8. TRAFFIC HANDLING CAPACITY

8.1. Grades of service

Where DDI is used to route PSN calls to a PTN over a group of exchange lines, the minimum number of lines in each DDI group should be at minimum the number required to ensure that the Grade of Service provided by these lines is not worse than 0.02 (i.e. one failure due to insufficient lines in fifty (50) attempts. Optimally, it is recommended that a Grade of Service of 0.01 (i.e. one failure in 100 attempts) should be used in planning such groups.

The 0.01 Grade of Service should be used also for the dimensioning of outgoing, incoming, and both way routes to PSN and for PSN call routings through the PTN. This will ensure that the probability of insufficient capacity being available for calls to and from the PSN will not normally be worse than one in fifty.

Note 1. The Grade of Service of 0.02 or 0.01 relates only to a single link and does not consider the overall end to end Grades of Service.

Note 2. PSN operators usually will provide a grade of service of better than 0.005 (one failure in two hundred (200) attempts). The grade of service provided to users within the PTN will be determined by the Grade of Service of the PSN and PTN, e.g. a PSN provides a Grade of Service of 0.005 and the PTN provides a Grade of Service of 0.02, the effective Grade of Service presented to the PTN user during the busy hour will be worse than 0.02.

8.2. Representative Busy Hour

The Grade of Service should apply to the representative busy hour. This busy hour is initially assessed against estimated traffic and thereafter against measured traffic. When initially assessing traffic loads, care should be taken in understanding the varying holding time and call frequency characteristics associated with differing types of users within the PTN.

Incoming, outgoing, and/or both-way groups may experience different component busy hours from each other as wells as a busy hour different from the call routing system busy hour. In order to assure delivery of the desired Grade of Service to every component, a busy hour determination for each type of group (component) should be conducted.

Note. Busy hour determination study techniques are described in CCITT Recommendation E.500 Series, 1992.

9. ACCESS TO EMERGENCY SERVICES

9.1. General

Careful consideration should be given when configuring PTN with respect to the mechanism and ability for users to access the public emergency services.

9.2. Direct access to Public Emergency Services

Where access to the Public Emergency Services is provided the following recommendations apply:

a) Particularly where personnel are mobile the procedures and indications should be the same for all locations and departments covered by a PTN.

b) PTN access to the Public Emergency Services should be free from call barring restrictions.

Note 1. Access can be assisted by using direct access or a minimum of call paths.

Note 2. Both the "999" and "112" digit strings should be available.

c) Alternate routing, priority calling, special provision at times of high use or equivalent network features should be implemented to avoid the risk of congestion on calls to Public Emergency Services.

d) Access to the Public Emergency Services should be provided in conditions of power outage and equipment failure, for example, by use of battery backup and standby generators.

e) Where additional or alternative numbers are required to access the emergency services ensure these are readily available and well publicised.

f) Cordless telephones should not exclusively be used to provide access to emergency services.

Note. Call routing apparatus with analogue connections is required to provide some cut through circuits; approved phones operate on line power; designated ISDN terminals operate on restricted power.

9.3. Access to PTN emergency services

Where access to the Public Emergency Services is not provided alternative arrangements should be provided, for example, access to a PTN emergency services answering point.

The PTN emergency calls answering point should have direct access to the Public Emergency Services as in 9.2.

Note 1. Staffing of the answering point should be ensured at all times when direct access is barred.

Note 2. Examples of networks where internal PTN answering of emergency calls may be required are:

i) Businesses dealing in hazardous substances where specialist units or precautions from the Public Emergency services may be required.
ii) Businesses with their own Emergency services (e.g. Airports etc.)
iii) Businesses subject to a high degree of hoax calls (e.g. Colleges, Hotels).

10. ACCESS SECURITY

10.1. Software Access

It is recommended that software capable of configuring the network or individual apparatus should be either rendered secure by physical locks, or keys; be inaccessible without the use of tools; or be subject to software passwords.

Where a software password is used it should contain not less than 2×10^9 differs. This may be achieved by 6 or more alpha numeric characters or 10 numeric characters. Software passwords should be regularly changed avoiding reuse or
recycling of previous passwords.

10.2. DISA Access

It is recommended that the "Guidance and Best Practice for the Avoidance of Dial Through Fraud" should be taken into consideration when designing PTN.

ANNEXES

A (Text deleted)
Eds note. The Bibliography should have been put in this annex.

B LEASED LINES (Informative)

B.1. Link strategy

It is recommended that the Manager of the Private Telecommunications Network (PTN), together with the Network designer or integrator should determine the strategy to be applied to links interconnecting the nodes of the PTN. The strategy should identify each connection medium and state whether the links are to be self provided circuits, PTO leased circuits or provided by VPN circuits. The strategy should also determine the transmission medium, analogue, digital or radio.
There should be a rationale developed for each link. This should include the type of traffic to be carried and the expected density, the reliability required, the geographical data, plus the projected cost.
When determining the transmission plan for the PTN it is necessary to have available the transmission parameters for each of the links; to do this the transmission characteristics of all the component parts must be ascertained. It will be necessary to determine the values of the characteristics needed for planning purposes. Where the link is self provided it will be necessary to identify those transmission parameters which need to be taken into account, such as attenuation (loss), delay etc. Where the link is to be provided by a PTO, the planning information applicable to the type of circuit must be obtained from the provider. [It will be necessary to negotiate for special requirements.]

B.2. ONP Leased Lines

To encourage the development of Private Networks throughout Europe, the European Commission introduced a Council Directive 92/44/EEC which requires Member States to ensure that a minimum set of lease lines is available to Private Network Providers. These are listed in Annex II of the Directive. ETSI has produced a set of standards which are applicable to this set. The list of standards follows:

- Ordinary quality voice bandwidth 2-wire analogue leased line (A2O) Connection characteristics and interface presentation: - ETS 300 448
- Special quality voice bandwidth 2-wire analogue leased line (A2S) Connection characteristics and interface presentation:- ETS 300 449
- Ordinary quality voice bandwidth 4-wire analogue leased line (A4O) Connection characteristics and interface presentation:- ETS 300 451
- Special quality voice bandwidth 4-wire analogue leased line (A4S) Connection characteristics and interface presentation:- ETS 300 452
- 2 048 kbit/s digital unstructured and structured leased lines (D2048U and D2048S); Network interface presentation:- ETS 300 418
- 2 048 kbit/s digital unstructured leased line (D2048U); Connection characteristics:- ETS 300 247
- 2 048 kbit/s digital structured leased lines (D2048S); Connection characteristics:- ETS 300 419
- 64 kbit/s digital unrestricted leased line with octet integrity (D64U) Network interface presentation:- ETS 300 288
- 64 kbit/s digital unrestricted leased line with octet integrity (D64U);Connection characteristics:- ETS 300 289

Other types of leased line may be provided outside the scope of the Directive.

C INSTALLATION (Informative)

It is recommended that the Installer confirms that the users network and apparatus being installed will meet the relevant approval and licensing requirements necessary for the connection of his/her telecommunications system to a Public Telecommunication Networks.

A PTN may comprise several installations and it is important that the design of each installation is co-ordinated with the others to ensure that the performance requirements of the overall network are met.

The equipment and wiring should be checked during commissioning to **confirm that** it is safe, that it is functioning as intended and that the requirements of the PTN plan are being achieved.

Care should be exercised, particularly with DISA equipment, to avoid modes of operation that could lead to fraudulent misuse of the network.

While connections to the PSN may be made for commissioning **purposes, access to users** should not be permitted until the above checks have been **completed.**

Proposals for extensions to and repositioning of equipment should be checked to ensure continuing compliance with the PTN plan prior to implementation.

Records should be kept of the PTN plan showing all significant call paths with their planned transmission performance, the numbering plan and the synchronisation plan (where appropriate). Details of all PSN exchange lines and leased lines should be recorded. All equipment installed at each location should be listed, including model numbers, capacity, software releases, etc.

D BRINGING INTO SERVICE (Informative)

It is recommended that the contractor, who may not be the Installer, who connects the users private system to a Public Telecommunications Network, should be contracted to ensure that the network being connected conforms to relevant approval and licensing requirements.

E MAINTENANCE (Informative)

During maintenance of individual items of equipment, care should be taken that replacement items are installed and commissioned so as not to reduce the performance of the equipment or the whole PTN below the design level. In particular, hardware and software controls shall be correctly adjusted to match the plan.

A record of all maintenance activity should be kept with the appropriate equipment to assist with fault finding. Plant records should be updated as necessary to ensure that they reflect the current configuration of the equipment and the PTN. This should include details of connections to the PSN.

Although maintenance of telecommunication apparatus can be carried out by the user; it is strongly recommended that a company proficient in the maintenance of the equipment specifically installed as part of the PTN be contracted.

Any Maintainer contracted should be able to demonstrate that he is fully conversant with national and/or European regulatory requirements.

The following responsibilities should form part of any Maintenance contract:

- a duty on the Maintainer to inform the customers as to any breaches to regulatory and licensing requirements which are discovered during routine maintenance.

Note. The Maintainer in this case may only be considered to have the responsibility to ensure that the approval and licensing conditions are maintained to those set at the time when the Approved Telecommunications system and/or Apparatus was connected to a Public Telecommunication Network/s.

- a duty on the Maintainer to inform the customers as to any technical or functional changes to apparatus maintained which may change network values derived from this Code of Practice.

The user may have a responsibility to the contracted Maintainer for any subsequent modifications carried out to the customers system, after it's connection to a Public Telecommunication Network/s. These changes should be brought to the Maintainers notice. The Maintainer should ascertain, prior to acceptance for maintenance, that any modification to the customers telecommunication system does not invalidate the customers apparatus approval or licensing requirements.

F TRANSMISSION CHARACTERISTICS (Informative)

F.1 General

Recommendations for the level of impairment in PTNs for each of the principal transmission characteristics are given in the following paragraphs. These have been found to give satisfactory communication on telephone networks and are mostly based on the statistical analysis of listeners' responses under standardised conditions. For PTN to PSN calls the levels are given for several different types of PSN interface and are reduced by an allocation for the performance of equipment on the public network side of the PSN interface and private equipment at the distant end.

Note 1. By treating impairments to individual transmission characteristics in isolation this Code does not consider the combination effect of impairments. For example, satisfactory performance might be achieved even though one characteristic introduces impairments outside of the recommended range if all other impairments are very low. Sophisticated computer models are required to evaluate such combination effects.

Note 2. The ETSI has studied methods for evaluating the effects on speech transmission of impairments to transmission characteristics. ETR 250 presents the results of these studies and describes different techniques to those used in this Code.

F.2 Transmission levels

For speech calls the transmission performance, between acoustic reference points (mouth and ear) at each end of a call path, is specified in terms of an OLR. For evaluation purposes end-to-end transmission paths are assessed as three sections. the transmission performances between acoustic reference points and electrical reference points expressed in terms of SLR and RLR for each direction of transmission and the JLR which is the loss between the electrical reference points.

In setting OLR limits that give acceptable levels of satisfaction to the large majority of users the ITU has recommended 29 dB as a limiting value for OLR, 21 dB as the value to be used as a short-term improvement objective, and stated a preference for a value in the range 8 to 12 dB.

The recommendations in this Code of Practice are derived from the short-term improvement objective OLR of 21 dB.

These techniques are defined in ITU Recommendation P.76 (1989 Blue Book) and give a technical view of the "loudness" that users perceive during a telephone conversation. The electrical reference point chosen for the recommendations in this Code of Practice is the point at which the terminal or PTN is connected to a PSN, the network connection point or NTP.

Approval standards for simple analogue telephones, designed for direct connection to PSN lines, require them to have SLR and RLR values of 0 dB and -8 dB respectively at the NTP. Such apparatus is frequently used also on extensions to call routing apparatus or equivalent. The SLR and RLR values for digital apparatus are 7 and 3 dB respectively. The approval of other apparatus may not include any requirements for transmission performance so the equivalent information should be obtained from the terminal supplier.

PSNs are designed give performance better than the short term improvement objective of 21 dB overall. PTN engineered to have call paths of loss no greater than the remainder of the PSN analogue exchange line loss subtracted from 10 dB. For example, not more than 7 dB loss on paths connecting with 3 dB PSN lines, will meet the objective.

In most circumstances PTN planned to provide satisfactory OLR for terminals making PSN calls will be able to provide similarly acceptable values when these terminal make internal PTN calls.

F.3 Transmission delay, echo loss and stability.

F.3.1 General

The use in PTN and PSN of digital switching and transmission systems, that inherently have zero value of JLR and significant signal propagation delay times has increased the need to control echo path loss.

Experience has shown that a small amount of sidetone improves the acceptability of a call provided that the signal is not delayed by more than a few 10's of milliseconds. The acceptability of calls with longer echo path delays can be increased by reduction of the received echo signal level, i.e. increasing the echo path loss.

Even with relatively short delays there may be a need to increase the loss of an echo path. Such measures could include the installation of echo suppressers or cancellor functions at a strategic position in the PTN. Long call path delays, even in the absence of an echo signal, can render normal conversation difficult and require use of a special conversational protocol.

F.3.2 Echo path loss and echo delay

The echo path loss/delay characteristic of PSN-to-PTN call paths need to be controlled to protect the distant speaker, not the PTN speaker, from echoes arising from signals received from the distant speaker being returned to them at a level and time delay that could be disruptive to speech communication. The levels of performance for echo given in this Code take into account, the fact that echo control is not normally provided within PSN on national calls in the UK, and the existence and performance of echo control devices which are used in PSN to control echoes on international calls.

The echo path delay (sometimes called round-trip delay or both-way delay) in a PTN-to-PSN connection is the sum of the delay from the PSN connection point to the acoustic interface of the terminal apparatus and the delay from that acoustic interface to the PSN connection point.

For planning purposes the delay introduced by terminal telephone apparatus can be assumed to be zero unless the information provided by the supplier of the apparatus states otherwise.

The echo path loss for the path from the PSN interfaces to each 4-wire to 2-wire conversion point or terminal apparatus is the sum of the call path losses in each direction, and the balance return loss for the 4-wire to 2-wire conversion or the telephone acoustic loss as appropriate.

The two principal contributors of echo are the acoustic connection from the earpiece to the mouthpiece of a telephone, and the electrical connection between the forward and return pairs at any 4-wire to 2-wire conversion within the PTN. The acceptability of PTN echo on a PSN call depends on the combined effect of delay and echo loss of each possible echo path for a given call.

F.4 Quantizing Distortion

Quantizing distortion occurs in digital systems during the process in which an analogue signal is sampled and encoded into one of a finite set of values for digital transmission. The difference between the original analogue signal and that which is recovered after reconstitution is called quantizing distortion or quantizing noise, and is measured in quantizing distortion units (qdu). During the process of evolution from analogue to digital technology, several analogue/digital conversions may take place on a call path through public and private networks. The number of such conversions is expected to decline with time as more analogue systems are replaced with digital. However, new coding and voice compression techniques are being introduced that give rise to relatively high levels of distortion.

Use of the preferred values given in this Code should ensure satisfactory performance in most circumstances. Use of the limiting values could maintain intelligibility but may be perceived by users to be of lower quality.

The total number of qdu introduced into a PTN call path may be taken to be the arithmetic sum of the individual contributions within that call path which are to be assigned values in accordance with information provided by the supplier of approved apparatus or by the PTO providing leased lines. Typical values of qdu introduced by common digital processes are illustrated in Table F.4.

Table F.4: Quantizing distortion unit values for some digital processes.

Digital Process	Quantising distortion units
Processes involving analogue/digital conversion	
8-bit PCM codec-pair according to ITU-T Recommendation G.711 A-law or μ-law	1
7 bit PCM codec-pair (A-law or μ-law)	3
Transmultiplexor pair based on 8-bit PCM A-law or μ-law according to ITU-T Recommendation G.792	1
32 kbit/s ADPCM (with adaptive predictor) combination of an 8-bit PCM codec pair and a PCM-ADPCM-PCM tandem conversion	3.5
Cordless Telephone apparatus in accordance with BS6833 Parts 1 & 2	2
32 kbit/s CVSD. Combination of analogue-PCM-CSVD-PCM-analogue	6

16 kbit/s encoding. Combination of analogue-16 kbit/s encoding-analogue	10	
Purely digital processes		
Digital loss pad (8-bit PCM A-law or μ-law).	0.7	Note. 1
A-law/μ-law or μ-law/A-law converter according to Recommendation G.711	0.5	
A-law/μ-law/A-law tandem conversion	0.5	
μ-law/A-law/μ-law tandem conversion	0.25	
PCM to ADPCM to PCM tandem conversion according to Recommendation G.721	2.5	
8-7-8 transcoding (A-law or μ-law)	3	

Note. The impairment indicated is about the same for all digital pad values in the range 1 to 8 dB. One exception is the 6 dB (or multiple of 6 dB) A-law pad which introduces negligible impairment for signals down to -30 dBm0 and is thus attributed a 0 value for quantizing distortion units.

F.5 Synchronisation

Use of digital techniques in telecommunication networks gives rise to jitter and wander which affect the digital signals to an extent which may influence the service carried over a digital path. PSN are designed to contain the timing of digital signals within reasonable limits and may be used to derive timing to control PTNs.

Synchronisation 'slips' would need to occur quite frequently to have any noticeable effect on speech telephony

Synchronisation ‘slips’ have a serious effect on the throughput of digital data services and network signalling systems carried over digital paths due to error recovery routines.

F.6 Other Transmission Impairments

Certain other characteristics may adversely affect the performance of telephony calls and, more particularly, voice-band or digital data, e.g. facsimile. Since PSN are designed to contain these other impairments within limits specified in relevant ITU Recommendations it is recommended that, similarly, PTN are so designed. More specifically, It is desirable that PSN - PTN call paths, wholly within PTN call paths and PTN transit call paths, are not subject to excessive levels of impairment introduced by these other characteristics. At present such impairments have not been fully quantified and allocated to network segments with sufficient precision to allow specific allocation to PTN.

These other characteristics are: In-band noise, attenuation distortion or sensitivity variation, group delay distortion, side tone loss, intelligible crosstalk, bit error, signal power levels, impulsive noise and out-of-band noise. Apparatus designed to conform with recognised standards or recommendations

appropriate to the characteristic should be used in PTN. Some of these characteristics may become critical, particularly the noise level on radio links to off-shore installations.

G ECHO CANCELLERS (Informative)

G.1 Location

The correctly optimised location in the network for echo cancellation devices is very important. Ideally, echo chancellors should be provided in pairs, with each located as close as possible to each end user to increase the talker echo path loss for the other user. However, for local and international calls in the UK (where no echo cancellation devices are provided in the PSN) one echo cancellor of the pair should be positioned near the NTP and the other at the extremity of the long delay path, e.g. a leased line extension to a part of the PTN in another country via a satellite link.

It must be noted that in some cases echo cancellation is already built in to some specific terminal elements or connection elements within PTN, e.g. some ATM or low-bit-rate equipment. In such cases additional echo cancellation will not be required.

G.2 Type

Where bit transparent elements and standard coding/decoding functions are used at the terminating hybrid, echo chancellors in accordance with ITU-T Recommendation G.165 should be used.

> Note. Echo cancellors in accordance with ITU-T Recommendation G.165 use adaptation and cancellation algorithms that presume a linear echo path.

Efficient operation of such standard echo cancellors cannot be guaranteed if the echo path includes equipment that uses low-bit-rate coding.

When using low bit-rate or non-standard coding equipment preference should be given to equipment with already built-in echo cancellation or use echo cancellation equipment designed for the specific coding algorithm.

G.3 Data

When echo cancellors are inserted in a connection the bit transparency of the connection is destroyed. Thus for data transmission that requires transparent routing through an echo cancellor function the network designer should ensure that echo cancellors can be disabled by the 2100 Hz “disabling tone”.

BIBLIOGRAPHY

BS 6317: 1982: Specification for simple telephones for connection to public switched telephone networks run by certain public telecommunication operators.

BS 6328: Apparatus for connection to private circuits run by certain public telecommunication operators (multi-part standard).

BS 6450: Part 1: 1983 Specification for general requirements for private branch exchanges for connection to the British Telecommunications Public Switched Telephone Network.

Recommendation G.113: Transmission impairments.

Recommendation G.123: Circuit noise in national networks.

Recommendation G.151: General performance objectives applicable to all modern international circuits and national extension circuits.

Recommendation G.161: Echo suppressors suitable for circuits having either short or long propagation times.

Recommendation G.164: Echo suppressers.

Recommendation G.165: Echo cancellors.

Recommendation G.232: 12-channel terminal equipments.

Recommendation G.703: Physical/electrical characteristics of hierarchical digital interfaces.

Recommendation G.712: Performance characteristics of PCM channels between 4-wire interfaces at voice frequencies.

Recommendation G.821: Error performance of an international digital connection forming part of an integrated services digital network.

Recommendation M.1020: Characteristics of special quality international leased circuits with special bandwidth conditioning.

Recommendation M.1030: Characteristics of ordinary quality international leased circuits forming part of a private switched telephone network.

Recommendation M.1040: Characteristics of ordinary quality international leased circuits.

END