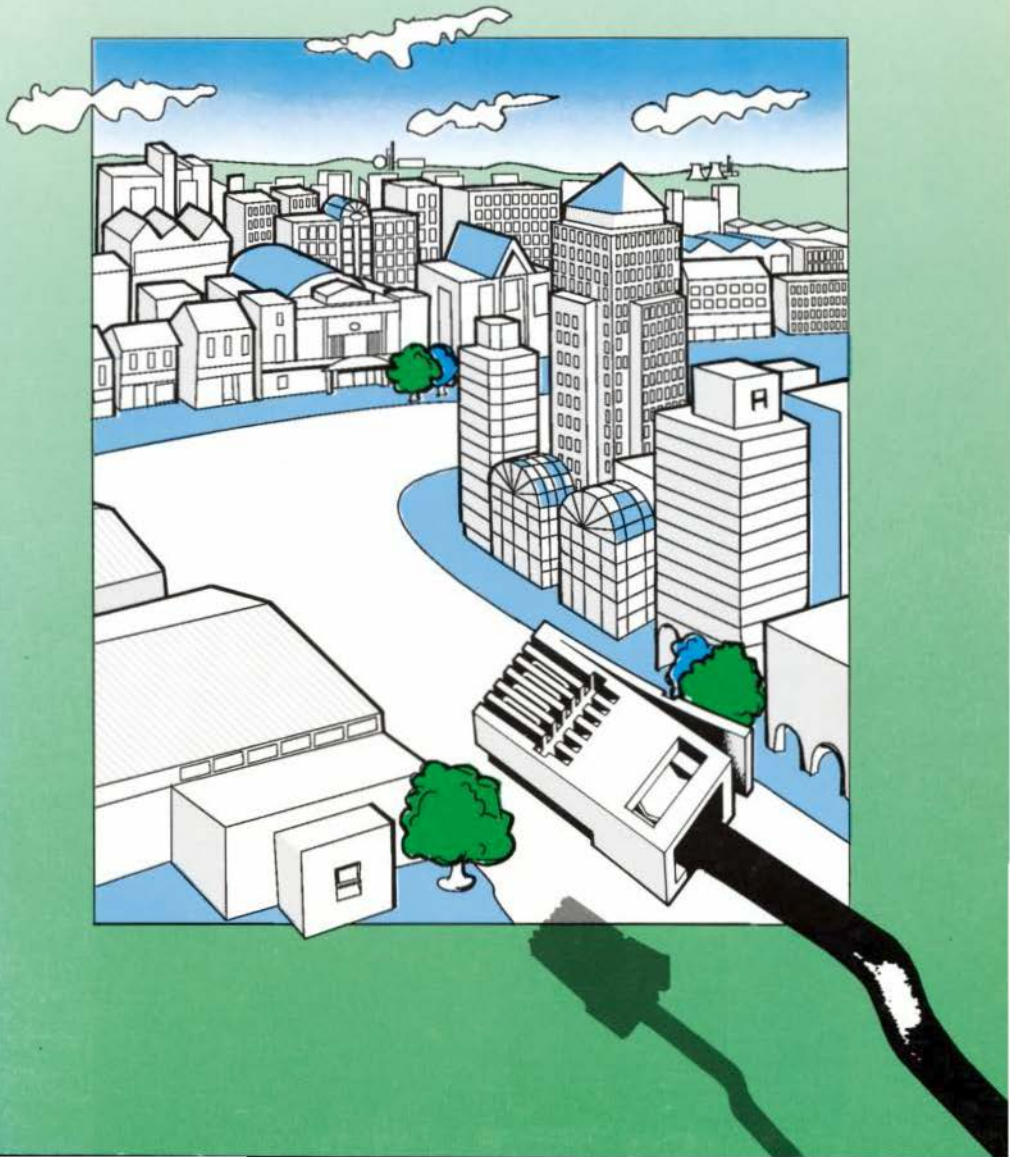
Oftel
Office of Telecommunications

THE WIRING CODE

PART 2

Business and Other Complex Installations



GLOSSARY OF ABBREVIATIONS

ac	alternating current
BS	British Standard (published by the British Standards Institution)
BSGL	Class Licence for the Running of Branch Telecommunication Systems*
BT	British Telecommunications plc
CCITT	International Telegraph and Telephone Consultative Committee
coax	coaxial cable
CRA	call routing apparatus
dc	direct current
DDI	direct dialling in
EMC	electromagnetic compatibility
ISDN	integrated services digital network
ISO	International Organisation for Standardisation
KCL	Kingston Communications (Hull) Ltd
MCL	Mercury Communications Ltd
MF	multi-frequency
NCOP	Code of Practice for the Design of Private Telecommunications Networks*
NTP	network termination point
NTTA	network terminating and test apparatus
OTR	OFTEL Technical Requirements*
PBX	private branch exchange
PTO	public telecommunications operator
PXML	private exchange master list
SCVF	single channel voice frequency
SIN	supplier's information note
TJF	test jack frame

*Published by OFTEL

CONTENTS

1 INTRODUCTION

1 This handbook is Part 2 of OFTEL's *Wiring Code* and covers complex systems on customers' premises such as those found in a business environment. Digital services as well as analogue telephony are covered. A typical installation will have more than one exchange line and will contain switching equipment such as a **private branch exchange (PBX)**.

2 Part 1 of OFTEL's *Wiring Code* deals with simple installations, and covers most domestic wiring situations. Except where it is necessary to expand the text, Part 2 does not repeat the material of Part 1 and you should refer to that part for the more basic material, particularly the wiring of single exchange lines in most of their application contexts. In Part 1 eight Principles are stated (A to H) - you will need to refer to these. Some further Principles (I onwards) are included in this part.

3 These Principles and the guidelines in this handbook are based on two legal obligations

- what you are licensed to do and
- what your apparatus is approved to do.

4 This introductory section explains:

the essential differences between wiring for analogue and digital purposes

- what is included and excluded under the wiring heading
- where the boundary lies between the **public telecommunication operator**'s (**PTO**'s) network and a private system
- briefly, the various basic types of line termination at the network boundary and
- refers to the concept of structured wiring.

5 This introductory section is followed by five major sections covering the following topics:

- **Section 2** covers general principles and practice, and explains the special wiring requirements for **call routing apparatus** (**CRA**).
- **Section 3** deals with performance objectives for analogue circuit wiring and suitable types of connector.
- **Section 4** covers similar ground to Section 3 but for digital circuit wiring.
- **Section 5** covers safety aspects in general.
- **Section 6** explains how existing wiring may be made available, upgraded and re-used. The principles relating to 'integrated' wiring, that is PTO and customer premises wiring sharing the same cable sheath, are discussed.
- **Section 7** covers record keeping

6 There are numerous references to **British Standards** (**BS**s) in the Code but, owing to recent changes in regulations and pending amendments to the standards, there may well be differences between what the standards say and what this Code says. OFTEL publishes a series of *Updates* which are issued as regulations are changed. *Updates* are available through a mailing list (tel: 071-822 1519) and provide the latest information.

Wiring for analogue and digital purposes

7 Part 1 covers analogue circuit wiring only but here we consider both analogue and digital circuit wiring and it is necessary to start by saying what is meant by these terms:

> **Analogue circuit wiring** is wiring carrying analogue voice band telecommunication services between analogue interfaces. For example, the majority of lines from the public switched telephone network (PSTN) are terminated in an analogue interface.

Digital circuit wiring carries messages or signals in digital form and it does not matter in this context whether such messages or signals represent speech or any other type of information provided that the wiring is connected to digital interfaces. An example of a digital interface is the interface to a digitally presented public telecommunication system, for example an **ISDN** (**integrated services digital network**) interface.

8 Wiring that is connected directly to an analogue voice band circuit of a public telecommunication system is not digital circuit wiring whatever the nature of the information conveyed over it because the interface is an analogue one. For example group III facsimile (fax) (which is digital information) is often conveyed to and from a public system via an analogue interface and connected via analogue circuit wiring to apparatus such as a PBX. On the customer side of the PBX, digital circuit wiring might then be used to provide the final link to the facsimile terminal equipment. However the apparatus involved in this indirect connection must contain code conversion circuits - for example a data adaptor or an analogue-to-digital and a digital-to-analogue convertor, in series with the communication path. The principles governing when digital, as opposed to analogue, circuit wiring apply are fairly complex and are treated in greater detail in paragraphs 27 and 28.

What 'wiring' includes and excludes

9 The term 'wiring' as used in this Code requires some explanation. For the purpose of this Code wiring includes:

- any tangible link between separated items of telecommunication apparatus
- any incidental wiring components or accessories (see paragraphs 24 and 25) connected to it **except** where such

apparatus is part of a public telecommunication system

- both internal (within a building) and external (between buildings on one site) wiring that is not part of a public telecommunication system. External wiring will require different wiring and wiring accessories to withstand a harsher environment but the principles and guidelines apply equally to both situations. The installation of external wiring is covered in the British Standard Code of Practice, BS 6701: Part 1, and is not considered in depth here.

Wiring excludes:

- radio links
- flexible leads that are approved with and supplied as part of the apparatus. (Such leads whether they are permanently attached or connected by plug and socket are treated as part of the apparatus to which they are attached.)
- any approved series apparatus for the regeneration of signals that is a necessary part of the connection and distribution process. When such apparatus is allowed it is not approved as part of the wiring.
- wiring of private telecommunication systems that are not connected, either directly or indirectly, to any public telecommunications system. Such systems are exempt from telecommunication regulations.

10 In this context 'public telecommunication systems' include systems run by BT, Mercury Communications, Kingston Communications (Hull), and systems run by operators licensed under section 73 of the Broadcasting Act 1990 to provide cable programme services. Examples of such systems are:

- the switched telephone or telex networks
- the newer digital systems, such as ISDN or packet switched public data networks

- private circuits of all descriptions (including 'tie lines', 'external extensions', 'AccessLines', analogue and digital circuits).

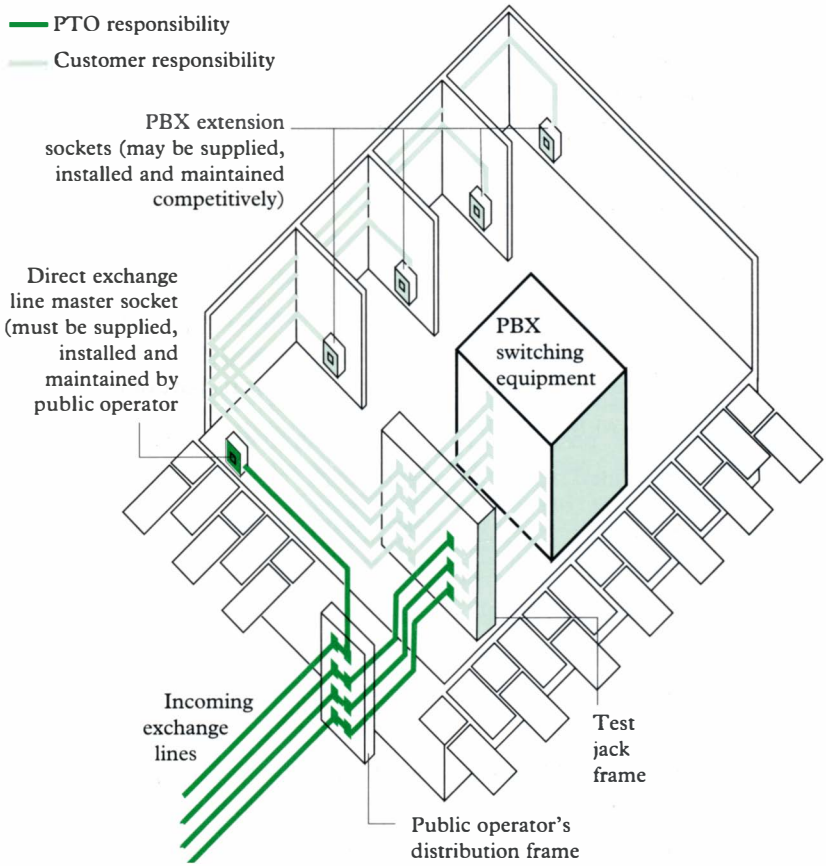
11 For the purposes of the principles given in this Code, telecommunication apparatus is regarded as being connected to one of these public telecommunication systems (directly or indirectly, according to the circumstances) if any kind of message or signal can pass between them.

The boundary between the PTO's and the customer's wiring

12 The distinction between wiring that forms part of a PTO's system and wiring connected to it that forms part of a private system is a very important one and it is therefore essential to identify clearly the *boundary* of a public telecommunication system. This boundary or demarcation point between the customer and the PTO is called the **network termination point** or **NTP**; a term that will be frequently encountered throughout the rest of this Code.

13 PTOs' licences require the boundary between a public system and a customer's installation to be on the customer's premises. The NTP is to be found at one or more connection points depending upon the services provided, eg a connection frame or master socket, at which approved apparatus (including wiring) may be connected and disconnected. For any circuit carrying messages or signals to and from a public system there is only one NTP. Thus the point at which an extension telephone or data terminal is connected to a PBX extension line is not the boundary of a public system because messages and signals to and from that terminal also pass across the point at which the private exchange itself (which is approved apparatus) is connected to the public network. Figure 1 illustrates the situation for a PBX

Figure 1 An example of how a simple business installation might look.



Notes:

1 Wiring shown in light colour is not part of the public system and may be supplied and installed competitively. It must be maintained by the maintainer of the PBX or his subcontractor.

2 When the test jack frame is the point of connection to the public network, the wiring shown in the dark colour is part of a public system and must be installed and maintained by the public operator. When the test jack frame is not the point of connection to the public network the wiring between it and the point of connection is the responsibility of the customer. Similarly, a master socket is not the only means of providing a direct exchange line connection point.

3 The specification for the PBX includes an upper limit on the length of wiring between the TJF and the switching equipment.

connected to analogue PTO lines and further details are given in paragraphs 35 to 46.

14 However, the PTO side of the boundary or NTP is not necessarily the last physical interconnection point before the public telecommunication system leaves the customer's premises because connection frames, junctions between external and internal grade cables, etc, belonging to the PTO may be located on those premises.

Types of connection at the network boundary

15 At the boundary between the PTO and the private network the connection can take a number of forms which include:

- for analogue telephones, a plug and socket as described in Part 1, paragraph 13, or a hard-wired connection as described in Part 1, paragraph 15
- for digital circuit terminations one of a number of specified plugs and sockets (see paragraphs 101 to 104 of this part)
- a connection strip
- a connection frame to which the customer's wiring may be connected by an approved plug or be hard-wired: note that in the case of CRA (see paragraphs 35 to 46) this frame may be the **test jack frame** (**TJF**)
- a flexible lead with a plug for the terminal apparatus that is hardwired to a connection strip at the boundary (particularly for connection to leased - ie private - circuits).

Structured wiring or cabling schemes

16 There are a number of structured wiring or cabling schemes that are available commercially and which may offer an attractive solution for customer wiring installations, particularly when such installations are large and complex. The basic objectives of such

schemes are to ensure adequate performance and provide the flexibility to make changes easily to building wiring. Professional advice may be required on the advisability of using such schemes and on how they may best be implemented.

General principles and guidelines

Applicability to telecommunication systems

17 All customer's installations discussed in this Code are telecommunications systems and by statute must either be exempt from licensing or must be run under a licence. (Exempt systems cannot be connected, directly or indirectly, to public telecommunication systems, and, as indicated above, are not subject to rules about wiring; nevertheless the content of this Code is of general value and may be usefully applied to exempt systems.) In most cases the licence that applies is the *Class Licence for the Running of Branch Telecommunication Systems* (often known as the **BSGL**). This licence specifies the circumstances in which the customer's wiring may leave any one set of premises. The principles contained in the BSGL are very important for the construction of lawful telecommunication systems, but are beyond the scope of this Code. Copies of the BSGL are available from OFTEL.

Network performance

18 Analogue circuit wiring and digital circuit wiring introduce impairments, such as attenuation and delay, that may affect the overall performance of an end-to-end connection. These impairments need to be considered, particularly when a complex private network is connected to a public network. This too is beyond the scope of this Code and you should consult OFTEL's *Code of Practice for the Design of Private Telecommunication Networks* (the so-called **NCOP**) for guidance on this and other topics concerned with network performance.

The four major wiring activities

19 The main points about wiring will be discussed under four headings - supply (paragraphs 21 to 25), installation (paragraphs 25, 37 and 38), bringing into service (paragraphs 26, 39 to 41 and 46 to 48) and maintenance of wiring (paragraphs 42 to 44).

20 Maintenance principles as stated here are based only on the legal obligations given in paragraph 3. In this context the BSGL is particularly relevant and may need to be consulted. Other obligations that may have been entered into as part of a commercial maintenance agreement may place additional constraints on users but such obligations are not considered here.

Wiring supply and installation

21 The basic Principles A and B of Part 1 regarding wiring responsibilities apply; note that these Principles are based on BS 6701. Note too, that in accordance with Principle C, the wiring, wiring components and the apparatus that wiring connects must all be approved.

22 For the provision of public system wiring PTOs will normally do all the work themselves, but in some circumstances, for example in unusually hazardous places, PTOs may agree to involve others as their agents in the provision of parts of their system.

23 For the provision of wiring on your side of the NTP, the following Principle applies:

I You should only use approved components for direct and indirect connection to the public network. There are no additional principles for supply and installation unless CRA is involved in which case Principle L also applies.

(See paragraphs 35 and 36 for a definition of CRA.)

24 As indicated above all relevant apparatus must be approved and this includes wiring and wiring accessories. The General

Approval process for wiring does not involve an independent approval body but is a self-certification procedure on the part of the manufacturer or supplier of the parts concerned. Currently there are two OFTEL General Approvals for wiring:

- Since 23 April 1990 certain components, including wire, cable, plugs, sockets, terminating blocks, etc, have been approved for use in connection with voiceband services. OFTEL General Approval number NS/G/23/L/100005 (abbreviated to GA5) contains details of these components.
- Since 13 February 1991 components for use in connection with digital interfaces have been similarly approved. OFTEL General Approval number NS/G/15/M/100009 (abbreviated to GA9) contains details of the types of component that can be approved for use with digital circuit wiring.

Prior to the above dates wiring was not covered by a General Approval and it was connected at the discretion of the relevant PTO.

25 Approved components or their packaging must be marked with the fact that they are approved and, where appropriate, the values of certain of their performance parameters. For example, the loss or loop resistance for a specified length of cable or wire could be marked on the cable drum. When installing components as part of a building wiring scheme due regard should be paid to the guidelines given with respect to distance and layout in general and, for digital circuit wiring, to data rates.

Bringing into service

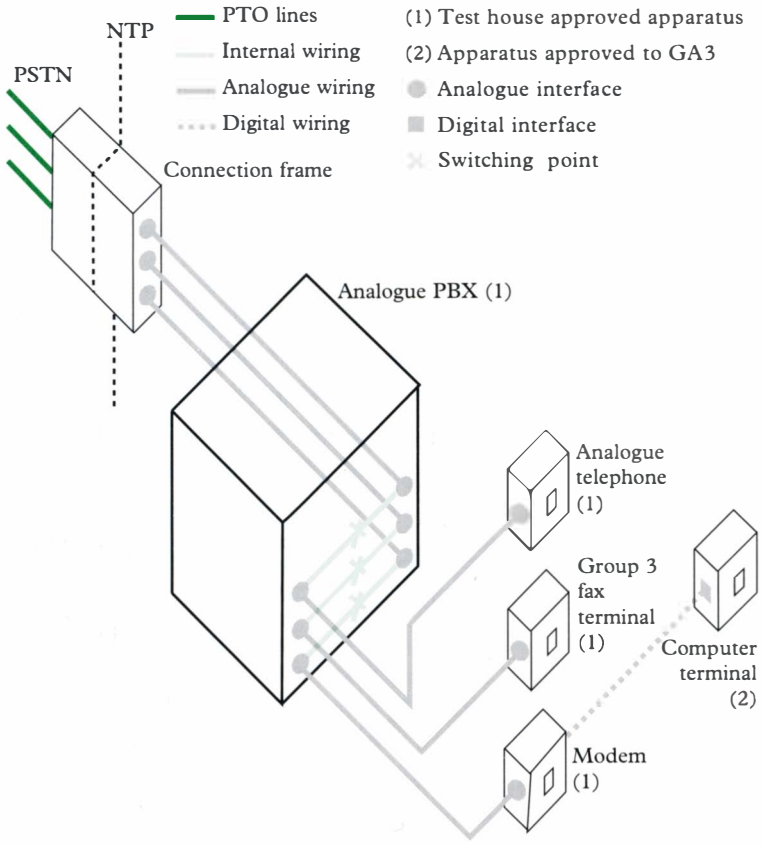
26 See Part 1, paragraphs 11 and 12, for the relevant basic Principles (D and E), and for general guidance. Different considerations will apply in the case of CRA and these are given in paragraphs 39 to 41 and 46.

Applicability of digital circuit wiring

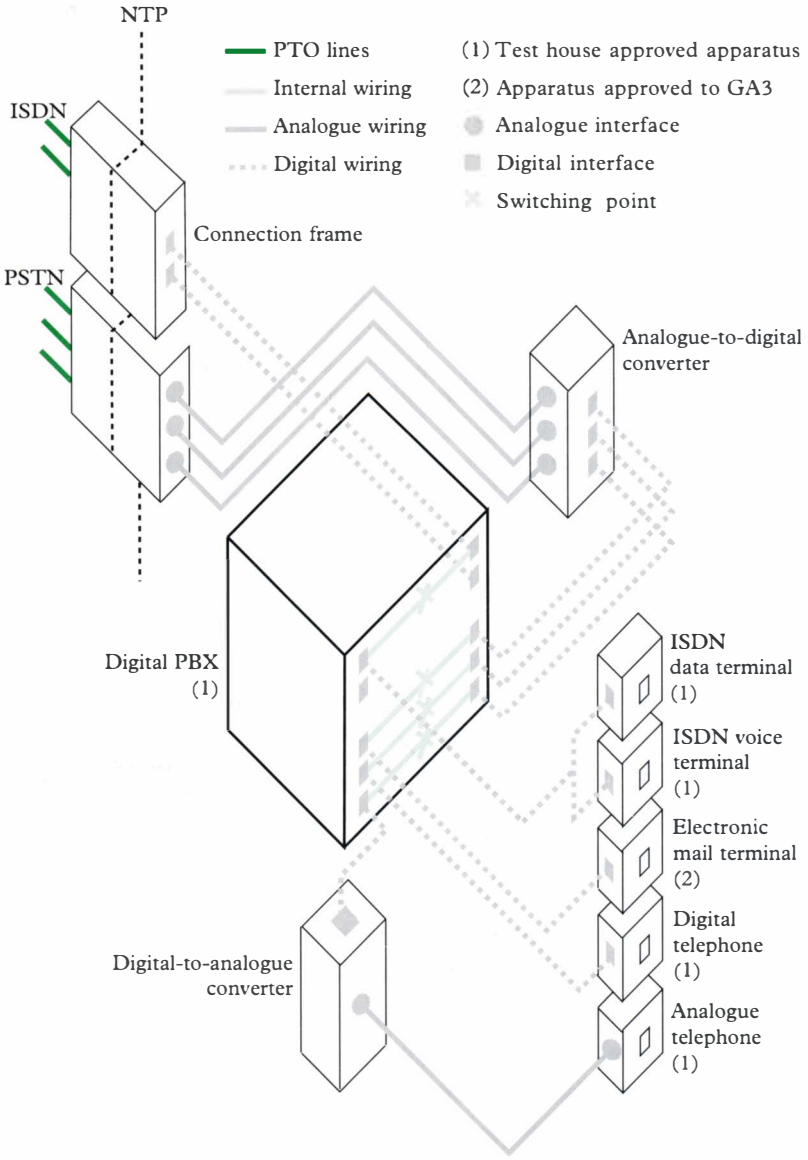
27 Digital circuit wiring can in principle carry any form of digital signal, but only analogue circuit wiring may be connected to analogue interfaces irrespective of the form of the signal being conveyed (see paragraph 8). This distinction is necessary because signals entering the public telecommunication network via an analogue interface need to meet specific noise margins at frequencies above the analogue speech band. This can be

Figure 2 examples of analogue and digital customer circuit wiring

(a) Example of analogue PBX wiring



(b) Example of digital PBX wiring



summarised in the form of two Principles:

J Analogue circuit wiring applies when:

- wiring carries analogue speech signals and when
- digitally encoded signals with a spectrum confined to the analogue voice band are carried by a circuit that is connected directly or indirectly by an analogue path to an analogue PTO voice band service.

K Digital circuit wiring applies to wiring carrying digitally encoded signals between digital interfaces.

28 Figure 2 shows examples of how these Principles apply to analogue and digital circuit wiring in a system having an analogue interface (figure 2a) and a system having an analogue and an ISDN digital interface (figure 2b).

General approval for indirectly connected digital apparatus

29 OFTEL General Approval Number NS/G/234/J/100003 (abbreviated to GA3) covers the approval of indirectly connected apparatus transmitting messages in digital form. However, the definition of digital messages in GA3 is different from, and more restrictive than, that intended here. Digital circuit wiring as defined here may carry digital messages using any form of digital encoding and may therefore in some circumstances be used to connect equipment that would not qualify as 'digital' under GA3.

Analogue and digital circuits within the same cable sheath

30 Following consultation with experts, OFTEL intends to issue Part 3 of the *Wiring Code* containing rules and guidelines to cover the situation where wiring within the one cable sheath is shared between analogue and digital services.

31 In the meantime, and in the absence of specific assurances on the part of the equipment supplier, it is recommended that such sharing be avoided. Because the ability to share wiring is a function of the cable parameters and the spectra of the signals

involved, the rules are likely to be relatively complex. (See paragraphs 96 to 99 for guidelines on digital signals sharing the same cable sheath.)

32 Figure 2b shows an example of a case where sharing may be satisfactory. On the bottom right of figure 2b, the connections to the analogue and digital telephones are both carrying speech and these connections can, subject to the PBX supplier's instructions for use, share the same cable sheath. Such sharing is acceptable because any out-of-band noise that may be coupled from the digital to analogue circuit is suppressed in the analogue-to-digital conversion process in the PBX.

Connection of cable screens

33 Cables may contain screens in the form of braiding and this braiding may be round individual pairs, round a group of pairs or be an outer braiding round the complete cable form. With balanced circuits the braiding should act only as a screen and should not carry information or power which means that it should be earthed at one end only. If it is earthed at both ends its effectiveness as a screen will be reduced. With unbalanced connections (eg coaxial cable) the braiding is a common return which carries signalling information and therefore must be connected (but not necessarily to earth) at both ends. When screens are required to be connected, or the outer of a coaxial cable earthed, at one end only it is necessary to determine which end that should be. In the absence of any specific information to the contrary, the following guidelines apply:

- When the circuits that are screened carry information in one direction only, the screen should be earthed at the transmitting end.
- When the circuits that are screened carrying information in both directions, the end at which the screen is earthed is arbitrary but note:

(a) When the connection is between a customer's premises and a PTO network it should be assumed that the screen is earthed at the PTO end.

(b) When one piece of customer premises equipment is common (eg a PBX) and another is separate (eg a terminal) then it would be good practice to earth screens at the common equipment end.

Wiring approved for digital and analogue use

34 Some wiring and wiring accessories are capable of being approved for both analogue and digital use and there may well be advantages in terms of increased flexibility and economies of scale in selecting (if possible) the same type of wiring or components for a mixed digital and analogue installation. (The re-use of analogue circuit wiring for digital services is covered in paragraph 113.)

Call routing apparatus and the wiring connected to it

Definition

35 **Call routing apparatus** (**CRA**) is switching equipment capable of switching live speech between two or more extensions and two or more exchange lines. (Note: the BSGL gives the full legal definition of CRA.)

36 CRA includes private branch exchanges (PBX). Some PBXs are approved in conjunction with proprietary extension telephones when they are commonly called 'black box' approved. With such approval, extension telephones are considered to be internal to the PBX and there may well be specific constraints on wiring lengths and layouts that are part of the PBX specification. Such constraints do not normally apply to wiring connected to PBXs which are approved with ports specified for the connection of other circuits and attachments.

Installation of CRA wiring

37 Wiring that is connected to CRA and is on the customer's side of a public network connection point may be supplied and installed competitively, subject to certain other constraints. Some of these constraints are specified as licence conditions, others derive from the conditions in the approval of CRA and in the designation of the standards for such apparatus. Whilst anybody may supply this wiring, the next Principle relates to installation:

L Wiring connected to CRA must either:

(a) be installed in accordance with the British Standard Code of Practice (BS 6701) currently in force or

(b) in the case of wiring installed before the current version of BS 6701, be installed in accordance with the code of practice in force at the time of its installation or

(c) be accepted as satisfactory by the PTO, or PTOs, which provides the NTP, or NTPs.

38 Principle L(b) (ie wiring not to BS 6701) applies mainly to existing wiring that is suitable for re-use. If a PBX is directly connected to circuits provided, say, by MCL and BT then the wiring would have to be acceptable to both these PTOs.

Connection of CRA

39 Under the terms of the BSGL the final connection of any CRA to a public telecommunication system may only be made by:

- a properly registered installer or properly registered Designated Maintainer, or
- by a PTO.

40 Whoever makes the connection will wish to verify that the apparatus is approved and has been correctly installed in accordance with that approval. This will include a check that the wiring has been installed in accordance with the Code of Practice (BS 6701). Under Principle L(c) above, a PTO has discretion to

connect wiring that has not been installed to BS 6701. This arrangement is intended to allow *in situ* wiring, which is safe and in good condition but may not comply with the Code of Practice, to be re-used when the CRA served by it is replaced.

41 British Standard Codes of Practice (QAS 7902/377 and QAS 7902/381) are available and a technical guide for installers and maintainers is under preparation by OFTEL. These cover the installation and bringing into service of CRA and associated wiring.

Maintenance of CRA wiring

42 A further Principle applies to the maintenance of wiring connected to CRA.

M All wiring connected to CRA must be maintained under a contract with the Designated Maintainer of that CRA. Where the wiring within a premises is connected to more than one item of CRA, it must be maintained by the Designated Maintainer of one of these items.

43 Principle M applies to all non-PTO wiring connected to CRA on both sides of the test jack frame; in particular it applies to customer wiring which under the new rules (see paragraphs 57 to 61) provides a connection between the TJF and NTP.

44 When wiring connected to CRA is required to share a cable sheath with wiring not connected to CRA, the total maintenance of that wiring is the responsibility of the Designated Maintainer. The Designated Maintainer may therefore refuse to allow such sharing in cases where he feels he cannot accept responsibility for the consequences.

The role of the Designated Maintainer

45 The Designated Maintainer may, if he wishes, sub-contract maintenance of the wiring, or some of the wiring, to a specialist contractor provided that he retains overall responsibility and monitors the quality of the work done.

Bringing into service wiring connected to CRA

46 Two further Principles in this group relate to the bringing into service of wiring that is connected to CRA.

N If, in order to bring into service wiring that is connected to CRA, it is necessary to alter that apparatus or remove its outer cover, then only the Designated Maintainer of the apparatus, his sub-contractor or an installer who is so authorised, may bring the wiring into service.

O If removal of an outer cover is not necessary and the CRA approval does not include the extension telephones (ports approval), then anybody may bring the wiring that provides the connections to extension apparatus into service provided that either:

- the Designated Maintainer has agreed; or
- the Designated Maintainer has been given 14 days written notice specifying the person who is to bring the wiring into service.

Note the distinction between bringing into service of the wiring alone covered by this clause and the bringing into service of the CRA plus wiring which is covered in paragraphs 39 to 41.

Wiring not connected to call routing apparatus

47 Paragraphs 37 to 46 do not apply where the wiring is not connected to CRA, providing such wiring is installed in accordance with OFTEL's *Wiring Code*. It follows that wiring that conforms to OFTEL's *Wiring Code* which is not connected to CRA may, if it is connected by an approved plug (see Principles D and E of Part 1), be brought into service by anyone.

48 Examples of wiring not connected to CRA are wiring attached to a single direct exchange line or to a single private circuit.

Distance and attenuation limitations

Enhanced and unenhanced exchange lines

49 Different principles apply depending upon whether the line, or lines, between the customer's premises and the exchange can be regarded as *enhanced* or *unenhanced*. Residential connections are to be regarded as being unenhanced and the treatment in Part 1 is based on that supposition. Most business premises, and particularly CRA, are connected to enhanced exchange lines and the limitations on the length of customers' wiring are expressed in ohms rather than metres. (This could give rise to some confusion because there is a limit of **250 metres** that applies to wiring connected to an unenhanced exchange line and a limit of **250 ohm** that applies when the exchange line is enhanced.) All MCL and KCL business exchange lines can be regarded as enhanced but older BT business lines or very long exchange lines may not be. If in doubt, you should consult the PTO direct, or via your supplier, and if you find that your lines are unenhanced you can ask for them to be upgraded, although in so doing you are likely to incur additional charges. In the case of BT, some direct dialling in (DDI) lines may not qualify as enhanced and you are advised to consult BT.

50 Note that 250 metres of wiring having a core diameter of 0.5 mm corresponds to a loop resistance of about 50 ohm or an attenuation of about 0.5 dB. A resistance of 250 ohm corresponds to a distance of about 1250 metres and an attenuation of about 2 dB.

Wiring connecting extension apparatus to direct exchange lines

51 **Unenhanced lines.** See Part 1, paragraphs 23 to 27, for details of the distance limit Principles for wiring and extension

apparatus connected to exchange lines without the involvement of CRA.

52 Extension wiring introduces impairments to the call paths in terms of the loop resistance, transmission loss, noise, crosstalk and dialling distortion, all of which can add to the difficulty of making a successful call. Adherence to Principles G and H will minimise these difficulties and it is recommended that when possible tone 'dialling' (or MF signalling), which is less susceptible to distortion than loop disconnect signalling, is used on the longer extensions.

53 If series apparatus (such as that used for trunk-choice routing) is inserted between the NTP and the customer's apparatus then use can be made of the principles outlined in BS 6789 for series connected (analogue) apparatus but a pro rata reduction in wiring length ensues.

54 The principles outlined in BS 6789 can be summarised as follows:

P The series loop resistance of wiring and series apparatus between the NTP and the main apparatus (which is not CRA) should not exceed 13 ohm or 53 ohm as specified in BS 6789.

55 The main apparatus is classified in BS 6789: Section 6.1 where the loop resistance limit on the series apparatus alone is specified according to type as 10 or 50 ohm.

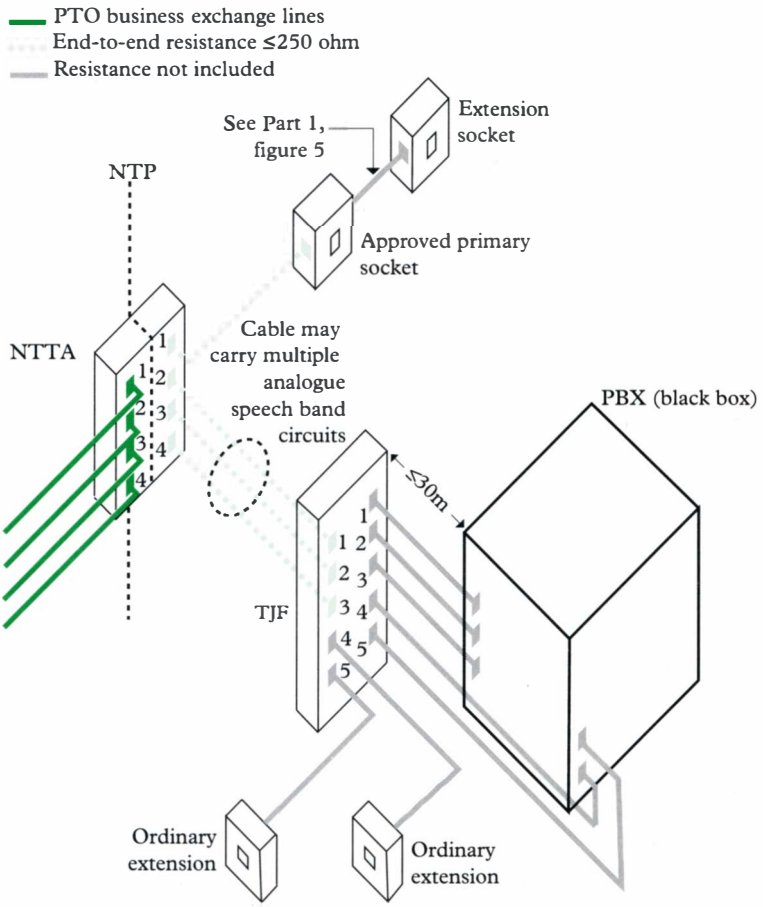
56 **Enhanced lines.** The following Principle applies:

Q For enhanced exchange lines, the series loop resistance of wiring and series apparatus between the NTP and primary socket should not exceed 250 ohm (figure 3).

Wiring connecting CRA to enhanced and unenhanced exchange lines

57 The Principles that apply to the series resistance of wiring and apparatus are as follows:

Figure 3 Guidelines for customer wiring with PTO enhanced exchange lines (see paragraphs 73 and 74 for a description of a primary socket).



R With unenhanced exchange lines, the series resistance of wiring-loop and approved series apparatus between the test jack frame (TJF) (which is at the NTP) and CRA (eg a PBX) should not exceed 13 ohm of which the series

apparatus resistance alone must not exceed 10 ohm. Nor should the distance between the CRA and the TJF exceed the value, normally 30 m, contained in the specification for CRA.

S For enhanced exchange lines, the series resistance of wiring-loop and series apparatus between the NTP and TJF associated with the CRA, should not exceed 250 ohm (figure 3), but see paragraphs 62 to 64 when through-feeding is used. The distance between CRA and its TJF should not exceed the value, normally 30 m, given in the CRA specification.

58 Note that information on CRA is contained in the specification against which approval was granted - the approval document - and for PBXs in an associated **private exchange master list** (normally abbreviated to **PXML**) as well as in the supplier's instructions for use. Note too that in Principles R and S the TJF is regarded as separate from the CRA although for a PBX the TJF is approved as a part of or in conjunction with the switching equipment.

59 Principle S is based on a combination of near worst case specified performance limits within the PTO network and the customer's branch system. Consequently, if customers operate their branch systems close to the limits of Principle S when exchange lines are also close to their specified performance limit, there may be problems arising from an adverse combination of operational tolerances. You are therefore advised, where possible, to operate your system below the limit or to take advice from your supplier if the planning documentation suggests there may be a problem. The NCOP gives guidance on preferred and limiting values of impairments relating to perceived performance of call paths.

60 For some types of CRA, if the attenuation between the

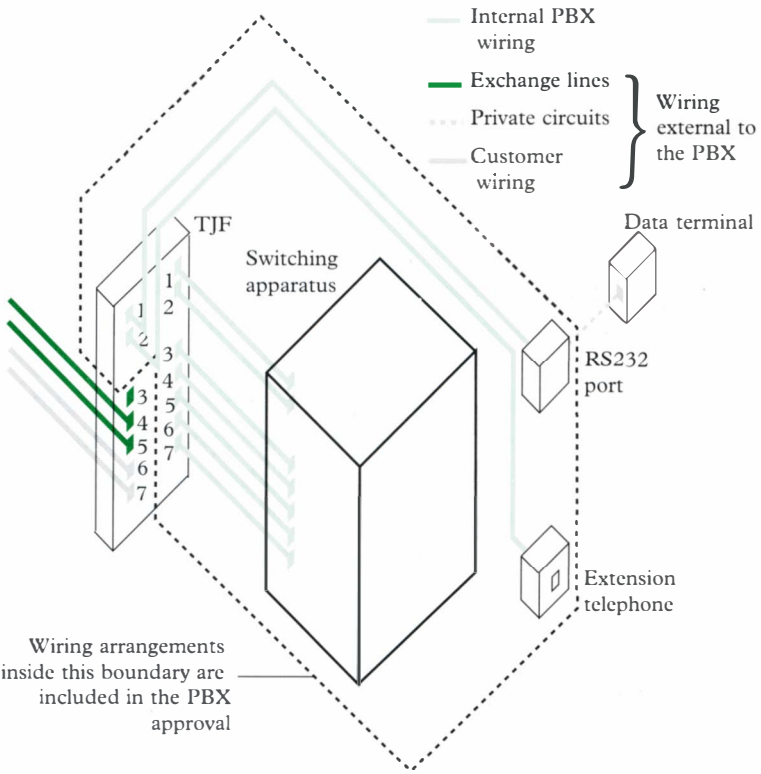
CRA and NTP is changed, it may be necessary for the Designated Maintainer to make compensatory changes (within the approval limits) to the CRA.

61 As Principle S states, the 250 ohm limit applies only to the wiring between the NTP and TJF; it is independent of any wiring arrangements that are part of a black box CRA (see figure 4).

Through-feeding

62 Through-feeding occurs when a PBX (CRA) connects (abnormally under equipment failure) extension apparatus to an

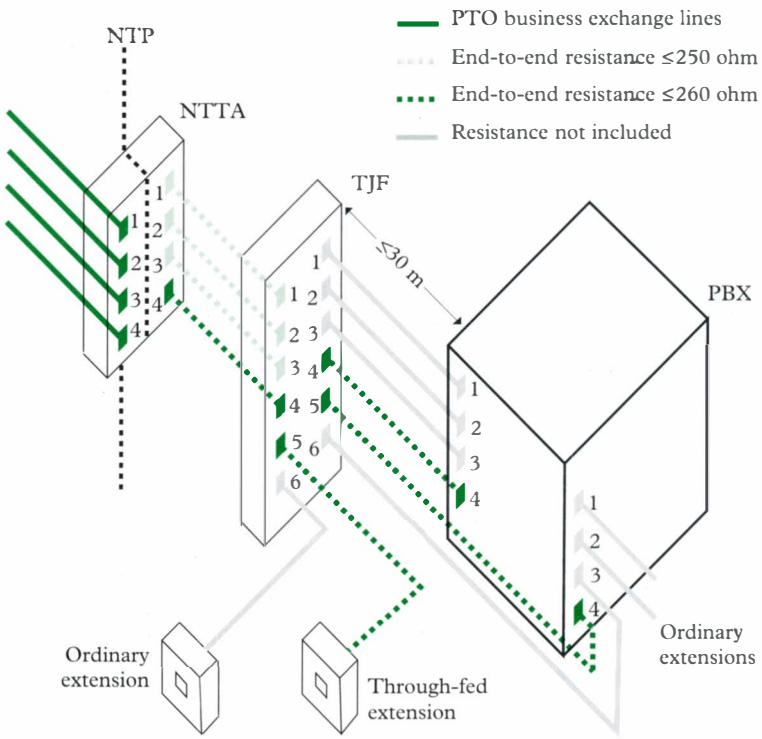
Figure 4 Example of wiring within and outside the PBX approval boundary.



exchange line and the power feed for the apparatus is provided by the public exchange rather than the PBX. The following Principle then applies.

T For enhanced exchange lines (see figure 5) where the PBX uses through-feeding, the total series resistance of wiring-loop and series apparatus should not exceed 260 ohm between the NTP, through the TJF and PBX, to extensions that are designated to make '999' calls or that are designated to receive incoming calls in accordance with BS 6450, Part 1, Clause 19 (power and equipment failure).

Figure 5 Guidelines for wiring with a through fed extension.



63 Allowing for the PBX and the extension wiring, a good rule of thumb would be that the total resistance of the wiring-loop and any series apparatus should not exceed 200 ohm. Some apparatus may not operate satisfactorily with more than 200 ohm. If in doubt, consult your suppliers.

64 Through-fed ports of apparatus that has been approved to OFTEL's standard OTR:001 (paragraph X 16.2.2) or equivalent may not work satisfactorily with these new arrangements - if in doubt, consult your supplier. (Note: The relevant part of OTR:001 is being superseded by BS 6450 Part 4.)

Wiring connected to analogue private circuits

65 Private circuits may be connected by wiring from an NTP to terminal apparatus or to a port on CRA.

66 **Direct connection.** Particular care is required with apparatus, such as a modem, that is sensitive to changes in signal level arising from an increase in wiring length. Consequently users are advised to seek professional advice or to test the apparatus with the proposed length of wiring (or its equivalent) to establish satisfactory working before installing the wiring permanently.

67 **CRA.** There is no reason in principle why wiring should not be inserted between the TJF and the NTP of private circuits. However the performance might be unsatisfactory unless adjustments are made to signal levels of the private circuit or the terminating apparatus. (For example ac signalling between PBXs is sensitive to the signal level.) Some apparatus may be provided with means for adjusting signal levels but, even if it is, the physical or permissible (within the approval limits) range of adjustment may not be adequate. When it is not possible to make adjustment, the following alternatives may be considered:

- selection of a private circuit having a lower loss
- local amplification or regeneration using approved apparatus

- digital rather than analogue private circuits if digital ports are available.

In any event the advice of the Designated Maintainer should be sought and any adjustments to apparatus that are made must be carried out by him.

Wiring connected to telex networks

68 In the great majority of cases when the PTO provides a single channel voice frequency (SCVF) interface, telex connections will continue to work satisfactorily in the presence of the added attenuation caused by extending the customers wiring by up to 250 ohm between the NTP and the telex apparatus. If your premises are a very long way from the telex exchange, you are advised to consult your PTO before considering extending your wiring beyond the distance explicitly or implicitly specified as part of the telex equipment approval.

69 The alternative PTO interface to the SCVF interface is a V.28 low voltage digital one and distance limitations are covered in paragraphs 101 to 104.

Performance of overvoltage protection circuits

70 The General Approval (GA5) for analogue wiring permits the use of overvoltage protective devices as wiring accessories and requires that their performance be specified. It is not mandatory to fit overvoltage protection circuits and users must make their own assessment regarding the need for them. Performance in the presence of an overvoltage, and recovery behaviour after that overvoltage is removed, needs to be specified and in this context the CCITT Recommendations K.11 and K.12 may well be relevant but there might be other, perhaps more onerous, requirements. For the purposes of this Code, however, only the behaviour of the protection circuit in the no overvoltage state is considered because it is only in that state that performance under normal operation is affected.

71 An overvoltage protection circuit can introduce series and/or shunt impedances and these are a potential source of impairment. The limits set on these parameters are dependent on how many protection circuits are, or can be, connected in tandem in an end-to-end connection. The following guidelines are based on the assumption that there is only one protection circuit present in the set of premises that makes one end of a connection and that the protection circuits associated with PTO lines are placed close to the NTP on the customer side of the NTP. In the event that there is more than one protection circuit then you should seek expert guidance on the effects of the cumulative impairments.

72 A single protection circuit should meet the following guidelines:

- The series loop impedance should not exceed 10 ohm at any frequency in the range 300 Hz to 3400 Hz. (However in the presence of series connected apparatus, see paragraphs 53 to 57, a check should be made to ensure that the total series impedance does not result in malfunctioning of the equipment.)
- The shunt impedance between any two conductors should be more than 10,000 ohm and between any one conductor and earth should be more than 30,000 ohm at any frequency between 300 Hz and 3400 Hz. (30,000 ohm at 3400 Hz corresponds to a capacitance of 1.5 nF.)
- The shunt resistance between any two conductors and between any one conductor and earth should be less than 5 Mohm when measured at 50 V dc.
- After the passage of a surge, the protection arrangement should cease its protective action and revert to its normal state when the dc voltage between a pair of protected conductors falls to a value of less than 80 V.

Connectors and connections

Master, primary and extension sockets

73 Details and Principles relating to the provision and wiring of master and extension sockets are to be found in Part 1, paragraphs 13 to 27 and in the section entitled *Wiring up a master socket.* (Note that the line cord plug shown in figure 1 of Part 1 is required to conform to BS 6312.) An additional Principle applies to enhanced exchange lines:

U Enhanced exchange lines not connected to CRA will be terminated at the NTP and should be connected from there by a balanced two-wire pair to a primary socket (see figure 3).

74 In this case the primary socket will contain the additional components (for ringing the bell) that are more normally located in the master socket. At the NTP, connections may be made using a connection strip type 237A or equivalent, or, if there is CRA on the premises, to spare positions on the connection frame (see section below).

Termination of CRA

75 All CRA ports are terminated on a TJF. Connection of customer equipment may be hard-wired or by approved plug and socket.

76 Where there is no customer wiring between the NTP and the TJF, apparatus should be terminated at the NTP in accordance with BS 6450: Part 1: 1983: Clause 7.3.

77 Where the TJF is separated from the NTP (figure 3), the PTO will terminate its circuits at the NTP which is contained within the **network terminating and test apparatus** (**NTTA**).

78 This NTTA is owned and supplied by the PTO and certain forms of access to it by the customer will be allowed in order that PTOs can carry out tests on their wiring in isolation from the customer premises wiring and apparatus.

79 Physical connection of the PTO network cable to any new NTTA or NTP can be carried out only by the PTO.

Termination of telex apparatus

80 The recommended single channel voice frequency (SCVF) termination is a plug complying with BS 6312 wired in accordance with BS 7362, clause 4.1.1. This plug is attached to the end of a cord which is an integral part of the telex apparatus. Older installations generally, or large new installations, may have their SCVF interface attached to a connector strip supplied by the PTO. Principles D and E apply and hence when a telex terminal is connected by a plug it can be brought into service by anyone.

81 The low voltage interface (see BS 7362, clause 4.1.2) is a digital one and uses an ISO (BS 6623: Part 1) connector, see paragraph 101 for details.

Compatibility of plugs and sockets

82 Plugs to BS 6312 are used for telephone and telex apparatus and it is advisable that sockets for telex apparatus are marked to that effect. No damage will occur if a telex plug is connected to a telephone socket or vice versa. The same cannot be said if ISO 8877 (RJ45) connectors are used at an intermediate point, eg a patch panel, in the (structured) wiring scheme to give flexibility. Analogue circuits inadvertently connected to data equipment can cause damage.

4 PERFORMANCE OBJECTIVES FOR DIGITAL WIRING

Performance limitations

Digital circuit wiring concepts

83 Whereas with analogue circuit wiring one type of wiring is capable of carrying all PTO analogue voice band services, this is unlikely to be the case with digital circuit wiring where the most

economic choice of wiring depends on the bit rate or rates of the service or services that are handled. There is a need, particularly at high bit rates, to treat a connecting link as a whole rather than something that can be assembled from any miscellaneous set of off-the-shelf components. Any discontinuities in the wiring characteristics, eg patch panels, are a potential source of impedance mismatch and noise, and care has to be taken that the characteristic impedance and noise level of the link is maintained within some specified limit from end-to-end. A number of international and European standards are beginning to emerge that will enable digital wiring systems to be specified with confidence and as these become available references to them will be included in subsequent editions of this Code. For example we might expect to see three recommended categories of wiring covering the data rate spectrum from a few kHz up to 10-20 MHz.

84 Digital circuit wiring can take a number of forms, for example two twisted pairs per circuit with one pair providing the transmit channel and the other pair the receive channel. Alternatively coaxial cable or optical fibre can be used, usually with the receive and transmit channels on separate cables. If control signals as well as data signals are carried then the circuit can consist of more than four wires; hence the need for plugs and sockets having (see paragraph 101) a considerable number of poles.

85 In the next two sections the International Telegraph and Telephone Consultative Committee (CCITT) Recommendations for various digital interfaces are summarised. These Recommendations relate to end-to-end link performance and do not mention the types of wire or cable necessary to achieve that performance. Again emerging standards should repair that omission (for ISDN at least); when these standards are firm and generally available Section 4 will be extended.

86 In the case of optical fibre there is a draft British Standard Code of Practice for its installation (90/29606 DC). However optical fibre cabling is a highly specialised topic and not one that can be appropriately covered here.

Interfaces to public networks

87 For public data services the interface to the public telecommunications system may be one of a number of interfaces that are specified under CCITT Recommendations. The choice of interface will depend upon the service provided - for example packet switched services, specified according to Recommendation X.25, will demand a different set of interfaces from ISDN which is specified in the I.400 series of Recommendations. Recommendations at the higher levels in the hierarchy of Recommendations, which are concerned with the nature of a particular service, call upon lower level ones and at the physical layer level (which is concerned with such things as plugs and sockets and transmission levels) a limited number of lower level V., X. and I. series Recommendations apply. Most of these are called up by more than one higher level Recommendation. In the following the limitations of distance imposed on wiring under these lower level Recommendations are explained. In order to determine which of the lower level Recommendations applies, in the context of a specific data service, reference will need to be made to the higher level service Recommendations, or to information obtainable from the public service provider.

88 Paragraphs 91 to 94 apply to specific CCITT Recommendations, and these Recommendations indicate necessary but not always sufficient constraints on length. Interfaces are not however limited to this set and paragraphs 95 to 99 give more general guidance - guidance that may also be applicable to the CCITT interfaces.

89 A distinction is made between **passive** connections in

which there is no regeneration of the digital information and **active** connections in which the digital information is regenerated between the point of attachment to the public telecommunication system and the customer's other apparatus.

90 Any flexible leads that are not part of an approved apparatus but which join an approved apparatus to fixed wiring should be included in the total length of the wiring.

Distance limitations according to CCITT Recommendations

91 For passively connected customer apparatus where its own connection and the connection to the public network are in accordance with the same CCITT Recommendation the distance limitations as set out in Table 1 should apply.

92 For passively connected customer's apparatus where its own connection is V.10, V.11 or V.28 and the connection to the public network is a different one of these three Recommendations it is advisable to determine the maximum cable length from conditions imposed by the more restrictive of the dissimilar interfaces.

93 In general, and for V., X. and G. series interfaces in particular, it may be possible to overcome the distance limitations outlined above by means of an intermediate active connection or link between the customer's apparatus and the connection to the public network. An active transmission link entails amplification for data pulse regeneration and could employ either electric cable or optical fibre. In the case of optical fibre, data pulse regeneration involves conversion to the optical domain from the electrical domain and back again. The limitation on distance then depends on any additional loss and pulse distortion introduced by the active link, and consideration may need to be given to the overall delay. Note that in the case of ISDN one basic limitation on length is delay and it is therefore not advisable to extend the limit given in I.430 for delay whether the transmission link is active or

Table 1. Distance limitations for CCITT recommended interfaces

Recommendation and Comments		*Reference*	*Distance limit(1)*
V.10, Appendix II		See figure 6	V.10 corresponds to X.26
V.11, Appendix I		See figure 7	V.11 corresponds to X.27 *(2)*
V.28		15 metres	See *(3)*
V.35		60 metres	See *(4)*
G.703	64 kbit/s codirectional	Equivalent to 3 dB loss at 128 kHz	Balanced pairs (4 wires) at 120 ohm impedance
	2048 kbit/s	Equivalent to 6 dB loss at 1024 kHz	Coaxial cable 75 ohm *(5)*
	8448 kbit/s	Equivalent to 6 dB loss at 4224 kHz	Coaxial cable 75 ohm impedennce
I.430	S or T reference point	See Annex A of I.430	Limits on delay and attenuation are specified for various topologies *(6)*

Notes

(1) With the exception of I.430 all connections are point-to-point rather than point-to-multipoint.

(2) For V.11, see also BS 7248 (ISO 8482) *Multipoint interconnection of data communications equipment by twisted pair cable.*

(3) There is a load capacitance limit of 2500 pF which includes the capacitance of the connecting cable. The figure of 15 m is not contained within the V.28 Recommendation but is considered to be advisable.

(4) The 60 m limit is not contained in the V.35 Recommendation but is considered to be advisable. Note that V.35 is not recommended for new designs and the alternative Recommendations are V.36 for data rates of up to 72 kbit/s and V.37 for data rates above 72 kbit/s. For V.36 and V.37 an interface with the electrical characteristics of V.10 or V.11 as given in the table is recommended.

(5) The 6 dB loss allowed for the 2048 kbit/s G.703 interface corresponds to about 300 m of customer wiring.

(6) The limits given in I.430 may need to be treated with some caution. A European Standard is under preparation giving limits on distance when twisted pair telephone cable having a specified characteristic is used as the means of connection. OFTEL plans to incorporate material from this standard in subsequent editions of this Code.

Figure 6 Data signalling rate versus cable length for unbalanced interchange circuit (*source:* CCITT)

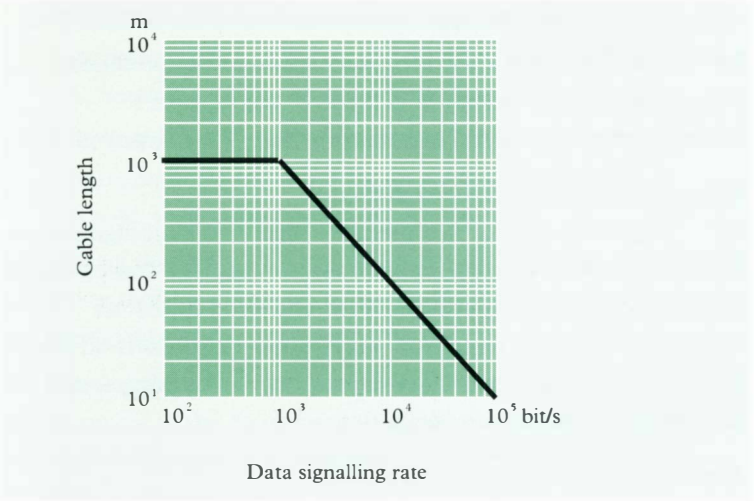
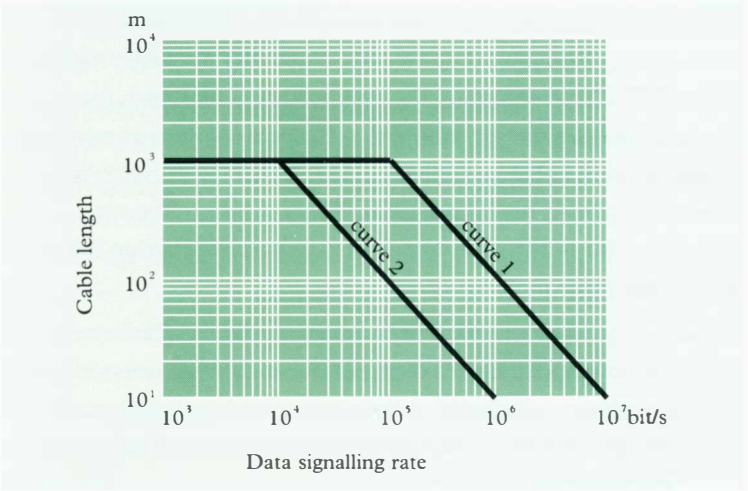


Figure 7 Data signalling rate verses cable for balanced interchange circuit. **Curve 1**- terminated interchange circuit; **curve 2** - unterminated interchange circuit. (*Source:* CCITT)



not. Note too that apparatus used for active connections needs to be covered by either a specific or general approval; it is not covered by the General Approval (GA9) for digital circuit wiring.

94 In the case of BT's ISDN2 service, customer premises wiring requirements are given in detail in the supplier's information note (SIN) 173 obtainable from BT Teleprove.

Other potential limitations on distance

95 In general, and for the interfaces identified in paragraphs 91 to 93, capacitance of apparatus and electromagnetic compatibility (EMC) requirements (particularly the emerging European Commission's EMC standards) may impose restrictions on length that are more severe than those imposed by the transmission properties of cable or wire alone.

Digital circuits sharing the same cable

96 Crosstalk (interference due to cross-coupling) between digital circuits sharing a common cable sheath can give rise to data errors. Crosstalk is worse with circuits that are unbalanced with respect to earth than with circuits that are balanced with respect to earth. (V.10 and V.28 are examples of unbalanced connections whereas V.11 is an example of a balanced connection.) Resultant data errors are not easy to isolate because of the difficulty in repeating the conditions under which they occur. This is a situation where the cheapest solution in terms of initial outlay in cable and other components may prove to the most expensive in the longer term. There are a number of techniques for reducing crosstalk between circuits within the same sheath and these include:

- the use of baluns with unbalance interfaces. (Baluns are usually passive devices (eg transformers) that convert from unbalance to balance at the sending end and make the complementary balanced-to-unbalanced conversion at the receiving end.)

- the use of cable in which the individual data circuits are balanced and individually screened from each other by a metallic screen or braid that is earthed according to the guidelines given in paragraph 33. (See also BS 6701: Part 1, Section 6.10 for functional earthing requirements.)
- the use of an 'active' transmission link as outlined in paragraphs 91 to 94 but for an electrical connection it would need to be a balanced arrangement.

97 Note that BS 6701: Part 1, Section 6.7.2 categorises circuits according to their sensitivity to interference and gives guidance for the segregation of circuits in general.

98 In using the techniques outlined above it is necessary to ensure that approval of the equipment to which the wiring is connected is not conditional upon a certain type of transmission method. For example, a balanced circuit cannot be terminated directly on equipment that is only approved for unbalanced operation.

99 Because crosstalk depends on the spectra of the signals involved and because national standards differ in respect of their spectral limits, it follows that, for example, wiring that may be satisfactorily shared in North America may not work in nominally the same configuration in the UK.

Performance of overvoltage protection circuits

100 OFTEL General Approval GA9 permits the use of overvoltage protection components as wiring accessories. For the corresponding analogue case guidelines are given in paragraphs 70 to 72 on the limits to be allowed for the impairments introduced by protection circuits. Because of the much wider frequency spectrum that may be associated with digital wiring the corresponding guidelines are of necessity more complex and need further consideration. It is intended to issue information on this topic at a later date when an agreed position has been established in the UK.

CCITT Recommendations for connectors

101 As well as recommending the limitations on distance as outlined in paragraphs 91 to 95, some CCITT Recommendations include references to the plugs and sockets that should be used in the context of a particular service and a particular interface to that service. Five types of plug and socket are commonly encountered and these are listed under their ISO and BSI designations, together with some of the Recommendations that may call them up, in Table 2. While all connectors meeting the requirements of the CCITT Recommendations should be suitable for approval under GA9 as approved components for digital circuit wiring, you should obtain information from the service provider regarding the exact nature of the interface in any particular circumstance before selecting a connector.

Other connections

102 When the connection to the public telecommunication system is specified as being other than any of the connectors listed in Table 2 then the more general considerations given in Schedule 2 of the digital circuit wiring General Approval (GA9) apply. However Table 3 contains details of PTO-specific connection arrangements as contained in BS 6328.

Flexible connecting leads and the use of telephone jacks

103 Wall or floor mounted sockets are sometimes attached to the fixed wiring to provide a means of attachment, via flexible leads, to approved terminal apparatus. When there is more than one set of interface conditions, it is recommended that different types of data jack are chosen, each of which is only capable of being connected to one type of data circuit socket and also that telephone jacks cannot be connected to data jacks and vice versa.

104 In paragraph 82 a warning is given that digital equipment

Table 2. ISO/BS connectors and service options

Connector			*CCITT Recommendations*
ISO	*BS*	*Poles*	
2110	6623: Part 1	25	X.20bis with V.2 X.21bis with V.28 V.24 with V.10 or V.11 or V.28
2593	6623: Part 4	34	X.21bis with V.35
4902	6623: Part 2	37	V.36 with V.10 or V.11 V.37 with V.10 or V.11 X.21bis with V.10 X.21bis to X.36 with V.10 or V.11 V.24 with V.10 or V.11 or V.28
4903	6623: Part 3	15	X.20 with V.10 or V.11 or V.28 X.21 with V.10 or V.11
8877	7266: Part 1	8	I.430

Table 3. PTO connector options

Connector			*PTO*	*Service*
ISO	*BS*	*Poles*		
2110	6623: Part 1	25	MCL	G.703, 64 kbit/s codirectional connecting cable permanently fixed to apparatus (BS 6328: Section 8.2, para 4.2)
-	9210: N0001: Part 2	2 coax 75 ohm BNC	BT KCL MCL	G.703, 2048 kbit/s connecting cable permanently fixed to apparatus (BS 6328: Section 8.1, para 4.2)

can be damaged if ISO 8877 (RJ45) connectors are used at flexibility points in mixed analogue-digital structured wiring schemes. Damage can also occur if different types of data circuit are incorrectly connected.

5 SAFETY

Earth connections

105 Protective earths are to be provided for safety in accordance with BS 6701: Part 1, Section 6.10 which refers to the IEE *Wiring Regulations.* In many situations it is necessary to have a functional earth which is separate from the protective earth in order to reduce susceptibility to mains borne interference. To distinguish between these two types of earth, BS 6701: Part 1, Section 6.10.3.2 recommends that the functional earth be coloured cream and that the sheath should be continually embossed with the words TELECOMMS FUNCTIONAL EARTH. On no account should the green and yellow coloured bands normally used for the protective earth be used for the functional earth.

Safe installation practice

Separation from electricity cables

106 Part 1, paragraph 30, contains some basic guidance on the separation between electrical supply cables and telecommunication cables. When the electrical supply voltage is less than 600 V ac or less than 900 V dc, the separation distance should be at least 50 mm unless a non-conductive divider is placed between the two types of cable. Further guidance may be found in BS 6701: Part 1, Section 6.7 relating (among other things) to situations where:

- the electrical supply voltage exceeds 600 V ac or 900 V dc, and
- telecommunication and electrical supply cables are surfaced wired in cable trays, in conduit, trunking or ducting.

Mains plugs

107 The types of plug used for the connection of apparatus to electricity power supplies must on no account be interchangeable with those used for the connection of telecommunication signals (see BS 6701: Part 1, Section 6.9.1.7).

Protection of external cable spans

108 BS 6701: Part 1, Section 6.3.9 contains surge protection recommendations for external cable spans and Section 6.3.4.3 makes recommendations for sharing poles with power distribution cables.

6 WIRING OWNERSHIP AND RE-USE, AND INTEGRATED WIRING

Use of wiring belonging to the apparatus supply business of a PTO

Making existing wiring available to the user

109 It frequently happens that a user wishes to replace apparatus but to connect the new apparatus to existing wiring. In many cases this wiring belongs to the apparatus supply business of a PTO which business will be referred to as 'the Company'. The terms on which the Company's wiring may be used can then become an important competitive element. To ensure fair competition, the PTO licences granted to BT, KCL and MCL contain conditions designed to ensure fair competition. PTOs are under the following obligation:

V When requested by a user, the Company must, where ever practicable, make available to the user any wiring that the Company owns, but which is not part of a public telecommunication system, and, except in the case of integrated wiring (see paragraphs 119 to 126) this must be

on terms that permit the maintenance of that wiring by someone other than the Company.

Options and terms for making wiring available

110 The Company can choose how they make the wiring available - whether by selling, renting or leasing, etc. If they retain ownership of the wiring, the terms of supply for that wiring must not depend on whether the apparatus connected by the wiring is supplied by them or not supplied by them.

111 If the Company agrees to sell the wiring, it must do so for a fair and reasonable sum.

BT's charging policy

112 In practice BT applies standard age-related charging scales to assess the price for buying internal and external extension wiring which does not form part of the public network. Separate charges - which take account of the age of the assets concerned and any contribution made by the customer towards the original installation cost - are levied for the purchase of on-site ducting and poles.

Using analogue circuit wiring for digital services

113 It does not necessarily follow that wiring installed initially for analogue use (if that is the case) is satisfactory for digital use and it may be necessary to seek professional advice regarding suitability. The use of existing wiring needs to be questioned on the grounds of *quantity* and *quality*. Quantity in that digital connections may need four (or more) wires whereas previously most analogue connections needed only two. Quality in that the electrical performance of existing wiring may be inadequate for use with some types of digital signal. Such re-use of wiring may cause considerable disruption to service while conversion is taking place.

Upgrading existing wiring for use with a new PBX

Inspection

114 When you approach BT to purchase existing wiring for re-use with a new PBX (obtained from any supplier), BT will carry out a free survey to set the price for sale. Where the survey indicates any significant defects which would prevent the proposed re-use without remedial work being conducted, BT will so advise you. Should you wish to have a more detailed inspection and a written report for your own purposes this will normally be arranged at a cost (payable by you) determined by the particular installation. You are then free to chose any contractor (including BT) to remedy the defects.

Criteria for wiring evaluation

115 BT apply the criteria to determine whether or not existing wiring is satisfactory evenhandedly - without taking account of whether the new apparatus is expected to be supplied by BT or a competitor; and the price of wiring that is to be sold to a customer must be priced at a level that is fixed regardless of the source of supply of the new apparatus. BT normally expect wiring to comply with BS 6701, although BT will generally accept existing wiring that does not fully comply provided that the essential safety and security safeguards are met. However the acceptance of PTOs other than BT may alternatively or additionally be required (see paragraphs 37 and 38).

116 Note that this represents a statement of current BT policy which could be subject to change. OFTEL would, however, need to be satisfied that any changes made were consistent with the requirements of fair competition within the regulatory system.

Remedial work

117 In general, remedial work may be necessary for reasons of general wear and tear, changes to the customer's site, or because

the standards applying at the time of the original installation have been superseded or because the system with which it was formerly used differs technically from the new one in a way that influences the kind of wiring that is appropriate. A case of particular interest is one in which digital circuit wiring is attached to a new digital PBX, when the considerations given in paragraph 113 regarding the use of analogue circuit wiring for digital connections apply.

118 Where existing wiring continues to be rented from BT, any renewal work will be carried out by BT with the cost being chargeable to the customer and being additional to the ongoing rental charged for all the services run on that wiring. The criteria that determine the need for remedial work are not such that they seek to uplift an existing system to the technical standards or appearance of one newly provided. The purpose is to ensure safety (of the user, of staff working on the system, and of the PTO's network and staff). It also ensures that the system is technically acceptable when connected to PTO networks.

Integrated* wiring and customer-owned exchange line wiring

Principles and exceptions

119 Wiring in office buildings is sometimes integrated. That is to say, circuits which are part of a public telecommunication system, as well as circuits which are not, are combined in the same multi-core cable and share the same distribution frames, junction boxes, etc. Such an arrangement provides flexibility for

*Note that there is a distinction here between the use of the terms *integrated* and *shared* as applied to wiring. Integrated applies only as defined in paragraph 119 whereas shared as used elsewhere in this Code applies to the sharing of wiring within a cable sheath between services on the customer side of the NTP.]

the re-arrangement of services as user needs change, but makes it impossible to separate the maintenance of public and non-public circuits. In practice, because the same person must maintain both the wiring and CRA connected to it (see paragraphs 42 to 44), any CRA connected to such integrated wiring must be maintained by the PTO performing the Designated Maintainer function, even where the apparatus itself could qualify for competitive maintenance. To overcome such anti-competitive effects of integrated wiring, two Principles apply.

W After 31 December 1985, no new integrated wiring (in the sense indicated above) may be installed so that it is to form part of a public telecommunication system.

X After 31 March 1985 PTOs must, where requested by the user of an existing integrated wiring scheme, provide separate wiring to carry the public network circuits requiredby the user.

120 These Principles are not quite absolute. For example, the Director General of Telecommunications may issue guidelines for the continuing installation of integrated wiring or for the provision of separate wiring (and may do so if technical or other changes make integrated wiring possible without anti-competitive effects).

121 Integrated wiring will be permitted if it is installed under a contract entered into before 31 December 1985, or where the structural provision for wiring has been designed before that date specifically for an integrated arrangement.

Provision of new wiring

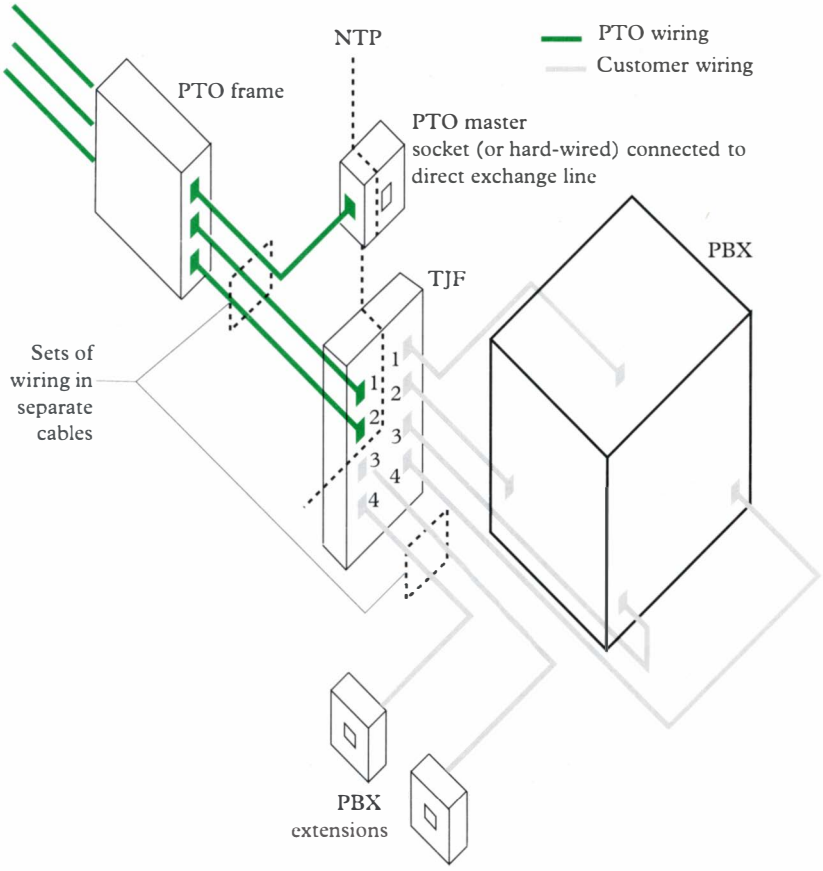
122 Of course, where a PTO provides new wiring in accordance with Principle X, it is entitled to charge for it as well as for any existing wiring which it is supplying to the user. PTO's licences forbid unfair discrimination between different users in these charges, as in all other terms and conditions of service.

Use of old wiring

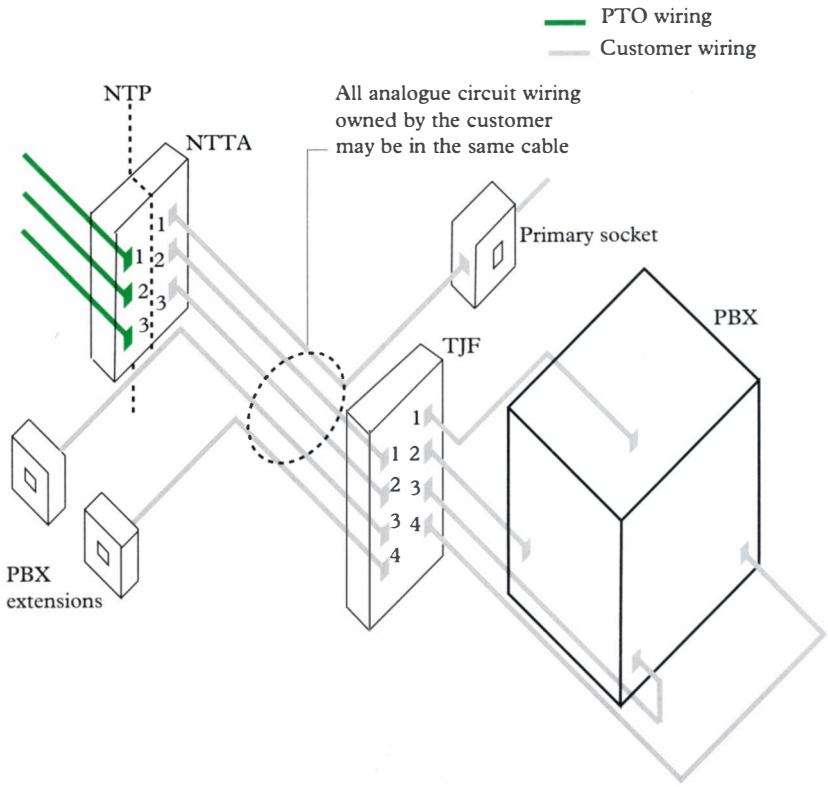
123 Once separate public network wiring has been provided, you may then make use of the old integrated wiring, for example as extension wiring for your private switchboard, under the rules already described.

Figure 8 Exchange line wiring

(a) Exchange line wiring owned by a PTO



(b) Exchange line wiring owned by the customer



Sharing integrated wiring

124 Where integrated wiring is still in joint use and you are considering the re-use of your circuits, PTOs may refuse to allow the sharing of circuits within the same cable sheath between analogue and digital circuits or between certain combinations of digital circuits.

Customer-owned exchange line wiring

125 When the NTTA is separated from the TJF, as for example in figure 3, there is no need for analogue exchange line wiring to

be separated from analogue PBX extension wiring because both sets of wiring are owned by the customer. The situation is illustrated in figures 8(a) and (b) which also show a single exchange line to a simple telephone or private payphone that may be present in some premises.

126 The ability for customers to own wiring between the NTP and the TJF means that an opportunity may exist to buy what was previously integrated wiring (as described in paragraph 119) owned by the PTO.

7 RECORD KEEPING

127 Good record keeping is important to the efficient and safe operation of complex installations. It is particularly important to ensure that terminal apparatus is not connected to network circuits that are incompatible from the point of view of performance or to which connection is not approved. In paragraphs 82 and 104 warnings are given of the problems that may arise at flexibility points if wrong connections are made and this is an example of a situation where good labelling and record keeping can prevent the terminal apparatus and the network from being harmed.

128 It is therefore in the licensee's own interest to ensure that the maintainer of the apparatus keeps adequate records. The licensee has obligations regarding record keeping that are set out in the licence under which the system is run and the maintainer of the apparatus if registered under a Quality Assurance scheme is likely to have additional obligations. A definition of what is adequate beyond these legal requirements is a matter for negotiation between the parties concerned. However the following paragraph gives brief guidelines on the type of records that might reasonably be kept.

129 Records fall into broad areas, layouts, equipment identities, connectivity and certification. The following are examples of what might be expected to be included in each of these categories but the list is far from exhaustive:

Site layout plans or schematics showing the position of distribution frames, outlets, connection boxes, internal cable runs, external cables runs, earthing points, earth runs, protection arrangements etc, etc.

The identity codes for terminating equipment, distribution frames, etc, the types of cable and their capacities. For each identified equipment item there should be a record of its approval status and the rules for connecting it.

Terminal identities and what each terminal is currently connected to, how each termination and cable circuit (pair, quad, etc) is identified and how much spare capacity is available.

Certificates of compliance with the various statutory requirements. Any potential health or equipment hazards.

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