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# ND1506:2004/11

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## **Report on the Mutual Compatibility of Transmission Systems used in Public Access & Private Networks**

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Issue 1

Network Interoperability Consultative Committee  
Ofcom  
Riverside House,  
2a Southwark Bridge Road,  
London SE1 9HA  
UK  
<http://www.nicc.org.uk>

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## 1. Foreword

This report has been produced by the NICC Task Group on Digital Subscriber Line (DSL) – Spectrum Management Plan. Network Operators, switch and terminal equipment manufacturers (including representatives of the TIA (Telecommunications Industry Association), test laboratories, DTI, and Ofcom (and previously OFTEL) participated in the Task Group).

## 2. Scope

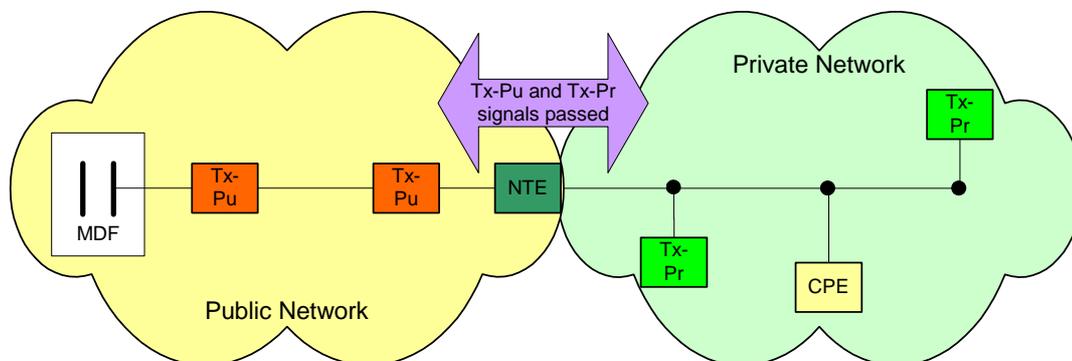
This report is produced in response to NICC Study Item 65 'Crosstalk Impact of Transmission Systems Installed in Private Networks'. This Study Item required the investigation of the crosstalk issues and impact on BT and KCH public access networks by transmission systems installed in private networks that use frequencies, which overlap those used by public access network xDSL systems (particularly ADSL, S(H)DSL, and VDSL). The scope of the study was limited to scenarios where the public and private network signals are transmitted over shared cabling, and to scenarios representing real, commercial public and private network implementations.

## 3. Introduction

As part of the Local Loop Unbundling (LLU) project in the UK, the NICC DSL Task Group developed Access Network Frequency Plans (ANFP) for both the BT [1] and KCH [2] networks. These ANFP specifications were necessary in order to manage crosstalk interference, particularly between xDSL systems, operating over a public access network in the multi-operator environment resulting from LLU. However, these ANFP specifications only considered the impact between transmission systems operating in the same access cable (i.e. between the MDF (Main Distribution Frame) in the local exchange and the NTE (Network Terminating Point) in the customers' premises).

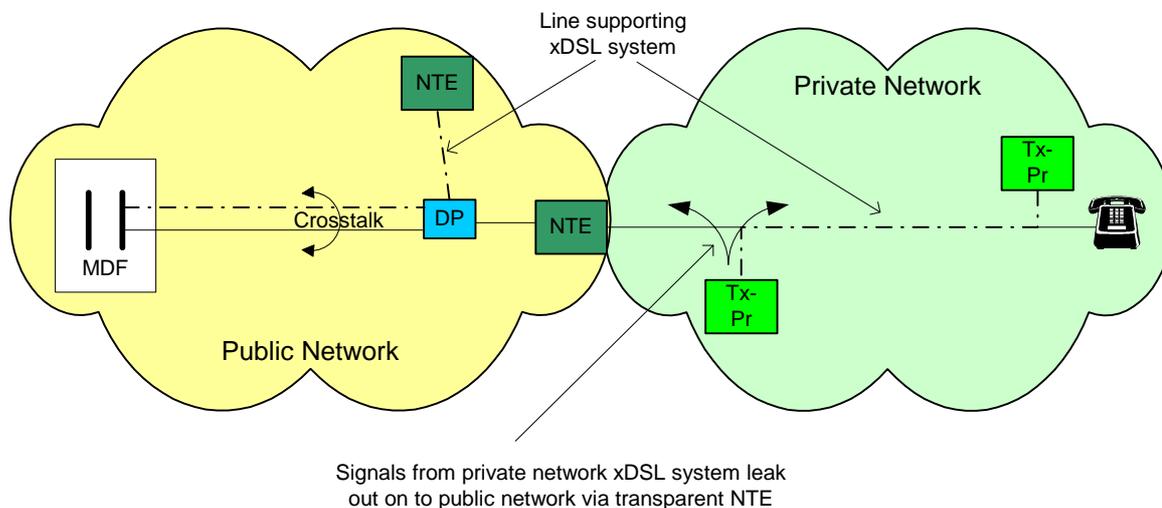
On public analogue services (which includes services provided using xDSL systems where the remote (i.e. customer-end) xDSL modem is CPE), the NTE is typically transparent to the telecommunication signals thus allowing the signals to pass between the public access network and the private network. Hence there is the potential possibility for interference between:

- transmission systems in the public and private network that are directly coupled via connection at the NTE (See Figure 1a)
- transmission systems in the public and private network that are not directly connected to each other but are indirectly coupled, via crosstalk in the access network or private network, or both. (See figure 1b).



**Figure 1a - Example of Interference between directly coupled transmission systems**

Note to Figure 1a: The CPE is using a service provided by the public network.



**Figure 1b - Example of Interference between indirectly coupled transmission systems in public and private networks**

**Key to Figures 1a, 1b and 1c**

	Network Terminating Equipment		Distribution Point
	Transmission Equipment in Private Network		Main Distribution Frame (in local exchange)
	Transmission Equipment in Public Network		Metallic pair
	Customer Premises (terminal) Equipment		Metallic pair supporting xDSL service

Another case of interference via indirectly coupled systems is the case of third wire crosstalk illustrated in Figure 1c. In this case, the metallic pairs of the affected systems are not themselves adjacent but both are adjacent to a common third metallic pair. Studies (see Annex A) have shown that third wire crosstalk can be an issue for ADSL systems and is likely to be even more of an issue for xDSL systems using higher frequency signals, such as VDSL.

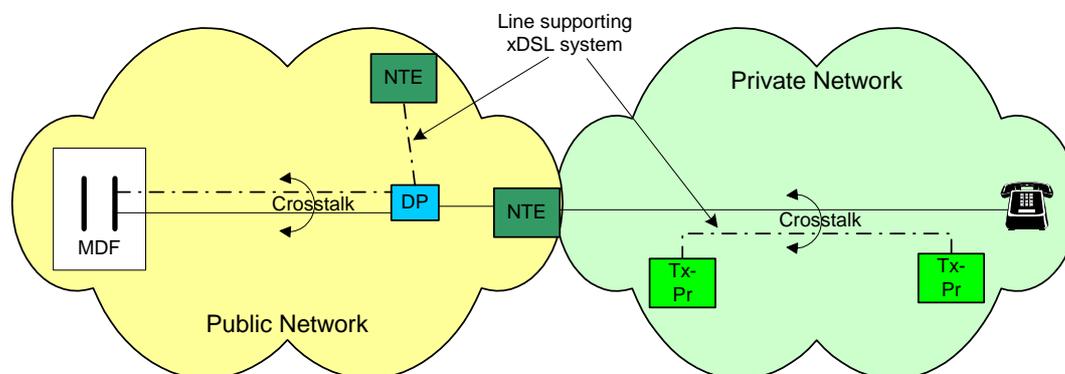


Figure 1c - Example of 3<sup>rd</sup> circuit crosstalk

It was noted that one of the early adopters of VDSL and other xDSL technology is private networks where it is used, for example, to provide distribution of broadband services around a building or multi-tenant premises, to provide extension of public network broadband services across the private network.

The ANFP defines the maximum power level for signals at a given frequency that may be injected into the public access network at the NTP. This specification is via the NTP PSD (Power Spectrum Density) mask that must not be exceeded. It can be seen from the examples illustrated in Figure 1 that without careful implementation of transmission systems in the private network, it is quite easy to unwittingly exceed the NTP PSD mask and thus cause interference with transmission systems in the public network (see note). Equally, private network implementers need to be aware of the PSD of signals that may be found on the access network and which may be injected into the private network, causing interference to private network transmission systems (see note).

**Note:** Interference between transmission systems is generally a 2-way action and whilst the degree of impact is dependent on the transmission system type and the service that it is supporting, the performance of both systems are likely to be impaired.

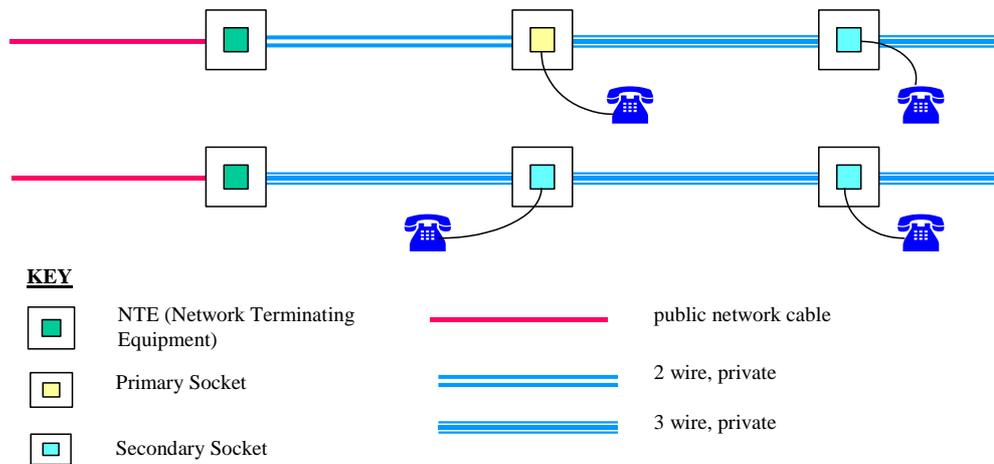
This report identifies a number of scenarios where there is potential for interference between public and private network transmission systems. For each scenario, a recommended solution for preventing such interference is provided.

#### 4. Private Network Wiring

Private telecommunication networks and their connection to public networks come in many forms extending from the simple internal residential house wiring for a few telephones to the highly complex international private network for multi-national companies. This report is only concerned with public and private networks using metallic connections (i.e. exclude optical and radio connections).

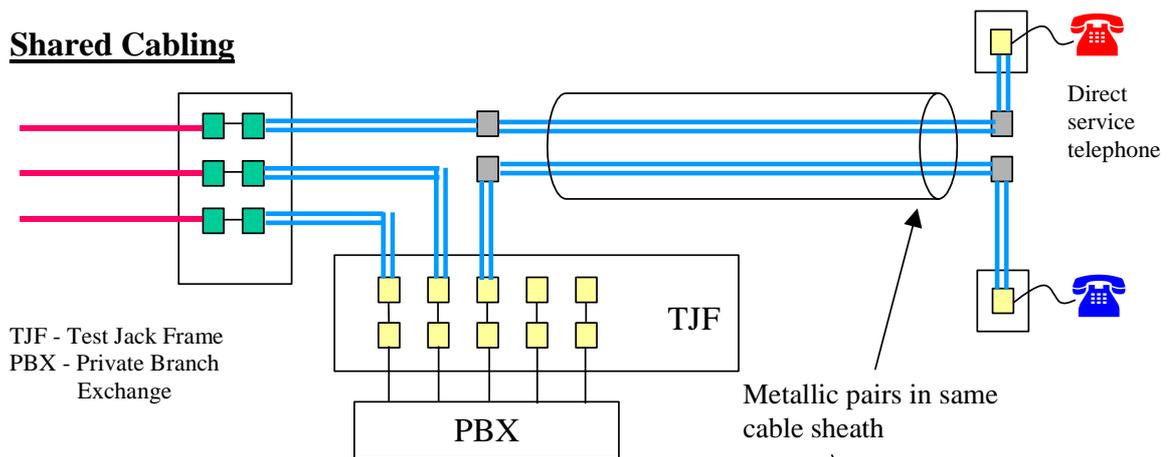
Cabling for private telecommunication networks is described in DISC PD1002 [3]. This characterises private network metallic cabling into simple, complex (shared and integrated), and structured/generic cabling. Examples of simple and complex cabling are shown in Figures 2.

**Simple Installation**

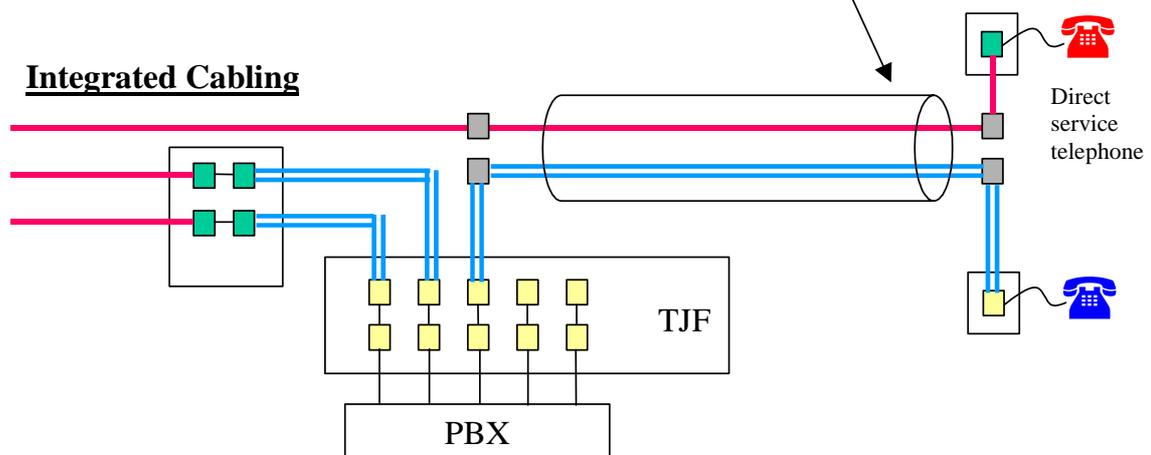


**Figure 2a - Examples of simple private network installation**

**Shared Cabling**



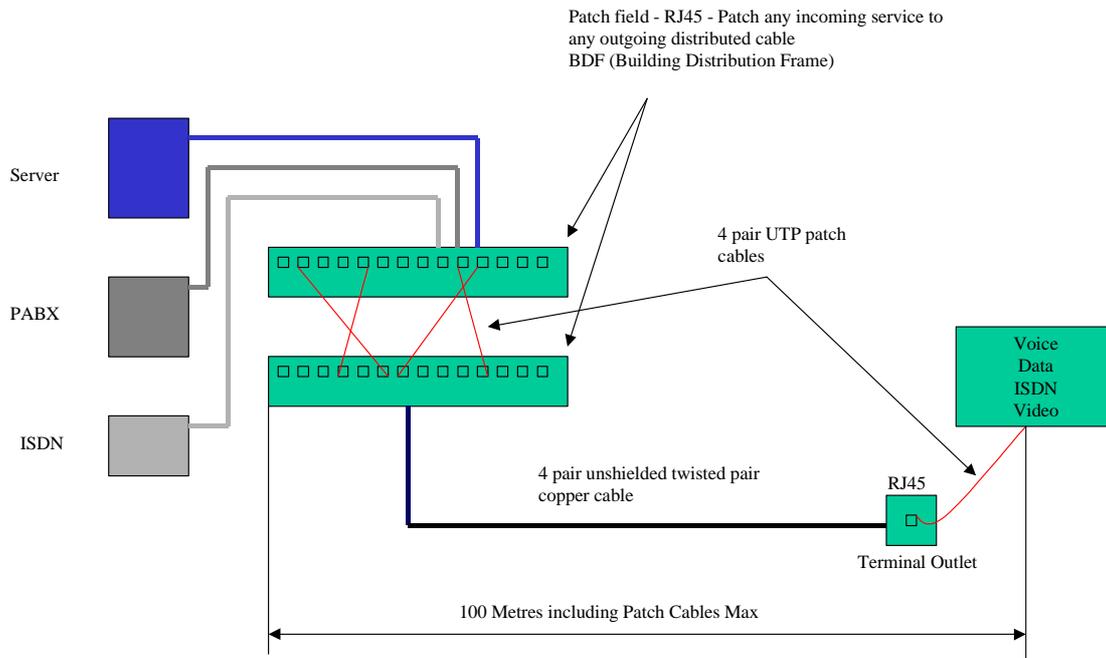
**Integrated Cabling**



**Figure 2b - Example of complex private network installation**

Structured/generic cabling is designed and installed to a standard that allows for flexibility and further extension of the cabling. The cabling is not application specific and typically will be over provisioned or 'flood-wired' to offer enhanced flexibility of floor layout.

Two examples of typical private network topologies for large installations are given in Figures 3a and 3b.



**Figure 3a - Example of Private Network Topology - Basic LAN**

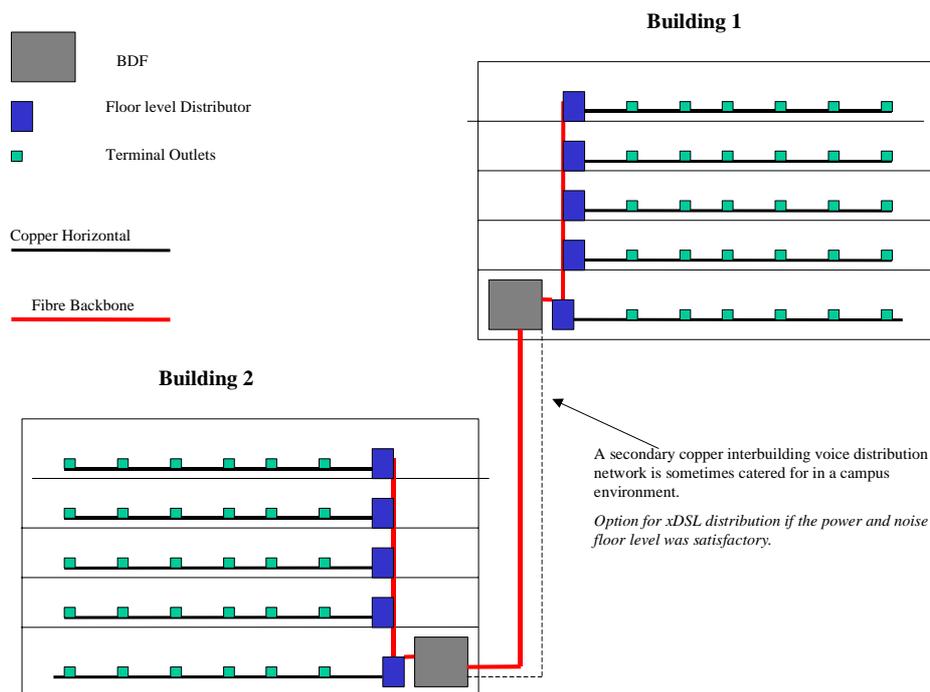


Figure 3b - Example of Private Network Topology - Extended LANS/Campus

## 5. Examples of Public Access and Private Network Incompatibilities

To date, there have been few, if any reported operational problems due to public/private network mutual interference in the UK. Whilst there have been reported mutual interference problems in China and Korea, where the current penetration of xDSL systems is much higher than the UK, it is understood that these problems have been resolved and that they are no longer an issue.

The purpose of this report is to highlight the potential mutual interference issues and by doing so, prevent their occurrence. It is anticipated that the issues of mutual interference between public and private networks are more likely to occur with residential private networks rather than large, corporate private networks. It is also considered that the main source of the mutual interference will be noise from the private network leaking out on to the public network and causing interference with public network xDSL systems.

The following scenarios are examples where there is a very real potential for mutual interference between public access and private network transmission systems.

### 5.1 Use of Phonerline Networking systems in private networks

Phonerline networking systems (also known as HPNA systems) use the telephone wiring within a customer's premises to provide a broadband transmission capability. Phonerline networking systems are defined in ITU-T Recommendation G.989.1 [4].

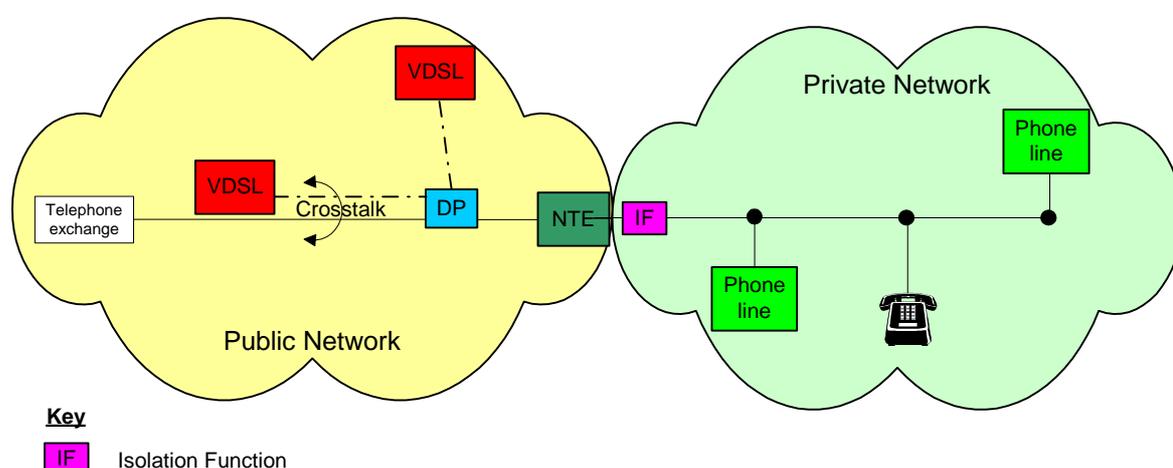
These systems use frequencies that overlap those used by VDSL [5] (and earlier versions of phonerline network systems used frequencies that overlapped with those used by ADSL [6]. However, it is believed that there are relatively few of these earlier systems in existence and hence these systems are not discussed further.) Like VDSL, Phonerline networking systems

are designed to use the frequencies above the voiceband and hence allow telephone and phoneline systems to simultaneously use the same cabling using frequency separation.

Because VDSL and Phoneline systems use some of the same frequencies, there is the potential for interference caused by:

- Direct coupling as illustrated in Figure 1a
- Indirect coupling via crosstalk in the public access network. (Note: as these systems typically use customer premises wiring that only supports a single circuit, the potential for indirect coupling via crosstalk in the private network is considered to be very low.)

Both of these cases of interference can be resolved with the implementation of an isolation function as recommended in Recommendation G.989.1 [4]. The isolation function prevents the signals from the phoneline networking system leaking out onto the public network and equally prevents the VDSL signals leaking into the private network and is defined in Recommendation G.989.3 [5].



**Figure 4 - Use of Isolation Filter to prevent interference between VDSL and Phoneline networking systems**

Clearly the location of the isolation function is critical if it is going to provide this function. It needs to be placed in series with the private network connection to the public network just before the NTE (as shown in Figure 4). This location is not associated with either the phoneline networking equipment or the customer telephony terminal equipment.

## 5.2 Use of xDSL systems in public and private networks

Public and private network operators and installers need to be aware and take account of the use of xDSL systems in the 2 domains in order to minimise the possibility of mutual interference.

The scenarios illustrated in Figures 1b and 1c are typical examples where the use of xDSL in the 2 domains is likely to give rise to mutual interference (as happened in cases in China and Korea). The UK deployment rule for private networks that would prevent interference with the public network is the requirement that the signals injected into all public network, metallic pairs at the NTE comply with the relevant ANFP. This applies irrespective of the service or transmission system used on the private network extension and account needs to be taken of both the intended and unintended (e.g. crosstalk) signals on the extension circuit. The fact that this requirement applies to all metallic connections to the public network resolves the

third circuit crosstalk issue illustrated in Figure 1c. E.g. if there is crosstalk in the private network from an xDSL circuit into a circuit supporting the extension of a voice telephony service, the ANFP rules require for the voice telephony circuit that the combined voice telephony and xDSL crosstalk signals to be within the relevant NTP PSD mask for that public network metallic pair. If this is achieved, then there should be no undue interference with the public network. However, Annex A gives an example for ADSL where the crosstalk signal on the voice telephony extension circuit will exceed the ANFP NTP PSD mask.

## **6. Principles and Guidance for avoiding Public Access and Private Network interference**

The application of the following principles will mitigate against mutual interference between public and private networks.

**Principle 1 - Compliance to the relevant ANFP NTP PSD mask is required for all private network, metallic connections to the public network. In determining compliance, account needs to be taken of both the intended and any unintended (e.g. crosstalk) signals.**

**Principle 2 - There are no equivalent ANFP rules for private networks. Hence implementers of private networks need to be aware and take account of the signals (both intended and crosstalk)<sup>1</sup> that may be injected into private network metallic connections that are directly connected to a public network NTE.**

One practical way of avoiding mutual interference between public and private networks is to separate the 2 domains as described in section 6.1.

### **6.1 Separation of public and private network services**

In order to avoid the potential interference between public and private networks due to either directly or indirectly coupling of systems, it is recommended that in private networks using metallic pairs, separate cable sheaths be used to support extension of public services and private network services. For example, applying this to the scenario illustrated in Figure 1c, the metallic pairs in the private network supporting the extension of the public network telephony service would be in a separate cable sheath to the private network pairs used to support the private network xDSL service. This prevents the crosstalk in the private network shown in Figure 1c and therefore ensures that signals at the NTE on the telephony circuits are ANFP compliant (ref. Principle 1).

An alternative measure is to fit a low pass filter at the NTE on all connections of the metallic private network circuits to the public network, other than for those public network circuits providing xDSL services (see also section 7). A suitable specification for such a low pass filter is given in ITU-T Recommendation G.989.3 [5]. Such filters are available and should be reasonably inexpensive.

Where it is not practical or economic to adopt such separation, then careful consideration needs to be given to assessing the potential for mutual interference and appropriate preventative measures taken accordingly.

## **7. Back hauling public network xDSL signals over private networks [9]**

A major requirement of private network implementers is to extend the provision of public network services from the NTE to the location of the CPE. xDSL services in particular are reach limited and whilst the public network xDSL services are designed to operate

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<sup>1</sup> This report only addresses signals present on a circuit due to their injection from equipment directly connected to that circuit or through crosstalk from an adjacent circuit. Implementers need to be aware that other signals may be present on the circuit due to ingress from radio transmitters or EMC from other electrical or electronic equipment.

satisfactorily over short extension wiring found typically in domestic premises, they are unlikely to work over long extension wiring that may be encountered in business or campus sites. A fuller description of these deployment issues is given in section 7.1.

Hence for private networks other than those with short extension cabling, action will need to be taken to transfer the xDSL signals across the private network between the public network NTE and the CPE. Without careful implementation, solutions to this problem can give rise to public/private network interference and guidance on how to avoid this is given in section 7.2.

### **7.1 Public Network xDSL Deployment Considerations**

When providing public network xDSL services, the service provider will have estimated whether the offered service would be able to operate correctly at the customer's boundary, based on information on the characteristics of the public network local loop. Rolled into this estimation process would be an assumption about the likely maximum levels of noise and interference that could be expected on such a loop. This estimation of noise is likely to allow for assumed crosstalk from other systems operating in the same cable that would be assumed to be ANFP compliant. The structure of the ANFP allows such calculations to be made, even though the cable providing the service may have pairs within it that have different ANFP categories from the pair providing the service.

The service provider will have provided the service having estimated that the service will have adequate signal-to-noise ratio at the boundary based on the above estimation process. It is unlikely the service provider will have allowed for interference from non-ANFP compliant potential noise sources (such as could occur once the service is being transported on customer premises wiring).

As a rule the service provider will deploy service with very little margin for extra attenuation and noise in a customer premises network. This is natural, as the service provider will want to maximise the proportion of public network loops over which he can provide a given service, so that the business proposition for the service is maximised.

So in general it cannot be assumed that there is scope for any extra allowable signal degeneration in the private network. If the service is provided on a loop length that, by the provider's estimation, is close to the maximum length for that service, then very little extra degradation may be possible before the service fails to meet agreed performance levels, or even to function at all.

The above consideration has focused on the downstream (exchange to customer) signal. A similar set of arguments applies to the upstream signal. Here the signal sent by the xDSL service remote equipment will be (usually) at some fixed agreed level as it leaves the equipment. The service provider will be aware of this level and also of the likely attenuation of the signal as it travels back to his head end equipment. He will also be aware of the likely noise environment that the signal will arrive in; again he can deduce this from assuming a mixture of ANFP compliant signals will be present in the cable in which the pair exists.

Again he will most likely want to be able to deploy the service on the longest possible loops compatible with that service type, to maximise the business proposition for that service. If the customer end equipment is moved further back into a customer-wiring environment the signal arriving at the service provider's head end will suffer extra attenuation.

As for the downstream case, if the service is provided on a loop length that, by the provider's estimation, is close to the maximum length for that service, then very little extra degradation may be possible before the service fails to meet agreed performance levels.

## **7.2 Guidance on hauling xDSL signals over the private network.**

As discussed section 7.1 above, in general it is not possible to carry access network signals into the private network for any significant distance without loss of performance or function.

While a xDSL system is traversing a private network it experiences attenuation and noise characteristics that may be different from those that pertain in the public access network. It will experience noise from both kinds of sources. However, it is likely that the noise in *modern* private networks in the band used for xDSL systems will be at lower levels than would be expected in the public network. This is because cables with better crosstalk characteristics are typically used, and also because private network transmission systems typically use much higher frequencies than access network transmission systems and hence there is reduced spectral overlap. (However there may be exceptions to this rule e.g. especially for VDSL).

As explained in Section 7.1, the level of **excess** signal-to-noise margin for an xDSL service at the public/private network boundary will be unknown and is likely to be very small on public network loops that meet the limits of the xDSL service provider's deployment rules. Hence on private networks with anything other than very short extension cabling, it will be necessary to either:

- a) Regenerate the xDSL signal at the public/private network boundary (see note); or alternatively
- b) Terminate the xDSL signal at the public/private network boundary and translate it into an alternate form for onward transmission over the customer's network.

Note: If regeneration is done for some xDSL signals at this boundary, it must be done for all since to raise the signal level of only some xDSL pairs with a regenerator but not others is simply to raise the level of crosstalk into those pairs that do not have the advantage of regeneration.

## **8. Conclusions**

This report identifies the potential for public/private network interference and the need for planners and implementers in both domains to be aware of the issue. In general, such interference can be avoided by adherence to the 2 Principles set out in Section 6.

It is expected that the use of xDSL systems in private networks will increase and this report gives practical guidance on their deployment to avoid interference with public networks.

## **9. Further Work**

Development in xDSL and other transmission system technology is continuing. Hence it is likely that additional incompatibility issues to those identified in section 5 will become apparent. This report may be updated from time to time as new incompatibility issues are identified. Any reader aware of such a potential incompatibility issue is welcome to forward the issue to the NICC DSL Task Group via Ofcom (see the contact details given on the front page) for consideration.

## **10. Abbreviations**

ADSL	Asymmetric Digital Subscriber Line
ANFP	Access Network Frequency Plan
BDF	Building Distribution Frame
BT	British Telecommunications plc
CPE	Customer Premises Equipment
DP	Distribution Point – the final flexibility point in the public access network before the line reaches its customer

DSL	Digital Subscriber Line - any of the modem technologies that send high-speed data over metallic telephone pairs. A DSL line has a dedicated modem at each end of the physical wire pair; typically one of these is in the exchange
DSLAM	Digital Subscriber Line Access Multiplexer
DSL TG	Digital Subscriber Line Task Group A subcommittee of PNO-IG under NICC
G.shdsl	The form of SDSL standardized in the ITU SG15/Q4
HDSL	High bit rate Digital Subscriber Line
HPNA	Home Phonenumber Networking Alliance (see <a href="http://www.homepna.org">http://www.homepna.org</a> )
ITU-T	International Telecommunication Union - Telecom Standardization
KCH	Kinston Communications (Hull) plc
MDF	Main Distribution Frame
NICC	Network Interoperability Consultative Committee - a committee of UK industry set up to advise Ofcom (and previously, Oftel) homepage: <a href="http://www.nicc.org.uk">http://www.nicc.org.uk</a>
NTE	Network Termination Equipment
NTP	Network Termination Point
PNO-IG	Public Network Operators Interest Group - an interest group within NICC
PSD	Power Spectral Density
SDSL	Symmetric Digital Subscriber Line - in this document 'SDSL' refers to that technology defined in ETSI TM6.
xDSL	any variant of DSL modem e.g. ADSL, HDSL, SDSL or VDSL
VDSL	Very high rate asymmetric Digital Subscriber Line

## 11. References

- [1] Specification of the Access Network Frequency Plan applicable to transmission systems used on the BT Access Network – ND1602 (*available on NICC website at [http://www.nicc.org.uk/nicc-public/Public/interconnectstandards/dsltg\\_spec/nd1602\\_2002\\_11\\_issue2.pdf](http://www.nicc.org.uk/nicc-public/Public/interconnectstandards/dsltg_spec/nd1602_2002_11_issue2.pdf)*)
- [2] Specification of the Access Network Frequency Plan applicable to transmission systems used on the KCH Access Network – ND1604 (*available on NICC website at [http://www.nicc.org.uk/nicc-public/Public/interconnectstandards/dsltg\\_spec/nd1604\\_2003\\_01\\_issue1.pdf](http://www.nicc.org.uk/nicc-public/Public/interconnectstandards/dsltg_spec/nd1604_2003_01_issue1.pdf)*)
- [3] DISC PD1002 'A guide to Cabling in Private Telecommunications Systems' (available from BSI - see <http://www.bsi-global.com>)
- [4] ITU-T Recommendation G.989.1 'Phonenumber networking transceivers – Foundation'
- [5] ITU-T Recommendation G.989.3 'Phone-line Networking Transceivers - Isolation Function'
- [6] ITU-T Recommendation G.993.1 'Very high speed digital subscriber line foundation'
- [7] ITU-T Recommendation G.992.1 'Asymmetrical digital subscriber line (ADSL) transceivers'
- [8] PNO-DSL/TG/CP35(03)2; Observation concerning NEXT from ADSL deployed in customer premises networks - John Cook, BT

- [9] PNO-DSL/G/CP34(03)3; Response to PNO-DSL/CP34(03)2 issues for private wiring- John Cook, BT

**12. History**

<b>Issue No.</b>	<b>Date</b>	<b>Comments</b>
1	Nov 2004	First Issue

Annex A

Observation concerning NEXT from ADSL deployed in customer premises networks [8]

A.1 Example of possible installation

The Figure A.1 below shows a possible installation of a DSLAM in a private network serving ADSL based services in the customer premises.

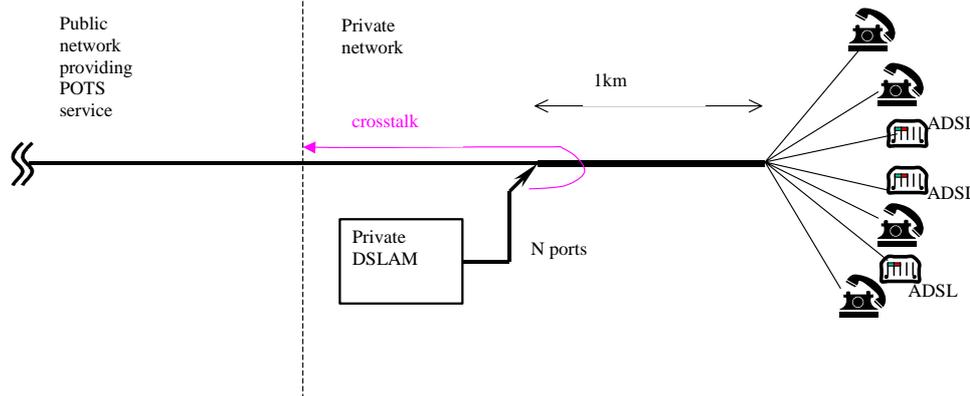


Figure A.1 Private/Public network crosstalk leakage mechanism

Here a private DSLAM located near to the place where public network services enter the customer premises, serves ADSL based services to terminals also in the private network, but over a cable that is shared with telephony (or other direct services) circuits being provided by the public network. In this case near end crosstalk in the shared cable results in crosstalk components leaking back into the public network.

If it is assumed that the quality of the shared cable is the same as that of the public network cable, (and of course in reality it may be better or worse), then the level of this crosstalk has been calculated (magenta, cyan and brown lines) and compared with the ANFP [1] long line mask (red line) and short line mask (green line) in Figure A.2 below, for three cases of number of shared ADSL ports in the cable, 1, 20 and 50.

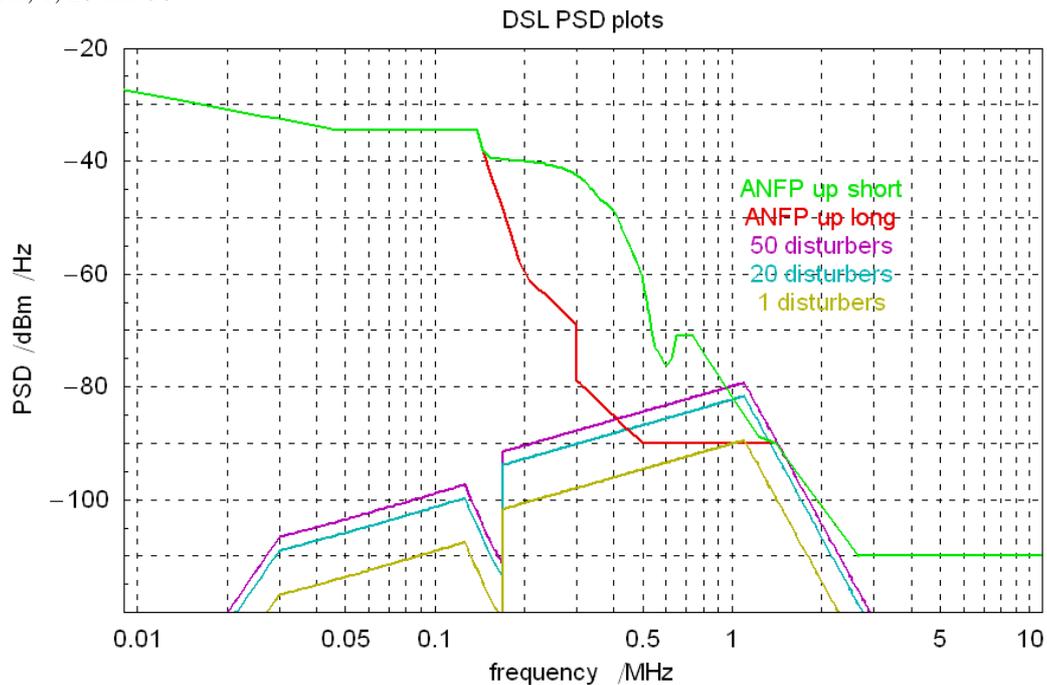


Figure A.2 Private/Public network crosstalk leakage levels

From the figure it can be seen that where there is more than one ADSL port in use it is likely that the crosstalk resulting from the ADSL, as seen going back into the public network, will exceed the long line upstream ANFP mask by a large amount, and even the short line mask to a lesser degree.

**A.2 Conclusions**

1. If a cable is used to support private and public network services, private network ADSL crosstalk into pairs supporting the public network services may make those pairs ANFP non-compliant.
2. In order to prevent mutual interference between public and private networks using xDSL, if xDSL is used in the private network it should not be used on cables also used to support extension of public network services (unless measures are taken to ensure that the pairs supporting the public network services remain ANFP compliant e.g. by fitting a low pass filter on each pair).

- END -