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SERIES L: CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

Copper networks for new services and systems ISDN, HDSL, ADSL and UADSL

ITU-T Recommendation L.19

(Formerly CCITT Recommendation)

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Summary

In clause 1 of this Recommendation some general considerations on the introduction of new services and systems, such as ISDN and xDLS to be supported by the access network, are shown. In clause 2 some requirements for the Digital Local Line characteristics are given, as a factor contributing to the provision of good quality service to the users.

Source

ITU-T Recommendation L.19 was revised by ITU-T Study Group 6 (1997-2000) and approved by the World Telecommunication Standardization Assembly (Montreal, 27 September – 6 October, 2000).

FOREWORD

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

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

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

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

CONTENTS

Introduction

The local subscriber network has been providing the means for subscriber connection to the basic telephone service, without encountering any major transmission problems at voice frequencies (300 to 3400 Hz). Therefore, it is necessary to establish the quality of the subscriber loops for new services and systems ISDN, HDSL, ADSL and UADSL.

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1 General considerations

1.1 Objectives

Considering that the digital access section between the local exchange and the customer is a key element of the successful introduction of new services and systems ISDN, HDSL, ADSL and UADSL, the following requirements for the network should be taken into account:

– the ability to operate on the existing two-wire unloaded lines, with open wires being excluded;

– the objective of achieving 100% cable fill for new services and systems ISDN, HDSL, ADSL and UADSL without pair selection, cable rearrangements or the removal of Bridged Taps (BTs);

– the objective of being able to extend the new services and systems ISDN, HDSL, ADSL and UADSL to the majority of customers without the use of regenerators. In the remaining few cases special arrangements may be required;

– the coexistence, in the same cable unit, with most of the existing services such as telephony and voiceband data transmission;

– various national regulations concerning Electro-Magnetic Compatibility (EMC);

– the provision of power feeding via the network under normal or restricted modes;

– the provision of the capability to support maintenance functions.

1.2 Deployment of xDSL technologies

The four most important xDSL technologies, shown in Table 1, are:

• ITU-T I.430 ISDN basic access which offers 160 kbit/s (2B+D) full duplex.

• ADSL which offers up to 6 Mbit/s downstream and a lower rate upstream using one copper pair (without interfering with voice telephony).

• HDSL: 2 Mbit/s in each direction, but requires up to 3 copper pairs.

• ITU-T G.996.1 ADSL (UADSL or Universal ADSL) which offers up to 1.5 Mbit/s bandwidth in both directions for fast Internet access but not video applications.

Table 1/L.19 – xDSL rates

xDSL "family"	Bit data rate downstream
ISDN	160 kbit/s
ADSL	up to 6 Mbit/s
HDSL	2 Mbit/s
UADSL	up to 1.5 Mbit/s

1.3 xDSL: Technical problems

There are technical problems with xDSL based services, especially if other operators are allowed to rent copper pairs in the access cables. The degree of interference between different applications, in the same cable, depends upon the technology used and the physical characteristics of the cabling (separation between pairs, insulation used, etc.). High powered xDSL technology such as ADSL creates the greatest interference problems while UADSL, for example, creates the fewest problems.

There are five main technical challenges to introducing xDSL services:

– the need to preserve the integrity of existing services. The interference created by xDSL loops can cause existing services (e.g. ISDN, HDSL on leased lines) to fail or to operate with significantly inferior performance;

– the need to modify line testing procedures. The presence of the ADSL modem in the local loop complicates line testing;

– a requirement to minimize interference between ISDN and UADSL transmission technologies. ISDN is extensively used in some countries;

– a need to maximize use of local loops for broadband xDSL services;

– how best to select lines for xDSL use. Not all lines are suitable for ADSL. The most important factor preventing the use of ADSL is signal loss. This is dependent on distance, but the exact distance over which ADSL will operate also depends on the characteristics of the loop and the intended data rate. Other factors also affect performance (e.g. noise, crosstalk or radio frequency interference, etc.).

1.4 Transmission medium

The transmission medium over which the digital transmission system is expected to operate is the access copper network which connects customers to the local exchange via local lines.

This network employs cables of copper pairs to provide services to customers.

A copper local line is expected to be able to simultaneously carry bidirectional digital transmission providing ISDN, HDSL, ADSL and UADSL rates between the Line Termination (LT) and Network Termination 1 (NT1) as shown in Figure 1.

To simplify the provision of ISDN, ADSL, HDSL and UADSL, a digital transmission system must be capable of satisfactory operation over the majority of the copper local lines without special conditioning. The maximum number of copper local lines that can be used for ISDN, HDSL, ADSL and UADSL, is obtained by keeping ISDN, HDSL, ADSL and UADSL, requirements to a minimum.

In the following, the term Digital Local Line (DLL) is used to describe a copper local line that meets minimum ISDN, HDSL, ADSL and UADSL requirements.

2 Recommended requirements

2.1 Minimum ISDN, HDSL, ADSL and UADSL requirements

A digital local line should not include loading coils or open wires.

When Bridge Taps (BTs) are present, these generally do not interfere significantly with voice telephony but they can degrade the performance of the transmission of ISDN, HDSL, ADSL and UADSL signals. The effect of the losses due to bridge taps in the transmission line is dependent of the signal frequency, velocity of propagation and the length of the BT.

The presence of a bridge tap in the subscriber line will add losses to the signal transmitted. The loss occurs because of the reflected power in the direction of the generator since there is no matching of the transmission line at the point of the bridge taps. The bridge taps generates reflections due to the transmission discontinuity which is caused by its open termination. The reflected signals add to the transmitted signal of the subscriber's line.

NOTE 1 – A bridged tap is an unterminated twisted pair section bridged across the line and connected at flexibility points or joints.

NOTE 2 – In the case that there are more than 2 BTs, the acceptable number of BTs depends on the BT's length.

2.2 Digital local line physical characteristics

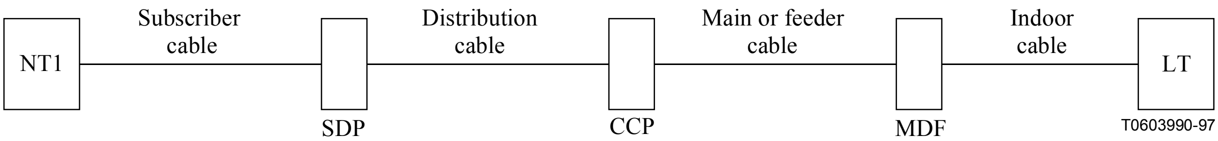
A digital local line is constructed of one or more cable sections that are spliced or interconnected together.

The distribution or main cable is configured as follows:

– cascade of cable sections of different diameters and lengths;

– one or more bridged taps may exist at various points in feeder and distribution cables.

A general description is shown in Figure 1 and typical examples of cable characteristics are given in Table 2.



Points of interconnection are:
MDF Main Distribution Frame
CCP Cross Connection Point (or splice)
SDP Subscriber Distribution point

Figure 1/L.19 – Digital local line physical model

Table 2/L.19 – Typical cable characteristics

	Indoor cable	Main cable	Distribution cable	Subscriber cable
Wired diameter (mm)	0.3 to 0.6	0.3 to 1.4	0.3 to 1.4	0.3 to 0.9
Structure	SQ or TP L or B	SQ or TP L or B	SQ or TP L or B	SQ, TP or UP
Maximum number of pairs	1200	2400/0.4 mm 4800/0.3 mm	600/0.4 mm	2 (aerial cable) 600 (indoor cable)
Mutual capacitance (nF/km at 800 Hz)	55 to 120	25 to 60	25 to 60	35 to 120
TP Twisted Pairs SQ Star Quads UP Untwisted Pairs L Layer B Bundles (units)				

2.3 Digital Local Line electrical and transmission characteristics

Taking into account that the transmitted signal will suffer impairment due to crosstalk, impulsive noise and the non-linear variation with frequency of digital local line characteristics.

2.4 Principal electrical and transmission characteristics for ISDN, HDSL, ADSL and UADSL services and systems

The principal electrical and transmission characteristics should be:

2.4.1 Insertion loss

Table 3 indicates the maximum insertion loss acceptable for ISDN, HDSL, ADSL and UADSL services and systems:

Table 3/L.19 – Maximum insertion loss

xDSL family	Test frequencies (kHz)	Max. insertion loss (dB)
ISDN (American)	40	42
ISDN (European)	40	36
HDSL	150	30
ADSL	300	41 dB for 6 Mbit/s
ADSL	300	47 dB for 4 Mbit/s
ADSL	300	49 dB for 2 Mbit/s
UADSL	300	49 dB for 1.5 Mbit/s

2.4.2 Crosstalk

Crosstalk noise, in general, is due to finite coupling loss between pairs sharing the same cable, especially those pairs that are close to each other. Finite coupling between pairs causes an interference of the signal flowing on one DLL (disturbing DLL) to be coupled into an adjacent DLL (disturbed DLL). This interference is known as crosstalk noise.

Near-End Crosstalk (NEXT) is assumed to be the dominant type of crosstalk in the copper cables used for symmetric pair systems.

NEXT: noise coupled into a disturbed digital local line from a number of digital local lines disturbers is represented as being due to an equivalent single disturber digital local line with a coupling loss versus frequency characteristic known as Power Sum Loss (PSL).

For ISDN the power sum loss value should not be less than 50 dB at 40 kHz (44 dB at 160 kHz) and decreases by 15 dB/decade with frequency.

2.4.3 Unbalance to earth

The digital local line will have finite unbalance to earth. Unbalance to earth is described in terms of Longitudinal Conversion Loss (LCL). Its limiting value should be greater than 40 dB at 40 kHz and decrease by 5 dB/decade with frequency.

2.4.4 Impulse noise

The digital local line will have impulse noise resulting from other systems sharing the same cables as well as from other sources. The impulse noise should be contained within the envelope given in Figure 2.

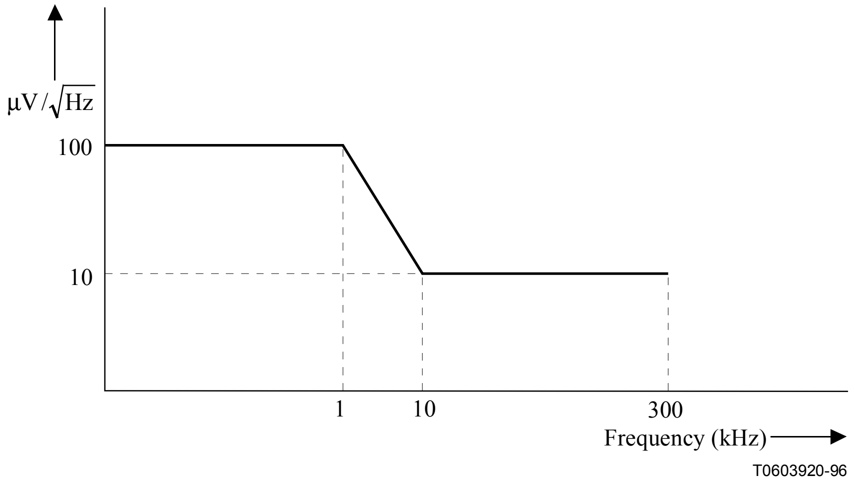


Figure 2/L.19 – Impulse noise

NOTE 1 – For ADSL and UADSL systems. the acceptable limits for FEXT noise are under study.

NOTE 2 – For HDSL, ADSL and UADSL systems the acceptable limits for NEXT noise are under study.

NOTE 3 – For HDSL, ADSL and UADL the acceptable limit for unbalance to earth is under study.

APPENDIX I

Bridge Taps (BT): Effect of the loss due to the length of a bridge tap

The effect of the loss due to the length of a bridge tap has been simulated for the systems given below.

For **ISDN** service, the loss in a transmission line with wires that have a gauge of 0.40 and 0.50 mm, or the ohmic resistance of 140.0 and 89.5 ohms/km respectively, in low frequency with an insulation of polyethylene (PE) and 0.40 mm (26 AWG) with a plastic insulation (135.1 ohms/km) and paper (135.2 ohms/km) is shown in Figure I.1. The simulated transmission line has a termination of 135 ohms resistive and the values of the losses are exclusively due to the presence of the bridge taps. The transmitted signal frequency test is 40 kHz and Figure I.1 shows the losses according to the bridge taps length, for a propagation velocity whose value is a function of the signal frequency and cable characteristics of the transmission line.

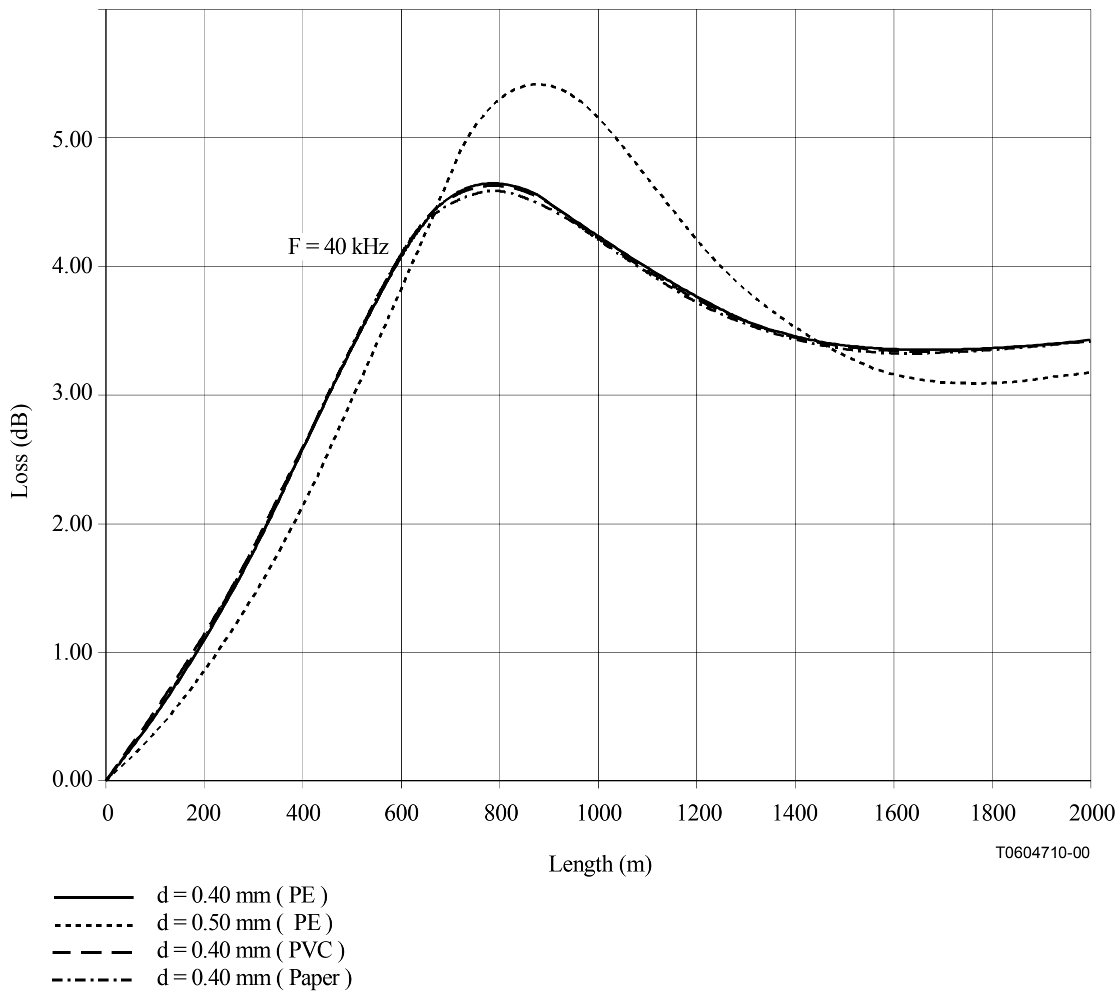


Figure I.1/L.19 – Loss due BT's in an ISDN transmission line (40 kHz)

For an **HDSL** system, the loss in a transmission line with wires that have a gauge of 0.40 and 0.50 mm, or the ohmic resistance of 140.0 and 89.5 ohms/km respectively, in low frequency with an insulation of polyethylene (PE) and 0.40 mm (26 AWG) with a plastic insulation (135.1 ohms/km) and paper (135.2 ohms/km) is shown in Figure I.2. The simulated transmission line has a termination of 135 ohms resistive and the values of the losses are exclusively due to the presence of the bridge taps. The transmitted signal frequency test is 150 kHz and Figure I.2 shows the losses according to the bridge taps length, for a propagation velocity whose value is a function of the signal frequency and cable characteristics of the transmission line.

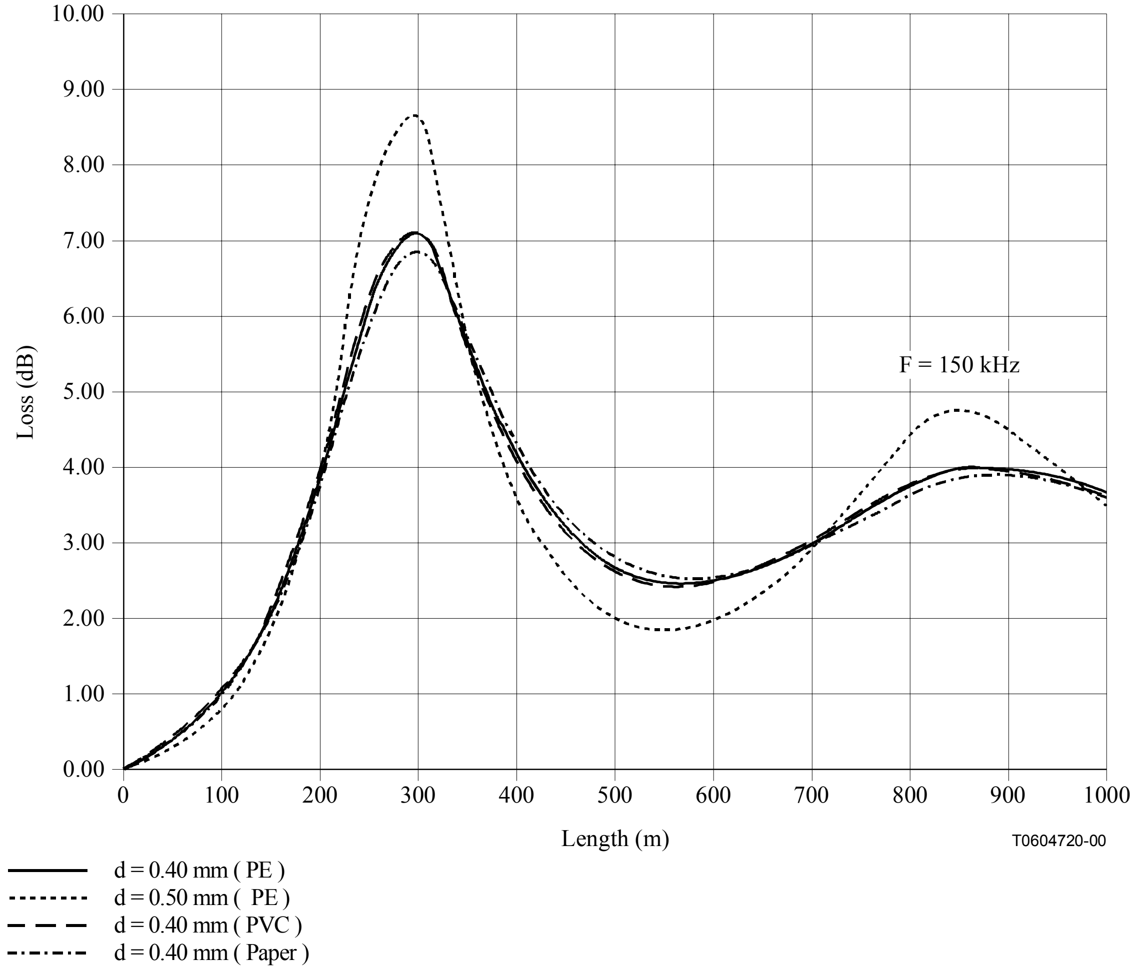


Figure I.2/L.19 – Loss due BT's in HDSL system (150 kHz)

For **ADSL** and **UADSL** systems, the loss in a transmission line with wires that have a gauge of 0.40 and 0.50 mm, or the ohmic resistance of 140.0 and 89.5 ohms/km respectively, in low frequency with an insulation of polyethylene (PE) and 0.40 mm (26 AWG) with a plastic insulation (135.1 ohms/km) and paper (135.2 ohms/km) is shown in Figure I.3. The simulated transmission line has a termination of 100 ohms resistive and the values of the losses are exclusively due to the presence of the bridge taps. The transmitted signal frequency test is 300 kHz and Figure I.3 shows the losses according to the bridge taps length, for a propagation velocity whose value is a function of the signal frequency and cable characteristics of the transmission line.

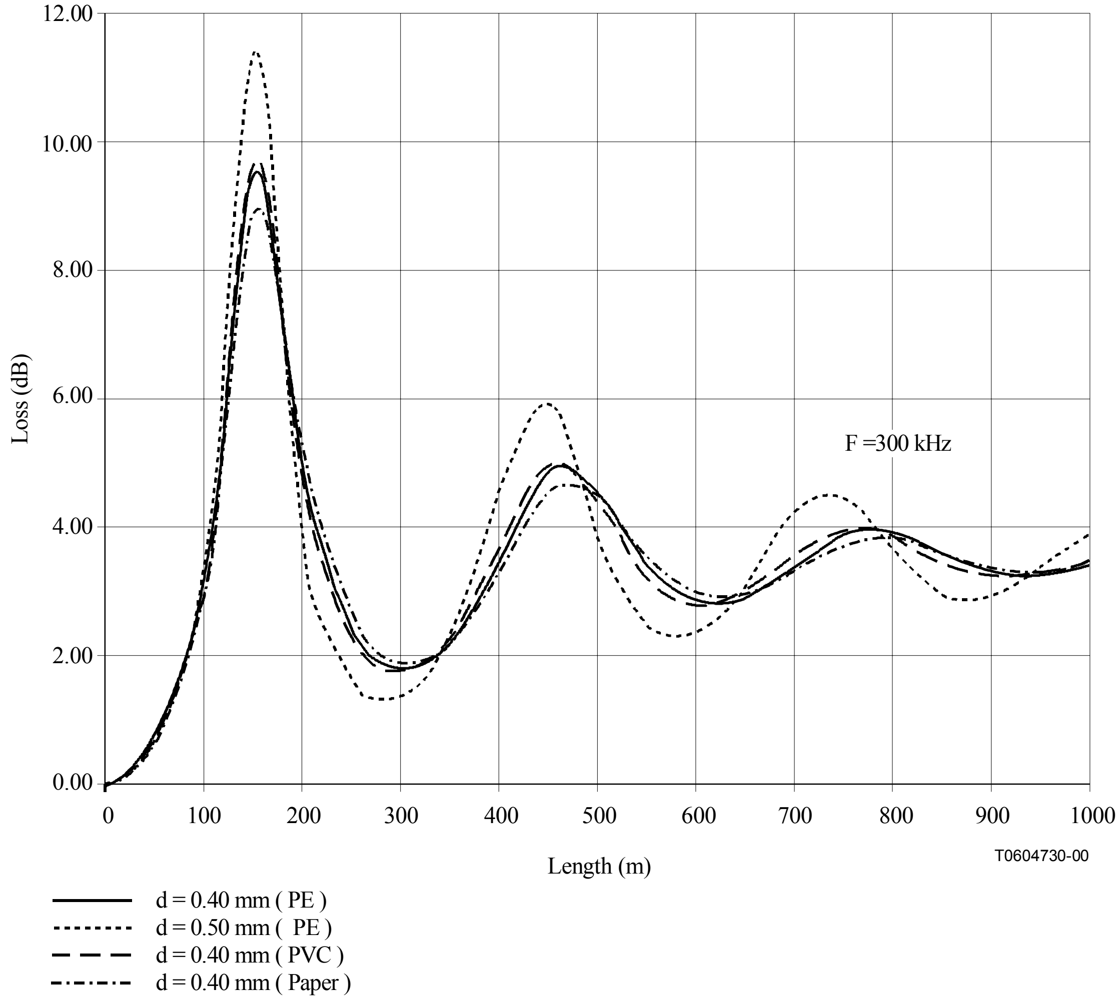


Figure I.3/L.19 – Loss due BT's in an ADSL and UADSL systems (300 kHz)

The transmission line impedance at the point of the bridge taps tends to zero for bridge taps lengths which are equal to the odd multiples of λ/4.

For very large bridge taps (bigger than 5 λ), having the same characteristics of the transmission line wires, there is a plane attenuation of 3.52 dB (2/3 of the signal power).

The transfer function of circuit does not depend on the position of the bridge taps when the transmission line is completely matched.

However, the losses will be different when there is no matching of the transmission lines or when there are gauge changes.

APPENDIX II

France Telecom experience

II.1 Mass deployment of ADSL: loop qualification process

The mass deployment of ADSL may give rise to unacceptable costs due to operational issues like service provision and repair. The main issue is to determine if an existing loop is able to support ADSL or not. The process of responding to a customer's order for a given service is specific to every telecom operator and should not be considered herein.

II.2 Maximum reach of ADSL systems

The reach of ADSL for a given transmission data rate is determined by the signal-to-noise ratio at both ends of the copper line which is strongly correlated to the following parameters: attenuation versus frequency, RF interferes, NEXT and FEXT.

On field noise measurements and software simulations would be enough to determine a maximum reach for a given service. This maximum reach can be calculated in dB at 300 kHz. The total loss should be estimated by summing up the loss of the lengths of copper pair cables of different gauges.

The accuracy of this estimation depends on the reliability of the plant records which should be checked previously.

II.3 On field quality of the copper pair

In order to reduce RF and impulse noise level, the copper pair has to be well balanced. For cost purposes, a network analyser is not appropriate. In most cases automatic electrical test measurement is implemented in every central office.

At first AC and DC measurements are required to check that no hazardous voltage is present on the copper pair.

Secondly, electrical measurements like resistance and capacitance are very useful to verify if the pair is balanced enough or not.

- The resistance is measured between the two wires and between the two wires and the ground using a direct voltage limited to 150 volts.
- Capacitance between the two wires and the ground is measured using an alternative current. A few ten Hz and signal processing is appropriate. In the labs measurements have been carried out to analyse the correlation between longitudinal unbalance and resistance and capacitance.

Resistance higher than 1 MOhm and capacitance unbalance (Δ C between wire A to earth and wire B to earth) less than 2% ensures that the cable has not been damaged (moisture, etc.) and that the longitudinal unbalance does not cause interference.

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