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Pre-Standard

First edition
2004-01

Safety aspects for xDSL signals on circuits connected to telecommunication networks (DSL: Digital Subscriber Line)

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CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

SAFETY ASPECTS FOR XDSL SIGNALS ON CIRCUITS CONNECTED TO TELECOMMUNICATION NETWORKS (DSL: DIGITAL SUBSCRIBER LINE)

FOREWORD

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Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC-TS 62367, which is a technical specification, has been prepared by IEC technical committee 108: Safety of electronic equipment within the field of audio/video, information technology and communication technology.

This technical specification is a pre-standard publication which may be updated in the future as an International Standard.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
108/61/DTS	108/90/RVC

Full information on the voting for the approval of this technical specification can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

In this standard, terms defined in 1.2 of IEC 60950-1are printed in SMALL CAPITALS.

The committee has decided that the contents of this publication will remain unchanged until 2007. At this date, the publication will be

- transformed into an International Standard;
- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

INTRODUCTION

xDSL signals are high-speed telecommunication signals that may be present on a telecommunication line, together with:

- analogue PSTN (Public Switched Telephone Network);
- ISDN (Integrated Services Digital Network) signals; or
- a d.c. power-feeding component.

An xDSL signal is characterised by an amplitude of the order of 3 V r.m.s. with superimposed spikes having very short duration (about 1 µs) and peak values not exceeding 30 V.

When combined with other services as above, the peak voltage can very occasionally exceed the limits for a TNV-3 CIRCUIT. However the excursions above these limits consist of these very short duration spikes.

There are no published documents from IEC on the effect of such spikes on the human body, but experience with xDSL is that the safety risk, if any, is very small because of:

- the low power of the spikes; and
- the limited accessibility of TNV circuits.

The amplitude and probability of the spikes have been calculated as follows:

- amplitude up to 15V/1µs with a probability of occurrence of one every few seconds to every few minutes;
- amplitude up to 20V/1µs with a probability of occurrence of one every few hours;
- amplitude up to 27V/1µs with a probability of occurrence of one every few years.

Annex A gives more detail on the operation of xDSL telecommunication systems.

SAFETY ASPECTS FOR XDSL SIGNALS ON CIRCUITS CONNECTED TO TELECOMMUNICATION NETWORKS (DSL: DIGITAL SUBSCRIBER LINE)

1 Scope

This technical specification addresses the safety implications of having xDSL signals on circuits in equipment connected to a TELECOMMUNICATION NETWORK, and gives rules for dealing with such equipment in the context of the IEC 60950 series.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60950 (all parts), *Information technology equipment – Safety*

IEC 60950-1 (all parts), *Information technology equipment – Safety – Part 1: General requirements*

3 Terms and definitions, and abbreviations

For the purposes of this document, the terms and definitions in the IEC 60950 series and the following abbreviations apply.

ADSL	Asymmetric Digital Subscriber Line
CF	Crest Factor
CO	Central Office
CPE	Customer Premises Equipment
DMT	Discrete Multi Tone
DSL	Digital Subscriber Line
HDSL	High Speed Digital Subscriber Line
IEC	International Electrotechnical Commission
ISDN	Integrated Services Digital Network
ITU	International Telecommunication Union
ITU-T	Telecommunication Standardization Sector of ITU
NT	Network Termination
PAR	Peak to Average Ratio
PSTN	Public Switched Telephone Network
QAM	Quadrature Amplitude Modulation
RSS	Remote Signal Source
SDSL	Symmetric Digital Subscriber Line
TNV	Telecommunication Network Voltage
VDSL	Very-high-bit-rate Digital Subscriber Line

4 xDSL signals on circuits connected to telecommunication networks

Based on the information presented in Annex A, it is recommended that for equipment within the scope of the IEC 60950 series of standards, the following rules be applied for xDSL signals on circuits connected to telecommunication networks.

Rule 1: Circuits carrying xDSL signals are classified as either TNV-1 CIRCUITS or TNV-3 CIRCUITS, depending on the normal operating voltage of the circuit.

Rule 2: When

a) assessing the voltages in circuits carrying xDSL signals with respect to the limits in 2.3.1 of IEC 60950-1, and when

b) determining the WORKING VOLTAGE of insulation in accordance with the IEC 60950 series,

the voltage of xDSL signals is regarded as zero and has no impact on the classification of the circuits.

Annex A
(informative)

xDSL telecommunication systems

A.1 Introduction

This annex describes the structure of xDSL signals, and explains why it is considered that there is no shock hazard associated with xDSL signals.

xDSL is a general expression for high-speed telecommunication signals such as ADSL (Asymmetric Digital Subscriber Line), VDSL (Very-high-bit-rate DSL), HDSL (High-Speed-DSL), SDSL (Symmetric DSL), etc. (see Figure A.1). xDSL signals are generally transmitted between the CO (Central Office) or RSS (Remote Signal Sources, such as repeaters and optical network units in street cabinets) and the CPE (customer premises equipment). These signals are transmitted over existing wires and cables. ADSL and VDSL signals may be transmitted in combination with existing telephone services such as PSTN and ISDN. In other cases the telecommunication line only carries the xDSL signal together with d.c. to power the CPE from the CO.

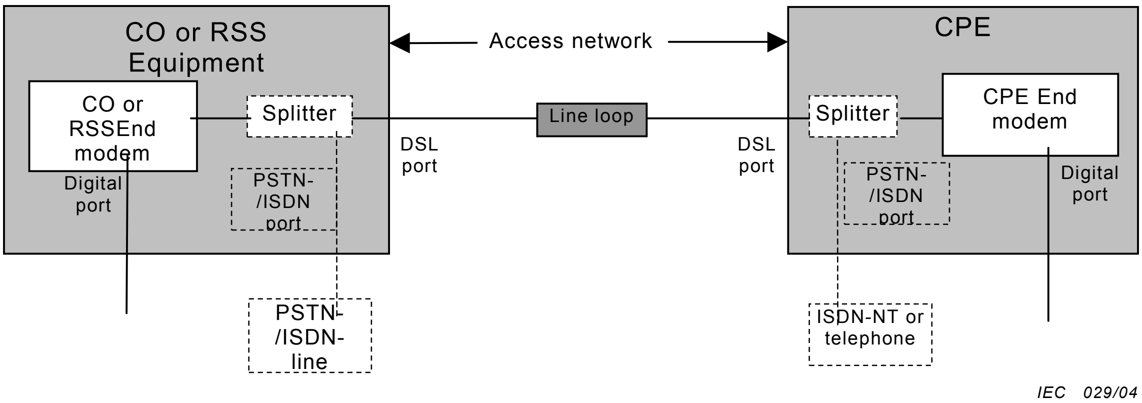

Figure A.1 – Typical configuration of an xDSL system

A.2 General description

An xDSL signal consists of an a.c. waveform with complex amplitude and frequency behaviour due to the use of special modulation techniques. Although xDSL signals are functional communication signals within a broadband frequency spectrum, their appearance on an oscilloscope is like “white-noise”, for example, a small average or r.m.s. value with occasional spikes (see Figure A.2).

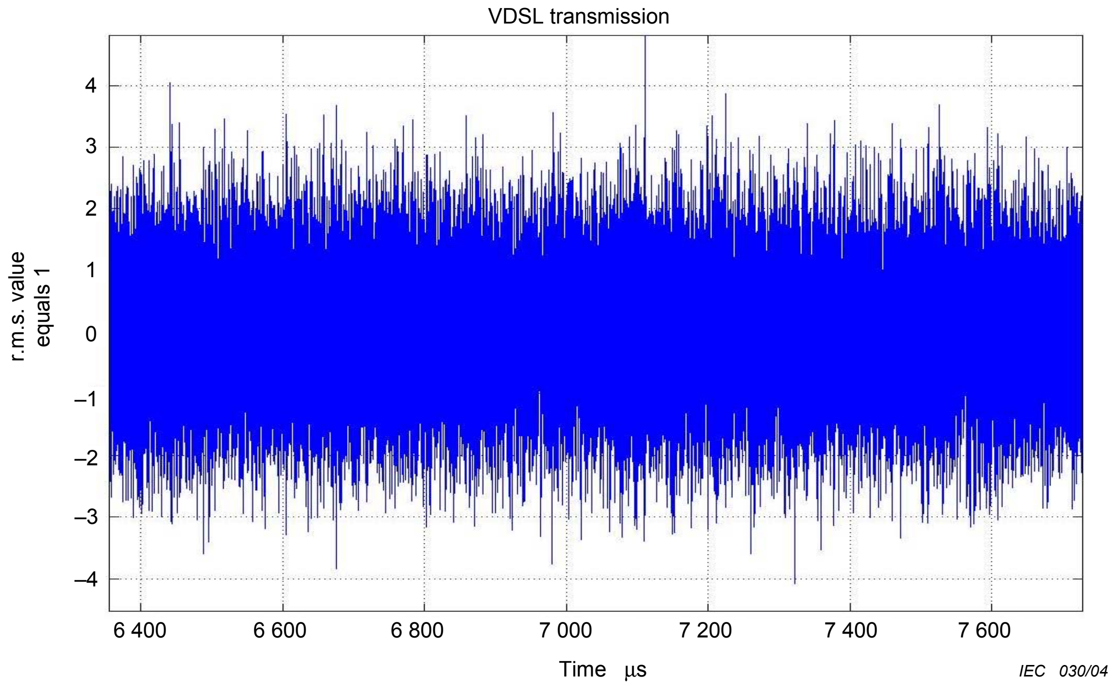

Figure A.2 – Typical xDSL (VDSL) signal in the time-domain

The magnitude of an xDSL signal is defined in the relevant functional standard by its mean power into a resistive load, within a specified frequency band. This mean power, in dBm, can be expressed as a well defined r.m.s. voltage value, in general in the order of a few volts. Of all xDSL signals, the worst case value, for ADSL combined with PSTN (ITU-T Recommendation G.992.1- Annex A), is 20,4 dBm into 100 Ω or 3,31 V r.m.s. in the downstream direction (from CO to CPE), and 12,5 dBm into 100 Ω or 1,33 V r.m.s. in the upstream direction (from CPE to CO).

The peak voltage however can be higher and depends on:

- peak-to average ratio (PAR) or crest factor (CF);
- CF distribution;
- real line-termination impedance, which is not purely resistive.

In A.3 and A.4 below, an explanation is given to show that:

- the value of the peak voltage is limited and
- the higher the value of the peak voltage, the lower probability of its occurrence.

A.3 Peak-to average ratio and CF

As the name indicates, the PAR of a symbol is the ratio of the maximum instantaneous power in the symbol to the average power. Without giving detailed information about a symbol, it is an indication for the occurrence of peaks in that symbol.

A large PAR value indicates that somewhere in the signal at least one sample takes on a (power) value that is large with respect to the average sample power. A small PAR value on the other hand indicates that the symbol varies evenly around the average power, without making any large excursions.

The CF is mostly used in standardization documents instead of the PAR. The CF is defined as the square root of the PAR (or half the PAR when the value is expressed in dB). In practice, ADSL systems are designed to cope with a CF of about 5 to 6. The probability of peak voltages above a certain threshold can be estimated by using the CF distribution. The relation is given by:

$$V_{\text{peak}} = CF \times V_{\text{r.m.s.}}$$

Since the CF is stochastic in the xDSL multi-carrier modulation, the same will be true for the peak voltage of the signal (evaluated over a limited period of time).

Given the worst case signal type, which is ADSL, and the assumption that upstream and downstream ADSL signals are cumulative on the telecommunication lines, the signal can theoretically go up to 27,8 V_{peak}, with a CF of 6. However, this peak voltage has only a very low probability of occurrence.

A.4 CF distribution

Figure A.3 shows the CF distribution of xDSL signals using two different modulation techniques, namely a Quadrature Amplitude Modulation (QAM) and a multi-carrier Discrete MultiTone (DMT). The figure is based on a Gaussian distribution and shows the relation between the probability (value in y-axis) that an xDSL signal has a CF larger than x (value in x--axis). The simulation was done with a non-resistive line impedance termination and shows a simulation for 24, 256 and 4 096 carriers or tones.

The figure shows that, if the number of carriers increases in a multi carrier DMT system, the probability that a signal with a higher CF occurs is more likely. However, differences between DMT and single carrier modulation are minimal.

As an example, the probability that the voltage value of a sample of the xDSL signal exceeds 6 times the r.m.s. value is about 10^{-6} for DMT (256 tones).

It must also be remarked that for a lower number of carriers, the upper limit is looser (for example, for 24 carriers, Figure A.3 gives an overestimation of the probability).

Figure A.4 shows the lower limit on the inter-arrival time (in seconds) of a symbol with a CF larger than x. The relation between Figure A.3 and Figure A.4 is determined by the sample rate of the symbol that equals 4 kHz. Again, for 24 carriers, the inter-arrival time of the lower limit is much worse than the inter-arrival time in reality.

In general, it can be concluded that the CF will be higher if the number of carriers increases. This number of carriers may be different for each type of xDSL and the actual operating conditions.

In the determination of the peak voltage, one must consider the combination of the CF and the r.m.s. voltage value, which is different for each type of xDSL.

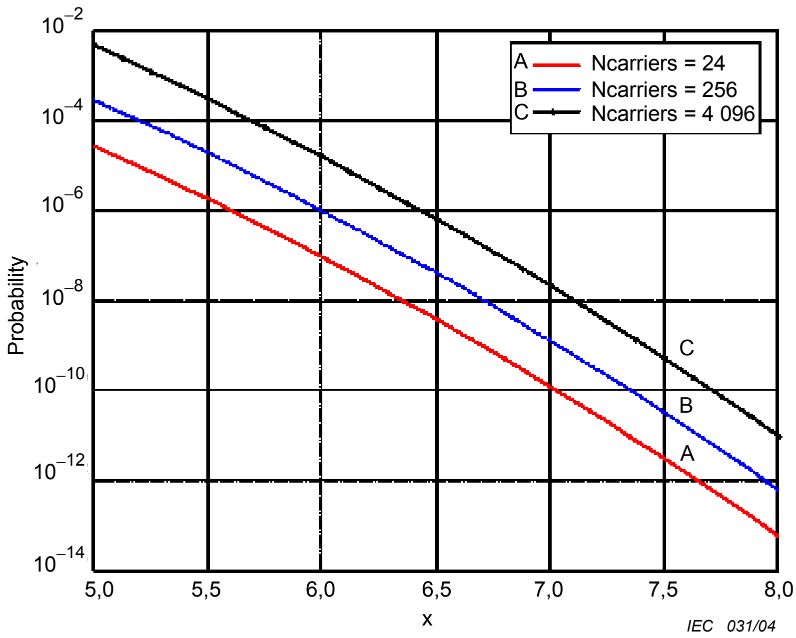

Figure A.3 – Probability of symbol with CF >x

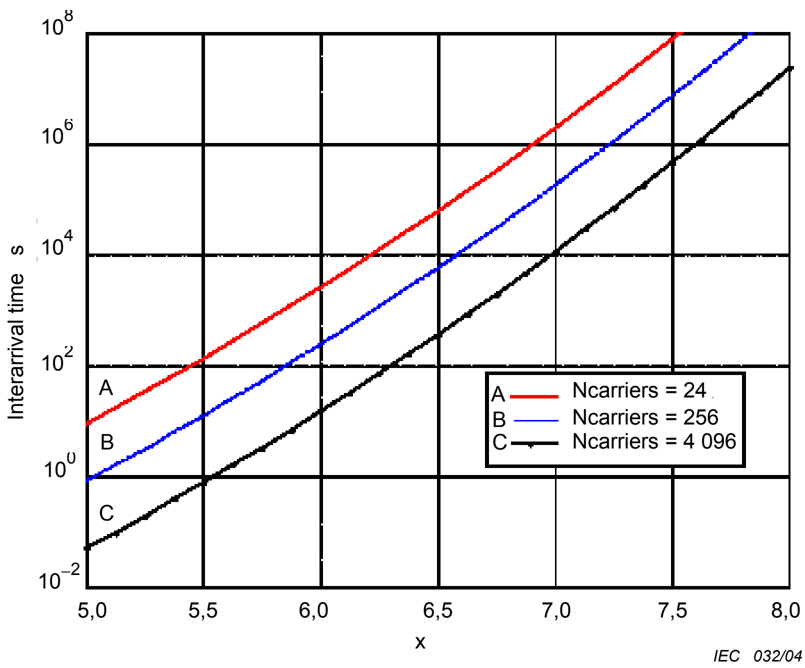

Figure A.4 – Inter-arrival time of symbol with CF > x (DMT-symbol rate = 4 kHz)

In the above discussion, the upstream and downstream signals are considered separately. In practice, these are on the telecommunication line simultaneously, and the sum of the two signals might result in a higher peak voltage. Taking the example of a CF = 6 with a probability of occurrence of 10^{-6}, and given the fact that both xDSL signals are independent, the probability of peaks from upstream and downstream adding coherently is 10^{-12}. This results in an average inter-arrival time of such peak voltages of a few years.

Moreover, on short lines, where there is not much line attenuation, xDSL systems provide an automatic transmit power cut-back feature which is intended to limit the maximum received power to approximately 8 dBm. In this way, the power, and thus the voltage on the telecommunication line, is brought back to a lower level. This will result in an overall lower voltage level on the individual xDSL signals and on the combined signal, with even lower probability of occurrence.

On long lines, the automatic power cut-back feature is not used, but it is quite obvious that the full power of the upstream and downstream signals, and thus the highest xDSL peak voltage values, are not present at the same time at the same point of the telecommunication line. At the CO, the downstream xDSL signal will be high in amplitude and combined with an attenuated upstream xDSL signal. At the CPE site, the opposite situation occurs. In general, the peak voltage value of just one xDSL signal will be significant in this situation.

Thus, it can be concluded that the occurrence of high peak voltages depends on the voltage value. The higher this value, the lower its probability of occurrence.

A.5 Line termination impedance

The xDSL signal is defined by its mean power (in dBm) into a resistive load within a specified frequency band.

Taking into account the CF, the maximum peak voltage that might occur on the telecommunication line can be determined with a certain probability of occurrence.

However, in real telecommunication systems, the loop and its termination impedance on the load side do not behave in a purely resistive manner. The channel has some phase distortion, which scrambles the alignment of the different carriers. This might result in higher peak voltages, but with the same very low probability of occurrence.

A.6 Measurement of xDSL parameters

ETSI technical report TR 101 830-1 provides definitions and characteristics of xDSL signal types as well as other signals on a telecommunication line. For each signal type, the total signal power and the peak amplitude are specified.

The measurement method for peak amplitude is described in TR 101 830-1 as follows:

> “The peak amplitude is defined as the peak voltage amplitude measured in a continuous sending signal such that the probability of exceeding that amplitude is less than 10^{-7}. It shall be measured into a resistive load R, and over a period of not less than 120 seconds. The bandwidth B of the measuring instrument shall be as defined in the specification for peak amplitude for the signal under test.
>
> The measurement period of at least 120 seconds is required to generate a peak amplitude to better than $1 \times e^{-7}$ probability for all known DSL types except DMT ADSL. DMT’s combination of near-Gaussian distribution and low symbol rate would require a measurement period on the order of 42 minutes to generate 10^{7} symbols, however, 120 seconds will generate a peak measurement on the order of 90% of the 10^{-7} peak.”

Bibliography

ETSI TR 101 830-1, *Transmission and Multiplexing (TM); Spectral management on metallic access networks; Part 1: Definitions and signal library.* (Obtainable free of charge from the following internet address: **http://pda.etsi.org/pda/queryform.asp)**

ITU-T Recommendation G.992.1: *Asymmetric digital subscriber line (ADSL) transceivers*

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