TITLE **Proposal to add a VDSL test set-up on crosstalk margins**

PROJECT VDSL

SOURCE: KPN (PTT Telecom, KPN Research)
author: Rob van den Brink

CONTACT R.F.M. van den Brink
KPN Research,
PO Box 421
2260 AK Leidschendam
The Netherlands
tel: +31 70 3325389
fax: +31 70 3326477
email: R.F.M.vandenBrink@research.kpn.com

STATUS Proposal

ABSTRACT This proposal is an extension to the transmission performance tests. The purpose is to enable operators to predict from a few standard tests the overall VDSL performance under *country specific operational conditions*. The proposal adds a test method for noise and impulse margins, and simplifies on the fly the choice of (1) the standard testloop insertion loss, and of (2) the levels of the two noise models and impulse signal(s).

Problem description

The current transmission performance tests with VDSL (and ADSL + HDSL too) are straight forward go no-go tests. This means that a modem can pass the ETSI testloops or not, and there is nothing in-between them. The disadvantage of this approach is twofold:

- The performance tests should be an excellent template for the "average" European access network under operational conditions. This requires an undisputed quantification of the "average" requirements for testloop insertion loss and noise model spectra. This is impossible because a clear view is lacking on (1) <u>future</u> VDSL modem performance, (2) country specific[1] insertion loss and crosstalk values of various European cables, and (3) what future mix of incompatible modem signals will interfere with VDSL signals.
- Passing go no-go tests is not very informative on how successful VDSL has passed these tests and how VDSL will perform under operational conditions that differ from the standard test conditions.

Another problem is that levels of transmitted signals, interfering noise, impulses and spectral masks are not *fully* unambiguous defined in the current VDSL draft. The current text leaves room for measuring meaningless levels by terminating VDSL with other impedance's than 135Ω. This may occur, for instance, when a 135Ω spectrum analyzer or a 135Ω power detector is connected directly in shunt with a VDSL link. The measured signal is lowered significantly by this, and by no way representative for operational conditions.

Solution

The solution is a simple extension of the performance tests that prescribes how the quantities *noise margin* and *impulse margin* are measured. This extension facilitates the following advantages:

- The *margin* is a measure on how much increase of crosstalk noise level or impulse level is permitted before VDSL links will fail. This information enables operators to translate test results under ETSI conditions into their (country specific) operational conditions. Furthermore it is an efficient discriminating factor between moderate and excellent modems.

[1] The country specificness of cable crosstalk is emphasized by a recent ETSI contribution [1] that reported a difference of +7dB between "standard" EL-FEXT, and the EL-FEXT of that particular cable sample. The generality of this observation cannot be judged today, because many operators are still characterizing their networks.

- The spin-off of this proposal is that the final choice on testloop insertion loss and levels of the noise models A and B has become less-critical. Any “fair” choice will be good enough, and makes discussions on noise levels superfluous.
- Another spin-off is that the various levels become well defined by this proposal, because it specifies on the fly the methods to measure them.

The proposed text below, can be copied literally into the VDSL draft, when accepted.

9. Transmission performance

9.1 Test loops

Editorial note: *Use the current draft text, and augment the insertion loss table with numbers on symmetrical bitrates. The rational behind the figures is the first order approximation that a 2×13 Mb/s symmetrical modem will have similar performance as a 1×26 Mb/s>. This reduces the number of testloop constructions.*

VDSL payload code	***test frequency f_T***	***insertion loss @135W, @ f_T***
A1 *(6.5 Mb/s)*	2.5 MHz	44 dB
A2 *(13 Mb/s)*	4 MHz	38 dB
A3 *(26 Mb/s)*	6 MHz	28 dB
A4 *(52 Mb/s)*	8 MHz	17 dB
S1 *(2×6.5 Mb/s)*	4 MHz	38 dB
S2 *(2×13 Mb/s)*	6 MHz	28 dB
S3 *(2×26 Mb/s)*	8 MHz	17 dB

Table 4. *Insertion loss and test frequencies (f_T) for loops #1 to #4*

9.2 Noise Models

Editorial note: *Use something similar to the current draft text, with a noise model ‘A’ and ‘B’. It is recommended to define noise models as a spectrum that is observed directly at the receiver side of the modem. FEXT coupling functions should also be defined in the appendix of the VDSL draft. Note that ‘length’ is an undefineable parameter in these functions, because the testloops are based on different cables. Parameters, such as insertion loss, are more appropriated to this purpose*

9.3 Impulse ~~Noise tests~~ Models

Editorial note: *Contributions invited*

9.x Noise and impulse margin Tests (NEW SECTION)

The purpose of this section is to provide an unambiguous specification of (1) the test set-up, (2) the insertion path and (3) the way signal levels are defined. The tests are focused on the margin, with respect to the crosstalk levels when VDSL signals are attenuated by standard testloops and interfered with standard crosstalk noise or impulses. This margin indicates what increase of noise or impulse level is allowed under (country specific) operational conditions to ensure sufficient transmission quality.

Editorial note: *The interpretation of noise or impulse margin, and the development of deployment rules based on minimum margin requirements under operational conditions, are not the responsibility of the modem manufacturers. Nevertheless it is recommended that manufacturers provide operators with models that enable them to do reliable predictions on modem behaviour under deviant insertion loss or crosstalk conditions. Different linecodings may behave differently on this topic.*

9.x.1 Test Set-up definition

Figure [x] illustrates the functional description of the test set-up. It includes:
- the testloops, as specified in section 9.1,
- an adding element to add the noise spectra specified in section 9.2 and/or impulsive signals specified in section 9.3,
- a noise or impulse extension with variable output level (build-in or external),
- a high impedance differential voltage probe connected with level detectors such as a spectrum analyzer or a true rms voltage meter.

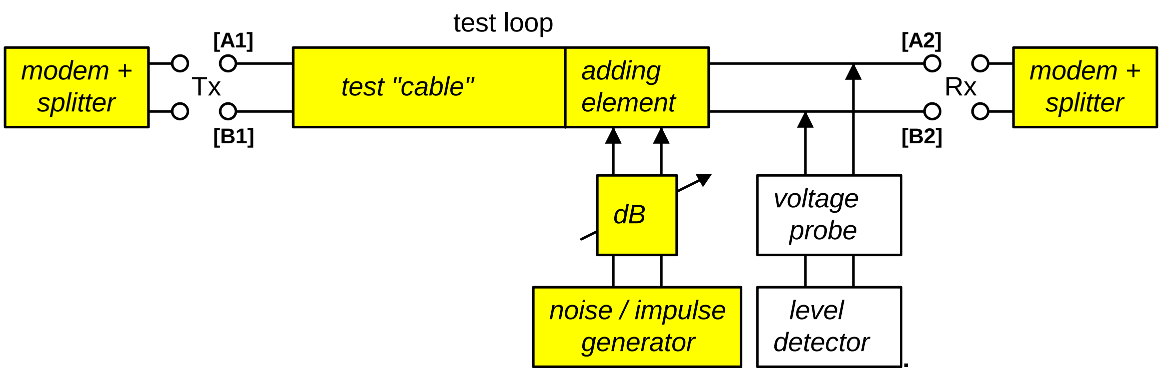

Figure x. *Functional description of the noise or impulse margin test set-up.*

The set-up requirements are as follows.
- The insertion loss of the testloop, as specified in section 9.1, is defined between port Tx (node pairs A1,B1) and port Rx (node pair A2,B2), and represents the combination of cable loss and a minor loss of the adding element.
- The signal flow through the test set-up is from port Tx to port Rx, which means that measuring upstream and downstream performance requires an interchange of modem position (or test set-up).
  - ⇒ The received signal level at port Rx is the level, measured between node A2 and B2, when port Tx as well as port Rx are terminated with the VDSL modems under test. The noise or impulse extension is switched off during this measurement.
  - ⇒ The transmitted signal level at port Tx is the level, measured between node A1 and B1, under the same conditions.
- The level of the noise or impulses is the level at port Rx, measured between node A2 and B2, while port Tx as well as port Rx are terminated with the design impedance R_V (135Ω). These impedance's shall be passive when the modem impedance at switched-off mode is different from this value.

9.x.2 Signal level definitions

The signal, noise and impulse levels are probed with a differential voltage probe, and the differential impedance between the tips of that probe should be higher than the shunt impedance of 100kΩ //

10pF. Figure [x] shows the probe position when measuring the Rx signal level. Measuring the Tx signal level requires the connection of the tips to node pair [A1,B1].

The various levels of signal, noise, impulses and spectral masks that are specified in this document are defined at the Tx or Rx side of this set-up. The various levels are defined while the set-up is terminated, as described above, with design impedance's R_V (135Ω) or with VDSL modems under test.

- Probing an rms-voltage U_{rms} [V] in this set-up, over the full signal band, means a power level of P [dBm] that equals:
  $P = 10 \times {}^{10}\log(U_{rms}^2 / R_V \times 1000)$ [dBm]
- Probing an rms-voltage U_{rms} [V] in this set-up, within a small frequency band of Δf (in Herz), means an average spectral density level of P [dBm/Hz] within that filtered band that equals:
  $P = 10 \times {}^{10}\log(U_{rms}^2 / R_V \times 1000 / \Delta f)$ [dBm/Hz]
  The bandwidth Δf identifies the *noise bandwidth* of the filter, and not the –3dB bandwidth.

9.x.3 Noise and impulse margin

At start-up, the level and shape of noise or impulses are adjusted, while their level is probed at port Rx to meet the requirements of section 9.2 or section 9.3. This relative level is referred to as 0 dB.
The modem link is subsequently activated, and the bit-error-rate of the link is monitored.

Next the noise or impulse level is increased, equally over the full VDSL frequency band, until the bit error rate is less than 1 in 10^4. This BER will be achieved at an increase of noise or impulse level of *x* dB, with a small uncertainty of Δx dB. This value x is defined as the *noise margin* with respect to a standard noise model A or B, or the *impulse margin* with respect to a standard impulsive signal.

The purpose of the unusual $BER=10^{-4}$ in this test is to fasten the iterative search for the noise or impulse margins. The BER requirements of 1 in 10^7 in section 9.6 remain valid to pass the transmission performance tests.

The noise and impulse margins shall be measured for upstream as well as downstream transmission under testloop condition #1, #2, #3, and #4.

References

[1] G. **Huang**, J.J. **Werner**: *A cable characterization method and procedure*. ETSI-TM6 contribution TD23 [963t23r0], Lucent technologies, Sophia Antipolis, Dec 1996.