International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

G.996.2

Amendment 5

(12/2017)

SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

Digital sections and digital line system – Metallic access networks

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Single-ended line testing for digital subscriber lines (DSL)

Amendment 5

Recommendation ITU-T G.996.2 (2009) – Amendment 5

International Telecommunication Union

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Recommendation ITU-T G.996.2

Single-ended line testing for digital subscriber lines (DSL)

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Summary

Amendment 5 to Recommendation ITU-T G.996.2 (2009) provides updates to Annexes A and B, defining SELT operating in conjunction with ITU-T G.9701 transceivers.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T G.996.2	2009-05-22	15	11.1002/1000/9666
1.1	ITU-T G.996.2 (2009) Amd. 1	2009-10-09	15	11.1002/1000/9892
1.2	ITU-T G.996.2 (2009) Amd. 2	2012-04-06	15	11.1002/1000/11503
1.3	ITU-T G.996.2 (2009) Amd. 3	2013-03-16	15	11.1002/1000/11892
1.4	ITU-T G.996.2 (2009) Amd. 4	2013-08-29	15	11.1002/1000/11995
1.5	ITU-T G.996.2 (2009) Amd. 5	2017-12-07	15	11.1002/1000/13309

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

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Single-ended line testing for digital subscriber lines (DSL)

Amendment 5

1) Updates to Annex A

Update Annex A as follows:

Annex A

Specific requirements of a SELT-PMD

(This annex forms an integral part of this Recommendation.)

A.1 SELT-PMD functions

A.1.1 SELT-PMD measurement functions

A.1.1.1 Measurement of uncalibrated echo response

The uncalibrated echo response function UER(f) is defined as the estimated mean value of the voltage ratio *V(f)*/E*(f)* measured inside the SELT-PMD.

$$UER(f) = Estimated\_Mean(X(f)) \quad \text{with} \quad X(f) = \left(\frac{V(f)}{E(f)}\right)$$

where *E(f)* is the excitation signal and *V(f)* the measured signal at frequency *f*.

E(f) is the voltage of a 0 ohm voltage source applied to the SELT-PMD transmitter front end, which transmits a voltage waveform V1+ on the SELT-PMD U-interface. The U-interface is connected to the one-port network (line) under test, that will generate a reflected voltage wave V1–. A linear combination of the voltage waveform V1+ and the reflected voltage wave V1– is transformed by the SELT-PMD receiver front end into a voltage *V(f)* measured with a high impedance voltage measurement unit.

The schematic representation of the SELT-PMD unit is shown in Figure A.1.

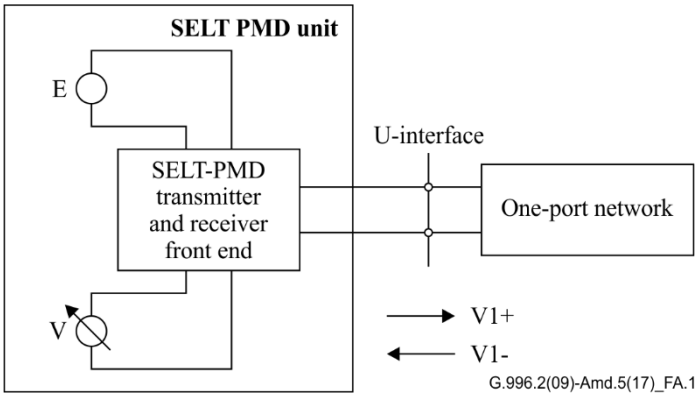

Figure A.1 – SELT-PMD during measurement of "uncalibrated echo response"

The transmit and receive parts of the front end includes all signal conditioning and processing until the U interface (linear time invariant networks, DSP-FE, amplifiers, filters, hybrid, POTS splitters, relays, connectors, protection circuitry, etc.). The SELT-PMD transmitter and receiver front end as a black box shall behave equivalently to a linear time invariant network. As a consequence, the UER(f) shall be independent of the analogue and digital gains used to perform the measurement. However, the UER(f) is the echo response measured without compensation of the time invariant effects of TX and RX AFE linear distortion.

The measurement and estimation duration shall be limited according to the configured SELT UER maximum measurement duration (see clause A.2.1.1). The actual physical line data acquisition time shall increase when the SELT UER maximum measurement duration is increased. This increase may have a step-wise character.

If a SELT-PMD-C, operating in conjunction with ITU-T G.9701 transceivers, transmits an excitation signal, this transmission shall be synchronized with the TDD timing of the ITU-T G.9701 ~~T~~timing ~~C~~control ~~E~~entity (TCE) in order to minimize the impact onto other ITU-T G.9701 transceivers in showtime.

NOTE 1 – SELT-PMD units usually have some freedom when configuring their front ends. However, because calibration arrays are often computed and stored outside of the SELT-PMD, the response of the SELT-PMD should be consistent over time in order for the calibration arrays to be valid. Therefore, it is recommended that the SELT-PMD use the same analogue and digital front-end configurations for all data collection.

NOTE 2 – The requirement that the SELT-PMD transmitter and receiver front end (as a black box) shall behave equivalently to a linear time invariant network may be realized by using fixed settings for the transmit front end and for the receive front end. Alternatively, inside the black box, an implementation may use time/channel dependent analogue gains in the transmitter and/or receiver. It should be noted that in this case it is the responsibility of the UER PMD implementation to compensate these analogue gains in such a way that the external characteristics of the black box are made equivalent to a linear time invariant network to satisfy the accuracy requirements. Digital scaling is inherently linear (except for increased quantization noise). Analogue gain scaling could introduce tolerances and frequency-dependent behaviour that depends on the analogue gain (e.g., gain of the transmit power amplifier, gain of the receive programmable-gain amplifiers (PGAs)). Transmit power amplifiers and receive path PGAs should be set so as to maximize the UER accuracy without incurring into significant non-linear distortion.

NOTE 3 – The SELT-PMD unit should select settings that minimize the attenuation and dispersion through its analogue and digital front ends. Any filters (e.g., high-pass, low-pass, band-pass, notch, and compensation filters) in either the transmit or receive path, that cause the response to deviate from a linear-phase all-pass characteristic, should be disabled if possible.

NOTE 4 – Digital echo cancellers should be turned off. Analogue echo cancellers should not be allowed to adapt during data collection because adaptation invalidates port calibrations and might cancel the desired echo.

A.1.1.2 Measurement of SELT quiet line noise

The quiet line noise SELTQLN(f) is the power spectral density (PSD), referred to a 100 ohm impedance, of the noise present on the line at frequency *f* when no near-end and far-end transmit signals are present on the line.

The quiet line SELTQLN(f) per sub-carrier shall be measured by the near-end receive PMD function.

The measured SELTQLN(f) shall reflect the actual PSD at the near-end U-interface related with the receive PMD. This means that the receive PMD function shall compensate for any used amplifier gains in the receiver and shall perform a best effort attempt to remove any impact of the near-end receiver filter characteristics.

The quiet line noise SELTQLN(f) shall be measured over a time interval complying to the configured SELT quiet line noise maximum measurement duration (see clause A.2.1.2). The actual physical line data acquisition time shall increase when the SELT QLN maximum measurement duration is increased. This increase may have a step-wise character.

Accuracy of SELT quiet line noise is for further study.

A.1.1.3 Measurement of impulse noise

Measurement of impulse noise is for further study.

A.1.1.4 Estimation of uncalibrated echo response variance

Noise during the measurement process of the echo response can lead to variation of the reported parameter UER(f). The uncalibrated echo response variance characterizes this variation.

NOTE – The variance parameter can be used to estimate the precision of UER(f).

To define the uncalibrated echo response variance, the echo measurement is considered to be a random process *X(f)* with expected value or mean value UER(f) as defined in clause A.1.1.1. The quantity UER(f) is derived using a vendor discretionary algorithm.

UER(f) can also be written as:

$$UER(f) = E[X(f)]$$ where $E[\ ]$ is the mathematical expectation operator.

The variation of UER is characterized by the relative variance of the uncalibrated echo response REL_VAR_UER(f) defined by:

$$REL\_VAR\_UER(f) = 10\log_{10}\left(\frac{VAR\_UER(f)}{|UER(f)|^2}\right)$$

where VAR_UER(f) is defined as:

$$VAR\_UER(f) = E\left[|X(f) - UER(f)|^2\right] = E\left[|X(f) - E[X(f)]|^2\right]$$

and $|x|$ denotes the absolute value of a complex valued number *x*.

The above definition of REL_VAR_UER(f) is an exact definition. The SELT-PMD entity shall report an estimate of this REL_VAR_UER(f). The exact algorithm to estimate the value of VAR_UER(f) estimation process is vendor discretionary.

The estimation of the uncalibrated echo response variance shall be performed within the same time period as the measurement of the uncalibrated echo response (see clause A.1.1.1).

A.2 SELT-PMD management entity

A.2.1 SELT-PMD configuration parameters

A.2.1.1 SELT UER maximum measurement duration

This parameter is the maximum allowed time for SELT uncalibrated echo response measurement, between the time of the start command written by the SELT-PMD-ME, and the time the result is available for read operation by SELT-PMD-ME.

NOTE – The above duration includes internal pre- and post-processing.

It is configurable between 5 seconds and 240 seconds, in steps of 1 second.

A.2.1.2 SELT quiet line noise maximum measurement duration

This parameter is the maximum allowed time for SELT quiet line noise measurement, between the time of the start command written by the SELT-PMD-ME, and the time the result is available for read operation by SELT-PMD-ME.

NOTE – The above duration includes internal pre- and post-processing.

It is configurable between 1 second and 240 seconds, in steps of 1 second.

A.2.2 SELT-PMD measurement parameters

The definition for reporting SELT uncalibrated echo response and SELT quiet line noise measurement parameters depends on whether or not the option for extended bandwidth SELT is applied.

NOTE – Using the option for extended bandwidth SELT facilitates SELT for ITU-T G.993.2 profile 35b and ITU-T G.9701 systems.

A.2.2.1 SELT uncalibrated echo response

The uncalibrated echo response, UER(i* UER_G*Df), shall be represented in linear format by a scale factor and a normalized complex number a(i)+j*b(i), where i is a frequency index i ranging from 0 to NSC–1, the subcarrier spacing, Df = 4.3125 kHz, and (NSC–1) × UER_G × Df is the highest frequency supported by the SELT-PMD functionality.

If the option for extended bandwidth SELT is not applied, then:

– The UER granularity parameter, UER_G, has two valid values: 1 and 2, indicating whether the measurements were performed using a ~~tone~~subcarrier spacing of 4.3125 kHz or of 8.625 kHz. If the uncalibrated echo response is being reported over a frequency range of 17.664 MHz or lower, UER_G shall be set to 1. If the uncalibrated echo response is being reported over a frequency range that is greater than 17.664 MHz, UER_G shall be set to 2.

If the option for extended bandwidth SELT is applied, then:

– The UER granularity parameter, UER_G, has three valid values: 1, 2 and 12, indicating whether the measurements were performed using a subcarrier spacing of 4.3125 kHz, 8.625 kHz, or 51.75 kHz, respectively.

The scale factor shall be coded as a 32-bit unsigned integer. Both a(i) and b(i) shall be coded as 32-bit 2's complement signed integers. The value of UER(i* UER_G*Df) shall be defined as: UER(i* UER_G*Df) = (scale/2^{31})*(a(i)+j*b(i))/2^{31}. In order to maximize precision, the scale factor shall be chosen such that max(|a(i)|, |b(i)|) over all i is equal to 2^{31}–1.

NOTE – This data format supports an UER(f) granularity of 2^{-31} and an UER(f) dynamic range of approximately +6 dB to –186 dB, however it does not imply any future accuracy requirements.

An UER(i*UER_G* Df) value indicated as a(i) = b(i) = $–2^{31}$ is a special value. It indicates that no measurement could be done for this subcarrier either because it is not supported by the SELT-PMD function, or that the value is out of range to be represented.

A.2.2.2 SELT uncalibrated echo response group size

The SELT uncalibrated echo response group size (SELT-UER_G) is a reported parameter identifying the UER frequency spacing, which is equal to SELT-UER_G × Df with Df = 4.3125 kHz. SELT-UER_G has three valid values: 1, 2 and 12. Clause A.2.2.1 refers to SELT-UER_G as the "UER granularity parameter, UER_G."

The SELT uncalibrated echo response group size shall be reported if the option for extended bandwidth UER SELT is supported; otherwise, reporting of the group size is optional. If the SELT uncalibrated echo response group size is not reported, the SELT uncalibrated echo response group size shall be equal to 1.

A.2.2.3 SELT variance of uncalibrated echo response

The REL_VAR_UER(f) provides the relative variance of the uncalibrated echo response by the SELT-PMD function for each frequency i × UER_G × Df, where i ranges from 0 to NSC–1, Df = 4.3125 kHz, and (NSC-1) × UER_G × Df is the highest frequency supported by the SELT-PMD functionality.

The relative variance of the uncalibrated echo response REL_VAR_UER(i× UER_G ×Df) shall be represented as an 8-bit unsigned integer v(i), where i is the subcarrier index i = 0 to NSC–1. The value of REL_VAR_UER(i× UER_G ×Df) shall be defined as REL_VAR_UER(i× UER_G ×Df) = 3 – v(i)/2 dB. The number v(i) is an 8-bit unsigned integer in the range 0 to 254. This data format supports a REL_VAR_UER(i) over a range from –124 dB to +3 dB for each carrier with a granularity from 0.5 dB. Out of range values shall be clamped to the closest range bound. The special value v(i) = 255 indicates that no measurement is available for that carrier.

A.2.2.~~3~~4 SELT quiet line noise

The SELT quiet line noise provides the quiet line noise PSD as measured by the SELT-PMD function (see clause A.1.1.2) for each sub-carrier frequency i × SELTQLN_G × Df where i ranges from 0 to NSC–1, Df = 4.3125 kHz, and (NSC–1) × SELTQLN_G × Df is the highest frequency supported by the SELT-PMD functionality.

If the option for extended bandwidth SELT is not applied, then:

– SELTQLN_G has two valid values: 1 and 2, indicating whether the measurements were performed using a ~~tone~~subcarrier spacing of 4.3125 kHz or of 8.625 kHz. If the SELT quiet line noise is being reported over a frequency range of 17.664 MHz or lower, SELTQLN_G shall be set to 1. If the SELT quiet line noise is being reported over a frequency range that is greater than 17.664 MHz, SELTQLN_G shall be set to 2.

If the option for extended bandwidth SELT is applied, then:

– SELTQLN_G has three valid values: 1, 2 and 12, indicating whether the measurements were performed using a subcarrier spacing of 4.3125 kHz, 8.625 kHz, or of 51.75 kHz, respectively.

SELT quiet line noise SELTQLN(i × SELTQLN_G × Df) shall be represented as an 8-bit unsigned integer n(i), where i is the subcarrier index i = 0 to NSC–1. The value of SELTQLN(i × SELTQLN_G × Df) shall be defined as SELTQLN(i × SELTQLN_G × Df) = –23 – (n(i)/2) dBm/Hz. This data format supports a SELTQLN(f) granularity of 0.5 dB and an SELTQLN(f) dynamic range of –150 to –23 dBm/Hz.

A.2.2.5 SELT quiet line noise group size

The SELT quiet line noise group size (SELTQLN_G) is a reported parameter identifying the SELTQLN frequency spacing, which is equal to SELTQLN_G × Df with Df = 4.3125 kHz. SELTQLN_G has three valid values: 1, 2 and 12.

The SELT quiet line noise group size shall be reported if the option for extended bandwidth QLN SELT is supported; otherwise, reporting of the group size is optional. If the SELT quiet line noise group size is not reported, the SELT quiet line noise group size shall be equal to 1.

A.2.2.~~4~~6 SELT impulse noise parameters

Impulse noise parameters are for further study.

A.2.3 SELT control parameters

A.2.3.1 SELT UER measurement enable C (SELT-UME-C)

This parameter is a binary variable, where "1" triggers the CO SELT PMD to start a UER measurement.

A.2.3.2 SELT UER measurement enable R (SELT-UME-R)

This parameter is a binary variable, where "1" triggers the CPE SELT PMD to start a UER measurement.

A.2.3.3 SELT QLN measurement enable C (SELT-QME-C)

This parameter is a binary variable, where "1" triggers the CO SELT PMD to start a QLN measurement.

A.2.3.4 SELT QLN measurement enable R (SELT-QME-R)

This parameter is a binary variable, where "1" triggers the CPE SELT PMD to start a QLN measurement.

A.2.4 SELT-PMD parameter partitioning

This clause defines the parameters which correspond to the specific reference points:

- η_C reference point.
- η_R reference point.

The parameters at the reference points are described by the following table, which indicates the status of the parameter at the corresponding reference points as:

- R are read only.
- W are write only.
- R/W are read and write.
- (M) are mandatory.
- (O) are optional.

R and W are defined as:

- η_C reference point:
  - W: parameter written by the SELT-ME-P-C to the SELT-ME-PMD-C.
  - R: parameter provided by the SELT-ME-PMD-C to be read by the SELT-ME-P-C.
- η_R reference point:
  - W: parameter written by the SELT-ME-P-R to the SELT-ME-PMD-R.
  - R: parameter provided by the SELT-ME-PMD-R to be read by the SELT-ME-P-R.

Table A.1 – Partitioning of SELT-PMD-ME parameters

Category/element	Defined in clause	η_C – reference point	η_R – reference point
SELT-PMD configuration parameters			
SELT UER maximum measurement duration C (SELT_UER_MMD_C)	A.2.1.1	R/W (M)	
SELT UER maximum measurement duration R (SELT_UER_MMD_R)	A.2.1.1		R/W (M)
SELT quiet line noise maximum measurement duration C (SELT_QLN_MMD_C)	A.2.1.2	R/W (M)	
SELT quiet line noise maximum measurement duration R (SELT_QLN_MMD_R)	A.2.1.2		R/W (M)
SELT-PMD measurement parameters			
SELT uncalibrated echo response C (SELT-UER-C)	A.2.2.1	R (M)	
SELT uncalibrated echo response R (SELT-UER-R)	A.2.2.1		R (M)

Table A.1 – Partitioning of SELT-PMD-ME parameters

Category/element	Defined in clause	η_C – reference point	η_R – reference point
SELT uncalibrated echo response group size C (SELT-UER_G-C)	A.2.2.2	R (M) (see Note 1)	
SELT uncalibrated echo response group size R (SELT-UER_G-R)	A.2.2.2		R (M) (see Note 1)
SELT variance of uncalibrated echo response C (SELT-UER-VAR-C)	A.2.2.~~2~~3	R (M)	
SELT variance of uncalibrated echo response R (SELT-UER-VAR-R)	A.2.2.3~~2~~		R (M)
SELT quiet line noise C (SELT_QLN_C)	A.2.2.~~3~~4	R (M)	
SELT quiet line noise R (SELT_QLN_R)	A.2.2.~~3~~4		R (M)
SELT quiet line noise group size C (SELTQLN_G-C)	A.2.2.5	R (M) (see Note 1)	
SELT quiet line noise group size R (SELTQLN_G-R)	A.2.2.5		R (M) (see Note 1)
SELT-PMD control parameters			
SELT UER measurement enable C (SELT-UME-C)	A.2.3.1	W(M)	
SELT UER measurement enable R (SELT-UME-R)	A.2.3.2		W(M)
SELT QLN measurement enable C (SELT-QME-C)	A.2.3.3	W(M)	
SELT QLN measurement enable R (SELT-QME-R)	A.2.3.4		W(M)
NOTE 1 – The SELT uncalibrated echo response group size (SELT-UER_G-C and SELT-UER_G-R) is mandatory only if the option for extended bandwidth UER SELT is supported; otherwise, reporting of the group size is optional. NOTE 2 – The SELT quiet line noise group size (SELTQLN_G-C and SELTQLN_G-R) is mandatory only if the option for extended bandwidth QLN SELT is supported; otherwise, reporting of the group size is optional.			

A.3 Test management and communications

Test management and communications are for further study.

2) Updates to Annex B

Update Annex B as follows:

Annex B

Specific requirements of a SELT-P

(This annex forms an integral part of this Recommendation.)

B.1 SELT-P functions

B.1.1 SELT-P derived parameters

B.1.1.1 Loop termination indicator

Loop termination indicator is a three state indication of the loop termination defined as follows.

- 'Open',
- 'Short',
- 'Powered on CPE',
- 'Unknown' (i.e., failure in identifying the termination).

Accuracy is for further study.

B.1.1.2 Loop length

This parameter is the physical length (in metres) of the loop between the U-C and the U-R interface.

The loop length shall be measured with a granularity of 1 m, with valid range of 0 to 16'383 m.

Accuracy is for further study.

B.1.1.3 Loop topology

The loop topology consists of a description of the loop structure, with indication of the physical length of each loop segment. In this parameter, a loop segment is defined as delimited by either a loop termination, or the presence of a bridged tap.

NOTE 1 – Two cables with different gauges/cable-types connected in series are considered as a single loop segment.

The loop topology is reported as a list of loop segments, using the following conventions:

1) The first loop segment in the list shall be the segment connected to the SELT-PMD block measuring the SELT-PMD measurement parameters (i.e., the SELT-PMD block shall be the starting point of the topology description).
2) Subsequent loop segments in the list shall describe the loop in the direction toward the far-end loop termination.
3) Consecutive loop segments indicated as 'bridged tap' represent bridged taps, each branching off from the main loop at the same point.

NOTE 2 – Identification of a bridged tap branching off on a bridged tap is not supported by this parameter.

A single loop segment is specified with two sub-parameters: loop segment length (see clause B.1.1.3.1) and loop segment bridged tap indicator (see clause B.1.1.3.2).

If this parameter is supported, reporting of up to three segments is a mandatory capability. Reporting of additional segments is optional.

Accuracy is for further study.

B.1.1.3.1 Loop segment length (LOOP_SEGM_LENGTH)

This parameter specifies the physical length of the loop segment, in metres.

The loop segment length shall be measured with a granularity of 1 m, with a valid range of 0 to 16'383 m.

B.1.1.3.2 Loop segment bridged tap indicator (LOOP_SEGM_BRIDGEDTAP)

This parameter specifies whether the loop segment is a bridged tap or arranged in series (i.e., not branching, not a bridged tap).

The valid values are:

- 'in series',
- 'bridged tap'.

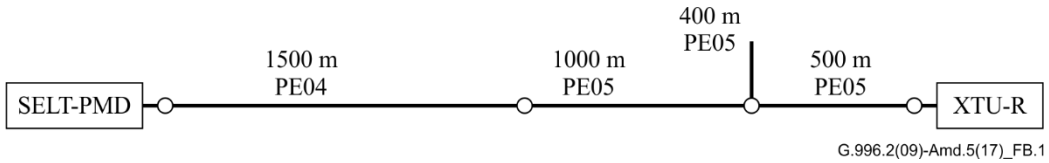

Figure B.1 – Example of loop

Table B.1 – Values of loop topology identification for the example loop

Loop topology	
LOOP_SEGM_LENGTH	**LOOP_SEGM_BRIDGEDTAP**
2500	0
400	1
500	0

B.1.1.4 Missing micro-filter or splitter

This parameter is a binary indication of a missing or incorrectly installed splitter or micro-filter at the U-R reference point. A value of 1 for this flag represents a missing splitter.

This parameter is only defined for the SELT-P-R functionality.

Accuracy is for further study.

B.1.1.5 Impulse noise statistics

Impulse noise statistics are for further study.

B.1.1.6 Attenuation characteristics

The line attenuation TFlog(f) is the logarithmic power transfer function of the line as a function of frequency when both the near-end and far-end line terminations have the following values:

- Source impedance = purely resistive equal to 100 ohms.
- Termination impedance = purely resistive equal to 100 ohms.

$$TF_{\log}(f) = 10\log_{10}\left(\left|\frac{V_{OUTPUT}(f)}{V_{INPUT}(f)}\right|^2\right)$$

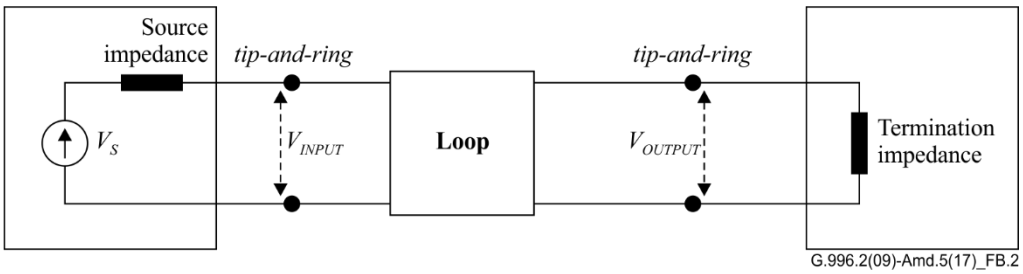

Figure B.2 – Attenuation characteristic

The definition for reporting the line attenuation TFlog(f) depends on whether or not the option for extended bandwidth SELT is applied.

The function TFlog(f) consists of an array of values TFlog(i × TFlog_G × Df), with Df = 4.3125 kHz.

NOTE – In the case where the instantiation of the LT unit is the same as the instantiation of the xTU transceiver unit, this value may be independent of the subcarrier spacing used for the xDSL DMT modulation.

The range of valid values for the index *i* is 0 to 8191.

If the option for extended bandwidth SELT is not applied, then TFlog_G = 1.

If the option for extended bandwidth SELT is applied, then:

– The attenuation characteristics group size, TFlog_G, has three valid values: 1, 2 and 12, indicating whether the measurements were performed using a subcarrier spacing of 4.3125 kHz, 8.625 kHz, or 51.75 kHz, respectively.

The range of valid values for TFlog(i × TFlog_G × Df) is from +6.0 dB down to –96.2 dB, with a granularity of 0.1 dB. A special value is used to indicate that no measurement could be done for this subcarrier because the attenuation is out of the range that can be represented.

Accuracy is for further study.

B.1.1.7 Attenuation characteristics group size

The attenuation characteristics group size (TFlog_G) is a reported parameter identifying the attenuation characteristics, TFlog(f), at a frequency spacing equal to TFlog_G × Df with Df = 4.3125 kHz. TFlog_G has three valid values: 1, 2 and 12.

The attenuation characteristics group size shall be reported if the option for extended bandwidth SELT is supported; otherwise, reporting of the group size is optional.

B.1.1.8 Capacity estimate

This parameter represents a best-effort estimate of the achievable net data rate (in kbit/s) on the loop under test, under the following assumptions:

- Fast mode (i.e., operation with interleaver depth D=1, and INP=0 (no impulse noise protection));
- use of Trellis coding;
- target margin equal to CAP-TARSNRM (see clause B.2.1.4);
- transmit signal PSD at the U-interface of the xTU-transmitter equal to CAP-SIGNALPSD (see clause B.2.1.2);
- noise PSD at the U-interface of the xTU-receiver equal to CAP-NOISEPSD (see clause B.2.1.3);
- support of bit loading from 1 to 15 bits included, in steps of 1 bit increments.

As the capacity is a best-effort estimate, accuracy for this parameter is vendor proprietary.

The parameter in the downstream direction is CAPACITYds, and the parameter in the upstream direction is CAPACITYus.

B.2 SELT-P management entity

B.2.1 SELT-P configuration parameters

B.2.1.1 Capacity estimate calculation enabling (CECE)

This parameter specifies if the SELT-P function shall perform the "downstream capacity" and "upstream capacity" estimations, if supported. This parameter is expressed as a binary flag and takes the value 0 if xDSL performance estimation is not required, 1 otherwise.

B.2.1.2 Capacity estimate signal PSD (CAP-SIGNALPSD)

This configuration parameter defines the PSD template of the transmit signal to be used in capacity estimate evaluation.

The PSD template CAP-SIGNALPSD shall be specified through a set of breakpoints. Each breakpoint shall consist of a frequency index, t_n, and a signal PSD level (expressed in dBm/Hz). The parameter shall be a set of breakpoints represented by [(t_1, PSD_1), (t_2, PSD_2), …, (t_N, PSD_N)], where t_1 and t_N represent, respectively, the lower frequency of the lowest band over which the capacity estimate is to be calculated, and the highest frequency of highest band over which the capacity estimate is to be calculated. In the case of an estimation of capacity for a multi-band xDSL, the set of breakpoints shall describe the stopbands situated inbetween passbands.

NOTE – Stopbands may be described as brickwall stopbands using the lowest valid value (–200 dBm/Hz) or may be described more elaborately.

The breakpoints shall be defined so that $t_n < t_{n+1}$ for $n = 1$ to $N - 1$. The frequency f_n corresponding to the index t_n can be found as: $f_n = t_n \times Df$. The value of $Df = 4.3125$ kHz and is independent of the subcarrier spacing used for the DMT modulation of the xDSL.

The range of valid values for index t_n is 0 to ~~8191~~49152 in steps of 1. The range of valid values for PSD is –30 to –200 dBm/Hz in steps of 0.1 dBm/Hz.

The PSD template in dBm/Hz, for any frequency $f = i \times Df$, shall be obtained by linear interpolation in dB on a linear frequency scale, as follows:

$$CAP-SIGNALPSD\ (i) = PSD_n + \left(PSD_{n+1} - PSD_n\right) \times \frac{(i - t_n)}{(t_{n+1} - t_n)} \quad t_n < i \le t_{n+1}$$

The parameter in the downstream direction is CAP-SIGNALPSDds, and the parameter in the upstream direction is CAP-SIGNALPSDus.

The maximum number of breakpoints in downstream is 48, and in upstream 48.

B.2.1.3 Capacity estimate noise PSD (CAP-NOISEPSD)

This configuration parameter defines the PSD template of the received noise to be used in capacity estimate evaluation.

The PSD template CAP-NOISEPSD shall be specified through a set of breakpoints. Each breakpoint shall consist of a frequency index t_n and a signal PSD level (expressed in dBm/Hz). The parameter shall be a set of breakpoints that are represented by [(t_1, PSD_1), (t_2, PSD_2), … , (t_N, PSD_N)], where t_1 and t_N are, respectively, the lower frequency of the lowest band over which the capacity estimate is to be calculated, and the highest frequency of highest band over which the capacity estimate is to be calculated.

In the case of an estimation of capacity for a multi-band xDSL, with the CAP-SIGNALPSD stopbands described as brickwall stopbands, the set of breakpoints for CAP-NOISEPSD is not required to describe the noise in the stopbands situated inbetween passbands. In case the CAP-SIGNALPSD stopbands are not described as brickwall stopbands, the set of breakpoints for CAP-NOISEPSD shall describe the noise in the stopbands situated inbetween passbands.

The breakpoints shall be defined so that $t_n < t_{n+1}$ for $n = 1$ to $N - 1$. The frequency f_n corresponding to the index t_n can be found as: $f_n = t_n \times Df$. The value of $Df = 4.3125$ kHz and is independent of the subcarrier spacing used for the DMT modulation of the xDSL.

The range of valid values for index t_n is 0 to ~~8191~~49152, in steps of 1. The range of valid values for PSD is –30 to –200 dBm/Hz, in steps of 0.1 dBm/Hz.

The PSD template in dBm/Hz, for any frequency $f = i \times Df$, shall be obtained by linear interpolation in dB on a linear frequency scale as follows:

$$CAP-NOISEPSD(i)=PSD_n+(PSD_{n+1}-PSD_n)\times\frac{(i-t_n)}{(t_{n+1}-t_n)} \quad t_n<i\le t_{n+1}$$

The parameter in the downstream direction is CAP-NOISEPSDds, and the parameter in the upstream direction is CAP-NOISEPSDus.

The maximum number of breakpoints in downstream is 128, and in upstream 128.

B.2.1.4 Capacity estimate target noise margin (CAP-TARSNRM)

This is the noise margin to be used in capacity estimate evaluation, relative to a BER requirement of 1E-7.

The range of valid values for CAP-TARSNRM expressed in dB is 0 to 31 dB, in steps of 0.1 dB.

The parameter in the downstream direction is CAP-TARSNRMds, and the parameter in the upstream direction is CAP-TARSNRMus.

B.2.2 SELT-P derived parameters

B.2.2.1 Loop termination indicator

The parameter in the SELT-P ME shall have the same format as the one specified for the SELT-P.

B.2.2.2 Loop length

The parameter in the SELT-P ME shall have the same format as the one specified for the SELT-P.

B.2.2.3 Loop topology

The parameter in the SELT-P ME shall have the same format as the one specified for the SELT-P.

B.2.2.4 Missing micro-filter or splitter

The parameter in the SELT-P ME shall have the same format as the one specified for the SELT-P.

B.2.2.5 Impulse noise statistics

Impulse noise statistics are for further study.

B.2.2.6 Attenuation characteristics

The parameter in the SELT-P ME shall have the same format as the one specified for the SELT-P.

B.2.2.7 Capacity estimate

The parameter in the SELT-P ME shall have the same format as the one specified for the SELT-P.

B.2.3 SELT-PMD network management element partitioning

This clause defines the network management elements which correspond to the specific management interfaces:

- Q-interface,
- G-interface,
- T-interface.

The parameters at the management interfaces are described in the following table, which indicates the status of the parameter at the corresponding management interface as:

- R are read only.
- W are write only.
- R/W are read and write.
- (M) are mandatory.
- (O) are optional.

Table B.2 – Partitioning of SELT-P-ME reporting parameters

Category/element	Defined in clause	Q - interface	G - interface	T - interface
SELT-P parameters				
SELT-P derived parameters				
Loop termination indicator (LOOP-TERM)	B.2.2.1	R (M)	R (O)	
Loop length (LOOP_LEN)	B.2.2.2	R (M)	R (O)	
Loop topology (LOOP-TOPOLOGY)	B.2.2.3	R (O)	R (O)	
Attenuation characteristics TFlog(f) (ATT-CHAR)	B.2.2.6	R (O)	R (O)	
Attenuation characteristics group size (TFlog_G)	B.1.1.8	R (O)	R (O)	
Missing micro-filter or splitter (MIS-FILTER)	B.2.2.4		R (O)	
Capacity estimate (CAP-EST)	B.2.2.7	R (O)	R (O)	
SELT-P configuration parameters				
Capacity estimate calculation enabling (CECE)	B.2.1.1	R/W (O)	R/W (O)	
Capacity estimate signal PSD (CAP-SIGNALPSD)	B.2.1.2	R/W (O)	R/W (O)	
Capacity estimate noise PSD (CAP-NOISEPSD)	B.2.1.3	R/W (O)	R/W (O)	
Capacity estimate target noise margin (CAP-TARSNRM)	B.2.1.4	R/W (O)	R/W (O)	
SELT-PMD parameters				
SELT-PMD measurement parameters				
SELT uncalibrated echo response C (SELT-UER-C)	A.2.2.1	R (M)		
SELT uncalibrated echo response R (SELT-UER-R)	A.2.2.1		R (M)	R(M)
SELT uncalibrated echo response group size C (SELT-UER_G-C).	A.2.2.2	R (M) (see Note 1)		
SELT uncalibrated echo response group size R (SELT-UER_G-R)	A.2.2.2		R (M) (see Note 1)	R (M) (see Note 1)

Table B.2 – Partitioning of SELT-P-ME reporting parameters

Category/element	Defined in clause	Q - interface	G - interface	T - interface
SELT variance of uncalibrated echo response C (SELT-UER-VAR-C)	A.2.2.~~2~~3	R (M)		
SELT variance of uncalibrated echo response R (SELT-UER-VAR-R)	A.2.2.~~2~~3		R (M)	R(M)
SELT quiet line noise C (SELT_QLN_C)	A.2.2.~~3~~4	R (M)		
SELT quiet line noise R (SELT_QLN_R)	A.2.2.~~3~~4		R (M)	R(M)
SELT quiet line noise group size C (SELTQLN_G-C)	A.2.2.5	R (M) (see Note 1)		
SELT quiet line noise group size R (SELTQLN_G-R)	A.2.2.5		R (M) (see Note 1)	R (M) (see Note 1)
SELT-PMD configuration parameters				
SELT UER maximum measurement duration C (SELT_UER_MMD_C)	A.2.1.1	R/W (M)		
SELT UER maximum measurement duration R (SELT_UER_MMD_R)	A.2.1.1		R/W (M)	R/W(M)
SELT quiet line noise maximum measurement duration C (SELT_QLN_MMD_C)	A.2.1.2	R/W (M)		
SELT quiet line noise maximum measurement duration R (SELT_QLN_MMD_R)	A.2.1.2		R/W (M)	R/W(M)
SELT-PMD control parameters				
SELT UER measurement enable C (SELT-UME-C)	A.2.3.1	W(M)		
SELT UER measurement enable R (SELT-UME-R)	A.2.3.2		W(M)	W(M)
SELT QLN measurement enable C (SELT-QME-C)	A.2.3.3	W(M)		
SELT QLN measurement enable R (SELT-QME-R)	A.2.3.4		W(M)	W(M)
NOTE 1 – The SELT uncalibrated echo response group size (SELT-UER_G-C and SELT-UER_G-R) is mandatory only if the option for extended bandwidth UER SELT is supported; otherwise, reporting of the group size is optional. NOTE 2 – The SELT quiet line noise group size (SELTQLN_G-C and SELTQLN_G-R) is mandatory only if the option for extended bandwidth QLN SELT is supported; otherwise, reporting of the group size is optional.				

B.3 Test management and communications

Test management and communications are for further study.

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Printed in Switzerland
Geneva, 2018