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

Digital transmission systems – Digital sections and digital  
line system – Access networks

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**Asymmetric digital subscriber line (ADSL)  
transceivers**

ITU-T Recommendation G.992.1

(Previously CCITT Recommendation)



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## ITU-T RECOMMENDATION G.992.1

### ASYMMETRIC DIGITAL SUBSCRIBER LINE (ADSL) TRANSCEIVERS

#### Summary

This Recommendation describes Asymmetric Digital Subscriber Line (ADSL) Transceivers on a metallic twisted pair that allows high-speed data transmission between the network operator end (ATU-C) and the customer end (ATU-R). This Recommendation provides a variety of bearer channels in conjunction with one of three other services dependent on the environment:

- 1) ADSL transmission simultaneously on the same pair with voice (band) service;
- 2) ADSL transmission simultaneously on the same pair with G.961 (Appendix I or II) ISDN services; or
- 3) ADSL transmission on the same pair with voiceband transmission and with TCM-ISDN (G.961 Appendix III) in an adjacent pair.

Systems allow approximately 6 Mbit/s downstream and approximately 640 kbit/s upstream data rates depending on the deployment and noise environment.

This Recommendation specifies the physical layer characteristics of the Asymmetric Digital Subscriber Line (ADSL) interface to metallic loops.

This Recommendation has been written to help ensure the proper interfacing and interworking of ADSL transmission units at the customer end (ATU-R) and at the network operator end (ATU-C) and also to define the transport capability of the units. Proper operation shall be ensured when these two units are manufactured and provided independently. A single twisted pair of telephone wires is used to connect the ATU-C to the ATU-R. The ADSL transmission units must deal with a variety of wire pair characteristics and typical impairments (e.g. crosstalk and noise).

An ADSL transmission unit can simultaneously convey all of the following: downstream simplex bearers, duplex bearers, a baseband analogue duplex channel, and ADSL line overhead for framing, error control, operations and maintenance. Systems support a minimum of 6.144 Mbit/s downstream and 640 kbit/s upstream.

This Recommendation includes mandatory requirements, recommendations and options; these are designated by the words "shall", "should" and "may" respectively. The word "will" is used only to designate events that take place under some defined set of circumstances.

Two categories of performance are specified. Category I performance is required for compliance with this Recommendation; performance enhancement options are not required for category I equipment. Category II is a higher level of performance (i.e. longer lines and greater impairments). Category II performance and characteristics are not required for compliance with this Recommendation.

This Recommendation defines several optional capabilities and features:

- echo cancellation;
- trellis coded modulation;
- dual latency;
- transport of a network timing reference;
- transport of STM and/or ATM;
- reduced overhead framing modes.

It is the intention of this Recommendation to provide, by negotiation during initialization, for U-interface compatibility and interoperability between transceivers complying to this Recommendation and between transceivers that include different combinations of options.

#### Source

ITU-T Recommendation G.992.1 was prepared by ITU-T Study Group 15 (1997-2000) and was approved under the WTSC Resolution No. 1 procedure on 22 June 1999.



location are specified. Equipment may be implemented with additional functions and procedures.

## 2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; all users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published.

- ITU-T Recommendation G.961 (1993), *Digital transmission system on metallic local lines for ISDN basic rate access.*
- ITU-T Recommendation G.994.1 (1999), *Handshake procedures for Digital Subscriber Line (DSL) transceivers.*
- ITU-T Recommendation G.996.1 (1999), *Test procedures for Digital Subscriber Line (DSL) transceivers.*
- ITU-T Recommendation G.997.1 (1999), *Physical layer management for Digital Subscriber Line (DSL) transceivers.*
- ITU-T Recommendation I.361 (1999), *B-ISDN ATM layer specification.*
- ITU-T Recommendation I.432.1 (1999), *B-ISDN user-network interface – Physical layer specification: General characteristics.*

### For Annex B

- ETSI TS 102 080 V1.3.1 (1998), *Transmission and Multiplexing (TM); Integrated Services Digital Network (ISDN) basic rate access; Digital transmission system on metallic local lines.*

### For Annex E

- ITU-T Recommendation G.117 (1996), *Transmission aspects of unbalance about earth.*
- ITU-T Recommendation Q.552 (1996), *Transmission characteristics at 2-wire analogue interfaces of digital exchanges.*
- ETSI ETS 300 001 ed.4 (1997), *Attachments to the Public Switched Telephone Network (PSTN); General technical requirements for equipment connected to an analogue subscriber interface in the PSTN.*

## 3 Definitions

This Recommendation defines the following terms:

**3.1 ADSL Lines:** See 5.1/G.997.1.

**3.2 ADSL system overhead:** All overhead needed for system control, including CRC, EOC, AOC synchronization bytes, fixed indicator bits for OAM, and FEC; that is, the difference between total data rate and net data rate.

- 3.3 aggregate data rate:** Data rate transmitted by an ADSL system in any one direction; it includes both net data rate and overhead used by the system for EOC, AOC, CRC check bytes, fixed indicator bits for OAM, synchronization control bytes and capacity for bearer channel synchronization control (i.e.  $K_F + K_I$  times 32 kbit/s); it does not include Reed-Solomon FEC redundancy.
- 3.4 anomalies:** An anomaly is a discrepancy between the actual and desired characteristics of an item. The desired characteristics may be expressed in the form of a specification. An anomaly may or may not affect the ability of an item to perform a required function. Performance anomalies are defined in 9.3.1.1 (see Figure 9-4).
- 3.5 bearer channel:** A user data stream of a specified data rate that is transported transparently by an ADSL system.
- 3.6 bridged taps:** Sections of unterminated twisted-pair cables connected in parallel across the cable under consideration.
- 3.7 category I:** Basic category of transceivers with no performance-enhancing options, which meet a basic set of performance requirements.
- 3.8 category II:** Category of transceivers with performance-enhancing options which meet an expanded set of performance requirements.
- 3.9 channelization:** Allocation of the net data rate to bearer channels.
- 3.10 data frame:** A grouping of bytes from fast and interleaved paths over a single symbol time period after addition of FEC bytes and after interleaving (at reference point C of Figure 7-5).
- 3.11 data symbol rate:** The net average rate (after allowing for the overhead of the synchronization symbol) at which symbols carrying user data are transmitted (= 4 kbaud).
- 3.12 dB<sub>rn</sub>:** Ratio (in decibels) of a power level with respect to a reference power of 1 pico-Watt (equivalent -90 dBm) (reference: Recommendation O.41 – Annex A).
- 3.13 defects:** A defect is a limited interruption in the ability of an item to perform a required function. It may or may not lead to maintenance action depending on the results of additional analysis. Successive anomalies causing a decrease in the ability of an item to perform a required function are considered as a defect (see Figure 9-4).
- 3.14 DMT symbol:** A set of complex values  $\{Z_i\}$  forming the frequency domain inputs to the inverse discrete Fourier transform (IDFT) (see 7.11.2). The DMT symbol is equivalently the set of real valued time samples,  $\{x_n\}$ , related to the set of  $\{Z_i\}$  via the IDFT.
- 3.15 downstream:** The transport of data in the ATU-C to ATU-R direction.
- 3.16 dual latency:** Simultaneous transport of multiple data bearer channels in any one direction, in which user data is allocated to both the fast and interleaved paths; that is,  $\text{sum}(B_F) > 0$  and  $\text{sum}(B_I) > 0$ .
- 3.17 embedded operations channel:** A component of ADSL system overhead which provides communications between management entities in the ATU-C and ATU-R. It includes both clear channel and stateful messaging modes.
- 3.18 far-end:** Far-end means performance of the downstream loop-side received signal at the input of the ATU-R, where this performance is reported to the ATU-C in upstream indicators (see Figure 9-4), or performance of the upstream loop-side received signal at the input of the ATU-C, where this performance is reported to the ATU-R in downstream overhead indicators; this case is a mirror image of the above (see Figure 9-4).

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