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

International telephone connections and circuits – General
definitions

The transmission plan

ITU-T Recommendation G.101

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ITU-T Recommendation G.101

The transmission plan

Summary

This Recommendation provides guidance for transmission planning of modern telecommunication networks. The primary emphasis is on provisioning of telephone connections. The transmission plan established by this Recommendation takes into account transmission parameters and impairments, different network configurations and elements and modern transmission techniques, as well as the effects resulting from the combination of the various factors having influence on the resulting transmission quality.

Source

ITU-T Recommendation G.101 was approved by ITU-T Study Group 12 (2001-2004) under the ITU-T Recommendation A.8 procedure on 13 November 2003.

FOREWORD

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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.

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Introduction

The goal of this transmission plan is to facilitate interconnection of all communication-related devices (terminals, network elements, public networks, private networks, etc.), independent of technology, so that end-user applications experience no unsatisfactory or annoying impairments. For speech applications this means the delivery of highly intelligible, natural-sounding speech signals at near-optimum acoustic levels, and free of bothersome levels of distortion, echo, and delay. For non-speech applications, this means that associated transactions (e.g., fax, interactive data, e-mail, web browsing, video streaming) can be completed satisfactorily.

This plan allows for service provider solutions that meet or exceed these criteria. Conversely, if an end user or network operator chooses network elements that cannot support this criterion, they do so with the understanding that all applications may not perform satisfactorily and thus interconnection to their network by other network operators may not be desirable.

ITU-T Recommendation G.101

The transmission plan

1 Scope

This Recommendation applies to the transmission planning necessitated by telecom deregulation, and in particular, the division of responsibility if multiple network operators are involved in a given connection.

The aim of this Recommendation is to provide guidance for transmission planning of telecommunication networks used primarily for narrow-band services. Traditionally this involved a subdivision of an international connection into "national systems" and an "international chain", usually in a regulated environment. As with previous versions of ITU-T Rec. G.101, this version can be used to do transmission planning for such an environment; however, this version can also be applied to the deregulated multi-operator environment in which there is no clear division of responsibilities. The reference model in this Recommendation is focused on supporting this latter case.

The transmission plan established by this Recommendation takes into account transmission parameters and impairments, different network configurations and elements, modern transmission techniques as well as effects resulting from the combination of the various factors having influence on the resulting transmission quality. The main focus of this Recommendation is transmission planning of voice services. Implications associated with the planning of other kind of services, e.g., data services, will also be discussed.

The transmission plan allows for the adjustment, i.e., staying within acceptable limits, of important transmission parameters and implementation of network configurations and components in order to guarantee adequate end-to-end transmission performance at all times and under all network-operating conditions. The aim is to allow for flexible control of transmission parameters instead of allocating defined limits. The various transmission parameters are not considered on an individual basis, rather the combined effects of variations in transmission parameters are assessed.

This Recommendation forms a framework for transmission planning. The intention is to: explain basic planning objectives and rules applicable to modern telecommunication networks, list the main technical (transmission) parameters of importance, and provide reference to relevant ITU-T Recommendations.

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; 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. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

- ITU-T Recommendation G.100 (2001), *Definitions used in Recommendations on general characteristics of international telephone connections and circuits*.
- ITU-T Recommendation G.100.1 (2001), *The use of the decibel and of relative levels in speechband telecommunications*.
- ITU-T Recommendation G.107 (2003), *The E-model, a computational model for use in transmission planning*.

- ITU-T Recommendation G.108 (1999), *Application of the E-model: A planning guide.*
- ITU-T Recommendation G.108.1 (2000), *Guidance for assessing conversational speech transmission quality effects not covered by the E-model.*
- ITU-T Recommendation G.108.2 (2003), *Transmission planning aspects of echo cancellers.*
- ITU-T Recommendation G.109 (1999), *Definition of categories of speech transmission quality.*
- ITU-T Recommendation G.111 (1993), *Loudness ratings (LRs) in an international connection.*
- ITU-T Recommendation G.113 (2001), *Transmission impairments due to speech processing.*
- ITU-T Recommendation G.113 Appendix I (2002), *Provisional planning values for the equipment impairment factor I_e and packet-loss robustness factor B_{pl} .*
- ITU-T Recommendation G.114 (2003), *One-way transmission time.*
- ITU-T Recommendation G.115 (1996), *Mean active speech level for announcement and speech synthesis systems.*
- ITU-T Recommendation G.116 (1999), *Transmission performance objectives applicable to end-to-end international connections.*
- ITU-T Recommendation G.117 (1996), *Transmission aspects of unbalance about earth.*
- ITU-T Recommendation G.120 (1998), *Transmission characteristics of national networks.*
- ITU-T Recommendation G.121 (1993), *Loudness ratings (LRs) of national systems.*
- ITU-T Recommendation G.122 (1993), *Influence of national systems on stability and talker echo in international connections.*
- ITU-T Recommendation G.126 (1993), *Listener echo in telephone networks.*
- ITU-T Recommendation G.131 (2003), *Talker echo and its control.*
- ITU-T Recommendation G.136 (1999), *Application rules for automatic level control devices.*
- ITU-T Recommendation G.142 (1998), *Transmission characteristics of exchanges.*
- ITU-T Recommendation G.161 (2002), *Interaction aspects of signal processing network equipment.*
- ITU-T Recommendation G.164 (1988), *Echo suppressors.*
- ITU-T Recommendation G.165 (1993), *Echo cancellers.*
- ITU-T Recommendation G.167 (1993), *Acoustic echo controllers.*
- ITU-T Recommendation G.168 (2002), *Digital network echo cancellers.*
- ITU-T Recommendation G.169 (1999), *Automatic level control devices.*
- ITU-T Recommendation G.172 (1988), *Transmission plan aspects of international conference calls.*
- ITU-T Recommendation G.173 (1993), *Transmission planning aspects of the speech service in digital public land mobile networks.*
- ITU-T Recommendation G.174 (1994), *Transmission performance objectives for terrestrial digital wireless systems using portable terminals to access the PSTN.*

- ITU-T Recommendation G.175 (2000), *Transmission planning for private/public network interconnection of voice traffic*.
- ITU-T Recommendation G.176 (1997), *Planning guidelines for the integration of ATM technology into networks supporting voiceband services*.
- ITU-T Recommendation G.177 (1999), *Transmission planning for voiceband services over hybrid Internet/PSTN connections*.
- ETSI EN 300 462-1-1 V1.1.1 (1998), *Transmission and Multiplexing (TM); Generic requirements for synchronization networks; Part 1-1: Definitions and terminology for synchronization networks*.
- ETSI EN 300 462-6-1 V1.1.1 (1998), *Transmission and Multiplexing (TM); Generic requirements for synchronization networks; Part 6-1: Timing characteristics of primary reference clocks*.
- ISO/IEC 11573:1994, *Information technology – Telecommunications and information exchange between systems – Synchronization methods and technical requirements for Private Integrated Services networks*.

3 Terms and definitions

This Recommendation defines the following term:

3.1 transmission reference point: A hypothetical point at or near the sending end of each channel (preceding the virtual switching point), used as the “zero relative level point”, in the computation of nominal relative levels. In the case of a digital end office, the main distribution frame is considered the 0 dBr point.

4 Abbreviations

This Recommendation uses the following abbreviations:

HRC	Hypothetical Reference Connection
NTP	Network Termination Point
PCM	Pulse Code Modulation
TE	Terminal Equipment
UNI	User-Network Interface

5 Fundamental principles of transmission planning

In general a good transmission plan is set up in order to deliver to users signals that are at a desirable level and free from objectionable amounts of delay, echo and distortion. Thus the transmission plan has to take into account transmission parameters and impairments, different network configurations and elements and provide guidance on adequate adjustment of network settings. Depending on the type of network, e.g., traditional narrow-band telephone networks, mobile networks, packet switched networks, specific transmission plans have to be set up in order to take care of specific transmission impairments and conditions.

Transmission planning is a subset of the total network planning, both when creating new networks or extending existing ones. Modern networks allow a very great flexibility in routing and "intelligent" switching features. It is important, however, that transmission aspects are not forgotten in the planning process.

For complicated networks, one should keep in mind the abilities of the particular signalling that is implemented. Advanced signalling systems could, in addition to performing their normal functions, convey information about certain transmission parameters in connections. (Examples of transmission parameters of interest are accumulated delay, existence of echo cancellers in the path, terminals not needing network echo control, accumulated impairments, choice of particular routes for calls with special requirements for high quality connections, etc.)

In order to set up a transmission plan, one has first to analyse the end-to-end connection(s) to be established by the telecommunication network that is being planned. This is done by defining a reference connection/configuration; depending on the complexity of the network, different reference configurations may be needed. A basic reference configuration is given in 6.1, and typical network configurations (as examples) are given in 7.2.

Based on these network configurations, the network components and the resulting transmission impairments need to be identified. Clause 7.1 provides guidance on network components and clause 8 on transmission impairments.

All this information is summarized in a transmission plan specifying the network configuration and requirements for transmission parameters.

In the following paragraph, a list of fundamental principles applicable to all kind of networks is provided and illustrated in Figure 1. Planning guidance on specific network configurations also follows.

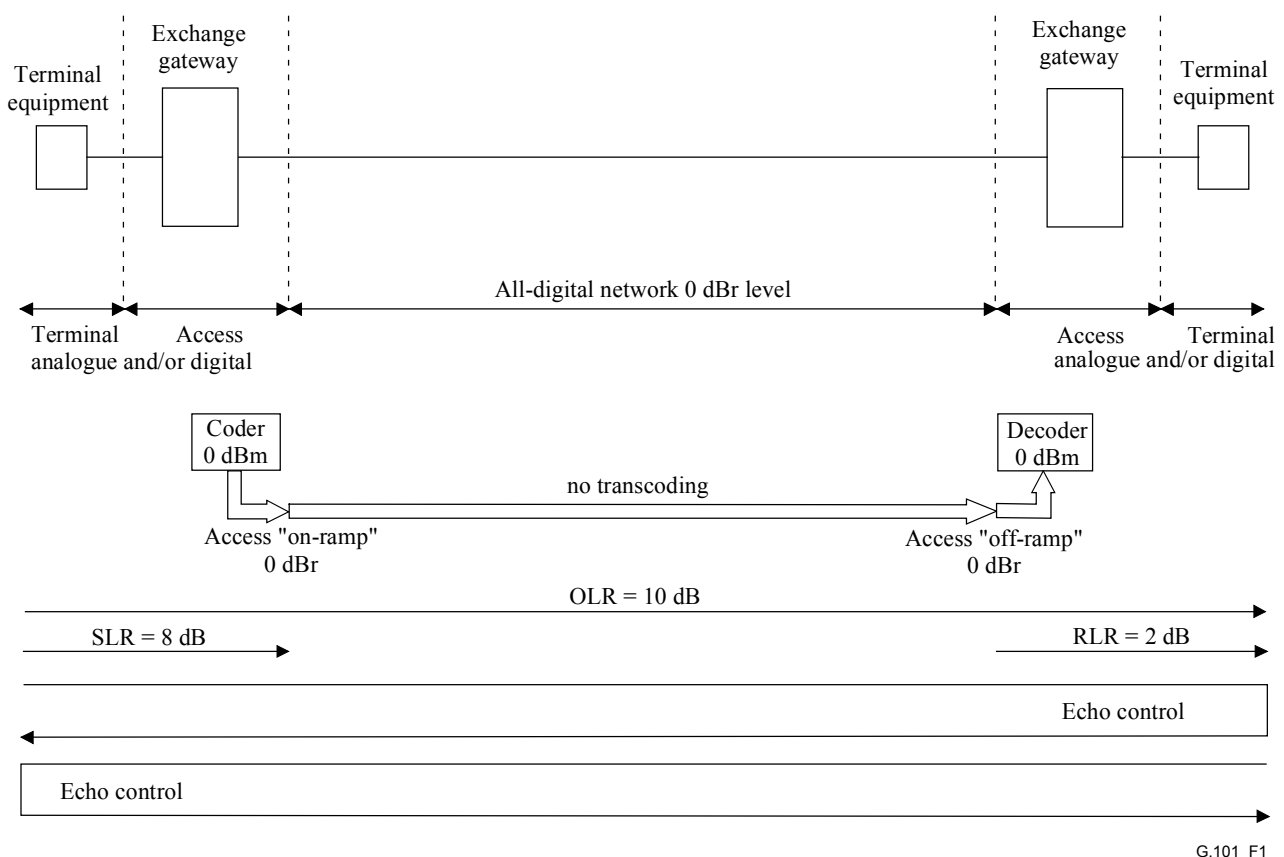


Figure 1/G.101 – Fundamental principles to transmission planning

- 1) The all-digital network is a lossless bidirectional data highway. This applies equally to TDM and packet switched networks.
- 2) Access to the all-digital data highway via the on- and off-ramps may be with a digital terminal, a voice gateway (VG)/PBX plus an analogue terminal, a digital local exchange line card plus an analogue terminal, etc.

NOTE 1 – An on-ramp and off-ramp to the data highway is defined as a 0 dBr point.

- 3) Ideally, loss/gain is inserted in the analogue domain. Inserting loss/gain in the digital domain can potentially cause quantization distortion.
- 4) Ideally, loss/gain is inserted in one location. Distributed loss plans can potentially cause increased distortion/reduced dynamic range.
- 5) The terminal/gateway devices, in conjunction with the digital local exchange loss plan, determine end-to-end acoustic levels.

The optimum end-to-end loudness is the Overall Loudness Rating $OLR = 10$ dB.

Digitally encoded speech levels on the digital data highway should be set to provide optimum dynamic range. This will be achieved if the Send and Receive Loudness Ratings are partitioned as: $SLR = 8$ dB, and $RLR = 2$ dB.

NOTE 2 – The loudness ratings are defined according to ITU-T Rec. P.79.

- 6) No echo paths shall exist between the on- and off-ramps within the network, i.e., U-turns are not permitted on the data highway.

Echo paths, between corresponding off- and on-ramps to the data highway, must be controlled to eliminate degradation due to echo.

- This will be achieved by appropriately specifying TELR values for the access system, in accordance with ITU-T Rec. G.131.
- Echo may be controlled with passive or active echo control devices or a combination of both.
- In principle, echo control devices should be located as close as possible to the source of the echo, to minimize echo tailpath delay.

- 7) Transcoding should be avoided.

For traditional networks supporting narrow-band services (e.g., 64 kbit/s PCM over the PSTN), the existing G.100-series of ITU-T Recommendations (e.g., G.113, G.131) provide guidance. It is recommended to use the E-model (ITU-T Rec. G.107) for confirmation that overall quality is as expected.

NOTE 3 – The E-model is a computational model for assessing the combined effects of variations in several transmission parameters that effect conversational quality of 3.1 kHz handset telephony. The output of the model can be transformed into an estimate of users' perception of end-to-end speech quality categories, allowing for relative comparisons of transmission conditions of various connection scenarios. The combined subjective effects of impairments due to speech compression, delay, packet loss, etc. are captured by the E-model and by no other method.

For networks using mobile access technology, low-bit-rate coding and/or packetized transport, additional guidance is required. The effects of impairments associated with these technologies are uniquely captured by the E-model and therefore it is recommended as the primary transmission planning tool.

Further guidance is given in the following ITU-T Recommendations: