Recommendation T/L 05-03 (Edinburgh 1988)

DIGITAL TRANSMISSION SYSTEM ON METALLIC LOCAL LINES FOR ISDN BASIC RATE ACCESS

Recommendation proposed by Working Group T/WG 12 "Transmission and multiplexing" (TM)

Text of Recommendation adopted by the "Telecommunications" Commission:

1. GENERAL

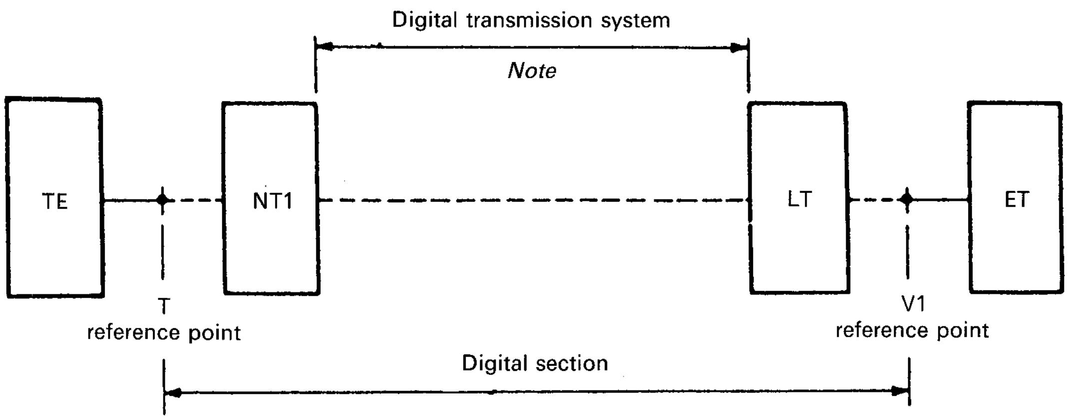
1.1. Scope

This Recommendation covers the characteristics and parameters of a digital transmission system at the network side of the NT1 to form part of the digital section for the ISDN basic rate access.

The system will support the
— full duplex
— bit sequence independent
transmission of two B channels and one D channel as defined in CCITT Recommendation I.412 and the supplementary functions of the digital section defined in CCITT Recommendation I.603 for operation and maintenance.

1.2. Definition

Figure 1 (T/L 05-03) shows the boundaries of the digital transmission system in relation to the digital section.



Note. In this Recommendation, Digital Transmission System refers to a line system using metallic lines. The use of one intermediate regenerator may be required.

Figure 1 (T/L 05-03). Digital section and transmission system boundaries.

The concept of the digital section is used in order to allow a functional and procedural description and a definition of the network requirements. Note that the reference points T and V1 are not identical and therefore the digital section is not symmetric.

The concept of a digital transmission system is used in order to describe the characteristics of an implementation, using a specific medium, in support of the digital section.

1.3. Objectives

Considering that the digital section between the local exchange and the customer is one key element of the successful introduction of ISDN into the network, the following requirements for the specification have been taken into account:
— to meet the error performance specified in Recommendation T/L 03-13 E;
— to operate on existing 2-wire unloaded local lines, open wires being excluded;

— the objective is to achieve 100% cable fill for ISDN basic access without pair selection, cable rearrangements or removal of bridged taps (BTs) which exist in many networks;
— the objective to be able to extend ISDN basic access provided services to the majority of customers without the use of regenerators. In the remaining few cases special arrangements may be required;
— coexistence in the same cable unit with most of the existing services like telephony and voice-band data transmission;
— various national regulations concerning EMI should be taken into account;
— power feeding from the network under normal or restricted conditions via the basic access shall be provided where the Administration provides this facility;
— the capability to support maintenance functions shall be provided.

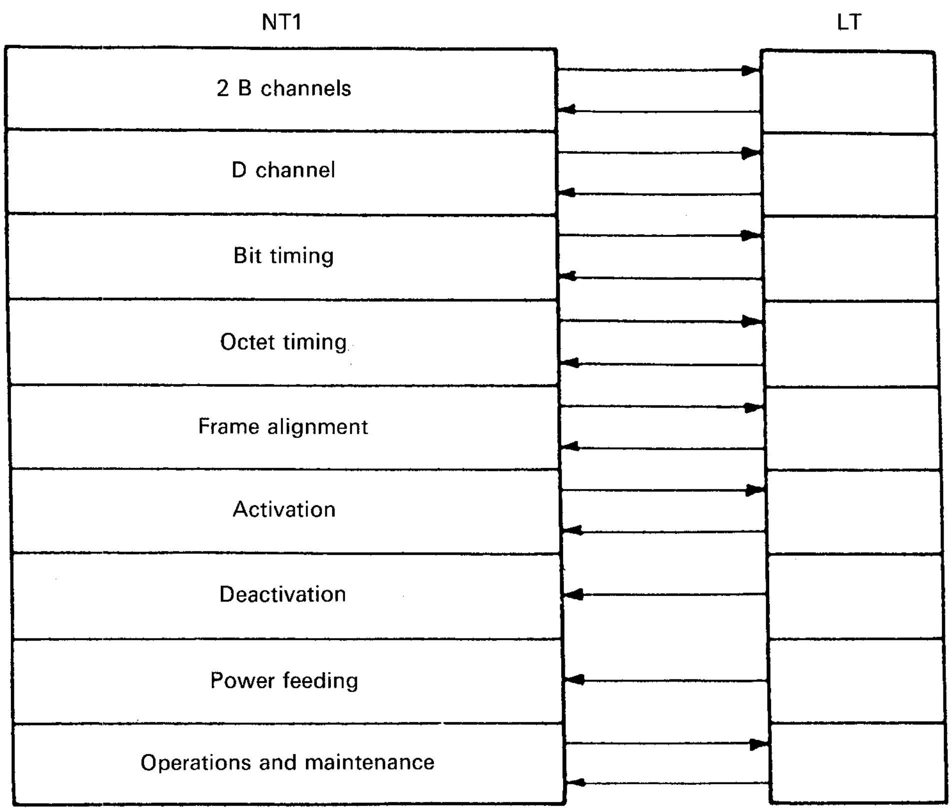
1.4. Abbreviations

A number of abbreviations are used in this Recommendation. Some of them are commonly used in the ISDN reference configuration while others are created only for this Recommendation. The last one are given in the following:

BER: Bit Error Ratio
BT: Bridged Tap
CISPR: Comité International Spécial de Perturbation Radioélectrique (now part of IEC)
CL: Control Channel of the line system
DLL: Digital Local Line
DTS: Digital Transmission System
ECH: Echo Cancellation
EMI: Electro-Magnetic Interference
NEXT: Near-End Crosstalk
PSL: Power Sum Loss
TCM: Time Compression Multiplex
UI: Unit Interval

2. FUNCTIONS

Figure 2 (T/L 05-03) shows the functions of the digital transmission system on metallic local lines.



Note 1. The optional use of one regenerator must be foreseen.

Figure 2 (T/L 05-03). Functions of the digital transmission system.

B channel

This function provides, for each direction of transmission, two independent 64 kbit/s channels for use as B channels (as defined in CCITT Recommendation I.412).

D channel

This function provides, for each direction of transmission, one D channel at a bit rate of 16 kbit/s (as defined in CCITT Recommendation I.412).

Bit Timing

This function provides bit (signal element) timing to enable the receiving equipment to recover information from the aggregate bit stream. Bit timing for the direction NT1 to LT shall be derived from the clock received by the NT1 from the LT.

Octet Timing

This function provides 8 kHz octet timing for the B channels. It shall be derived from frame alignment.

Frame Alignment

This function enables the NT1 and the LT to recover the time division multiplexed channels.

*Activation from LT or NT1 (*Note 3 *below)*

This function restores the Digital Transmission System (DTS) between the LT and NT1 to its normal operational status. Procedures required to implement this function are described in Section 6. of this Recommendation.

Activation from the LT could apply to the DTS only or to the DTS plus the customer equipment. In case the customer equipment is not connected, the DTS can still be activated.

*Deactivation (*Note 3 *below)*

This is specified in order to permit the NT1 and the regenerator (if it exists) to be placed in a low power consumption mode or to reduce intrasystem crosstalk to other systems. The procedures and exchange of information are described in Section 6. of this Recommendation. This deactivation should be initiated only by the exchange (ET).

Power Feeding

This function provides for remote power feeding of one regenerator (if required) and NT1. The provision of wetting current is recommended.

Note 1. The provision of line feed power to the user-network interface, normal or restricted power feeding as defined in Recommendation T/L 03-07 E is required by some Administrations.

Note 2. The general power feeding strategy, given in paragraph 8., may not be applicable for extremely long local lines. In those cases specific power feeding methods (e.g. use of batteries in the NT1 or local power feeding of the NT1) may be applied. Those specific methods are outside the scope of this Recommendation.

*Operations and Maintenance (*Note 3 *below)*

This function provides the recommended actions and information described in CCITT Recommendation I.603.

The following categories of functions have been identified:

— maintenance command (e.g. loopback control in the regenerator or the NT1)
— maintenance information (e.g. line errors)
— indication of fault conditions
— information regarding power feeding in NT1

Note 3. The functions required for operations and maintenance of the NT1 and one regenerator (if required) and for some activation/deactivation procedures are combined in one transport capability to be transmitted along with the 2 B+D channels. This transport capability is named the CL channel.

3. TRANSMISSION MEDIUM

3.1. Description

The transmission medium over which the digital transmission system is expected to operate is the local line distribution network.

A local line distribution network employs cables of pairs to provide services to customers.

In a local line distribution network, customers are connected to the local exchange via local lines.

A metallic local line is expected to be able to simultaneously carry bi-directional digital transmission providing ISDN basic access between LT and NT1.

To simplify the provision of ISDN basic access, a digital transmission system must be capable of satisfactory operation over the majority of metallic local lines without requirement of any special conditioning. Maximum penetration of metallic local lines is obtained by keeping ISDN requirements at a minimum.

In the following, the term Digital Local Line (DLL) is used to describe a metallic local line that meets minimum ISDN requirements.

3.2. Minimum ISDN Requirements

a) No loading coils

b) No open wires

c) When bridged taps (BTs) are present, the following rules apply:
- maximum number of BTs: 2 (*Note*)
- total length: for further study

Note. One Administration supports the presence of 3 BTs.

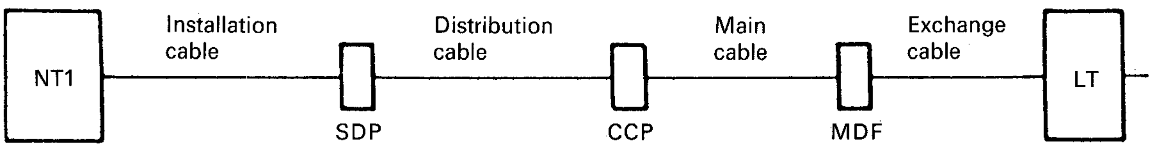
3.3. DLL Physical Characteristics

3.3.1. *DLL Structure*

In addition to satisfying the minimum ISDN requirements, a DLL is constructed of one or more twisted-pair sections that are spliced or interconnected together.

The distribution or main cable is structured as follows:
- cascade of cable sections of different diameters and lengths;
- one or more bridged taps (BTs) may exist at various points in feeder and distribution cables (a BT is an open twisted-pair section bridged across the line).

A general description is shown in Figure 3 (T/L 05-03).



Points of interconnection:
MDF: Main distribution frame
CCP: Cross connection point (or splice)
SDP: Subscriber distribution point

Figure 3 (T/L 05-03). DLL physical model.

3.3.2. *Cable Characteristics*

	Exchange cable	Main cable	Distribution cable	Customer cable
Wire diameter (mm)	0.5 - 0.6	0.3 - 0.32 - 0.4 - 0.5 - 0.6 0.63 - 0.8 - 0.9 - 1.0 - 1.4		0.4 - 0.5 - 0.6 - 0.8
Structure	TP; L or B	SQ or TP; L or B		SQ or TP or UP
Max. number of pairs	1200	2400 (0.4 mm) 4800 (0.3 mm)	600 (0.4 mm)	2 (aerial) 600 (in house)
Installation		Underground in ducts	Underground or aerial	Aerial (drop) in ducts (in house)
Capacitance (nF/km at 800 Hz)	80 ... 120	25 ... 36		80 ... 120
Wire insulation	PVC	Paper, pulp PE, cell. PE	Paper, PE, cell. PE	PE, PVC

TP: Twisted pairs
SQ: Star quads
UP: Untwisted pairs
L: Layer
B: Bundles (units)

PE: Polyethylene
PVC: Polyvinylchloride
Pulp: Pulp of paper
Cell. PE: Cellular Polyethylene (foam)

Note. The information in this table is provisional.

Table 1 (T/L 05-03). Cable characteristics.

3.4. DLL Electrical Characteristics

3.4.1. *Insertion Loss*

The DLL will have non-linear loss versus frequency characteristic. For any DLL of a particular gauge mix, with no BTs and with an insertion loss of X dB at 80 kHz, the typical behaviour of its insertion loss (measured between 130 Ω) versus frequency is depicted in Figure 4 (T/L 05-03).

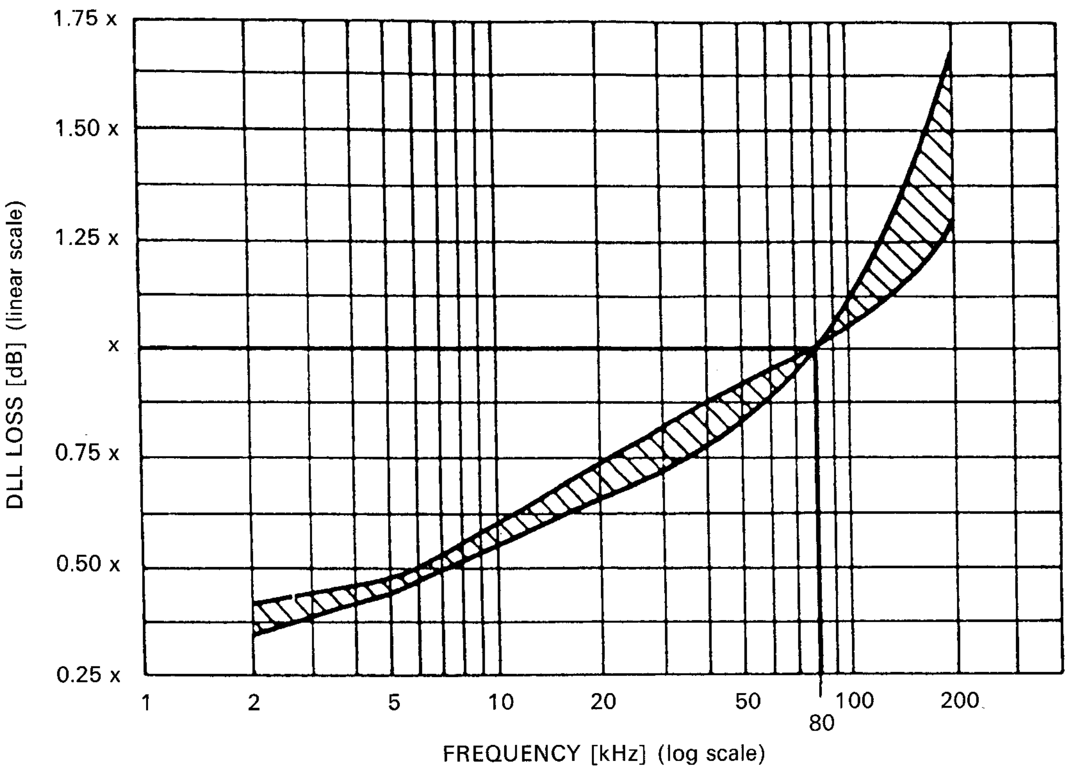


Figure 4 (T/L 05-03). Typical Insertion Loss Characteristic without Presence of BTs.

Note.
The maximum value of X ranges from 37 dB to 42 dB.
The minimum value could be close to zero.

3.4.2. *Group Delay*

Typical ranges of values of DLL group delay as a function of frequency are shown in Figure 5 (T/L 05-03).

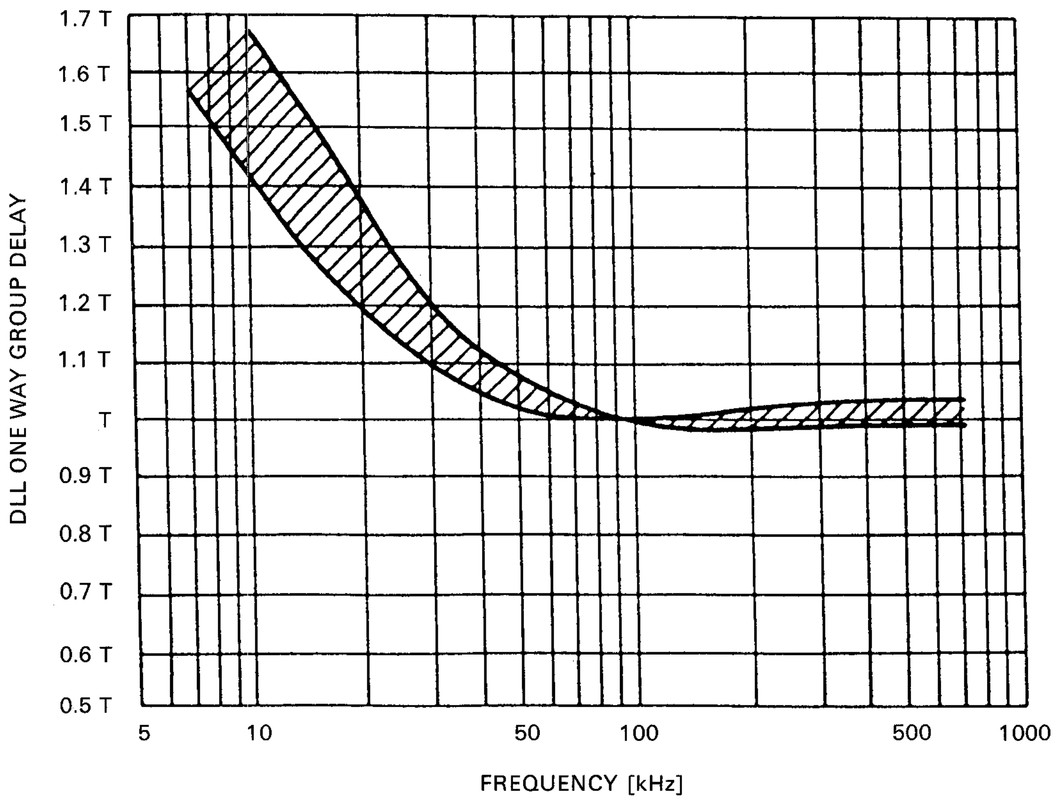


Figure 5 (T/L 05-03). Typical Group Delay Characteristic.

Note. The maximum value of one way group delay (T) ranges from 30 to 60 microseconds at 80 kHz.

3.4.3. *Characteristic Impedance*

Typical ranges of values of the real and imaginary parts of the characteristic impedance of twisted pairs in different types of cables are shown in Figure 6 (T/L 05-03).

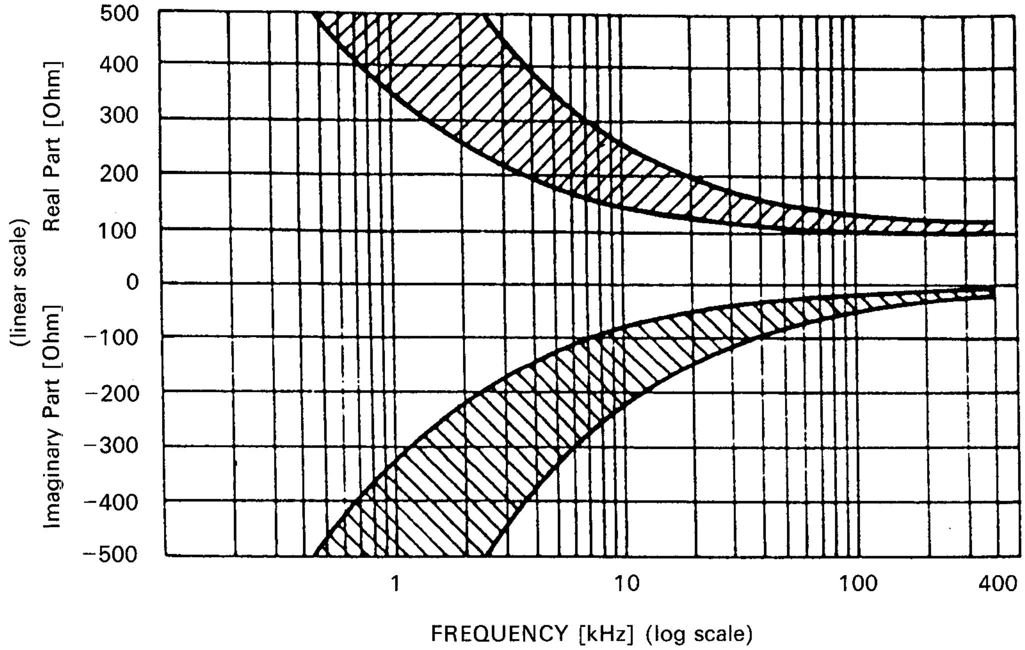


Figure 6 (T/L 05-03). Typical Ranges of Values of Real and Imaginary Parts of Characteristic Impedance.

3.4.4. *Near-End Crosstalk (NEXT)*

The DLL will have finite crosstalk coupling loss to other pairs sharing the same cable. Worst-case NEXT Power Sum Loss (PSL) is 44 dB at 80 kHz (refer to Section 4.2.2.).

The DLL Loss and PSL ranges have been independently specified. However, it is not required that all points in both ranges be satisfied simultaneously. A combined DLL Loss/PSL representation is shown in Figure 7 (T/L 05-03) to define the combined range of operation.

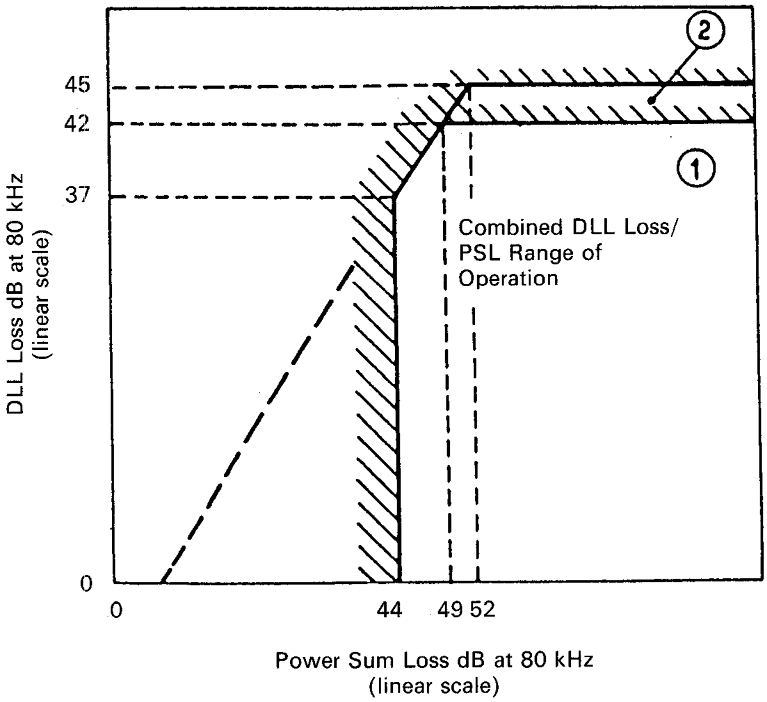


Figure 7 (T/L 05-03). Combined Representation of DLL Loss/PSL Range of Operation.

① In this area, it is mandatory that systems work in.

② In this area, it is desirable, but not mandatory, that systems can work in order to reduce the number of regenerators.

3.4.5. *Unbalance About Earth*

The DLL will have finite balance about earth. Unbalance about earth is described in terms of longitudinal conversion loss. Worst-case values are shown in Figure 8 (T/L 05-03).

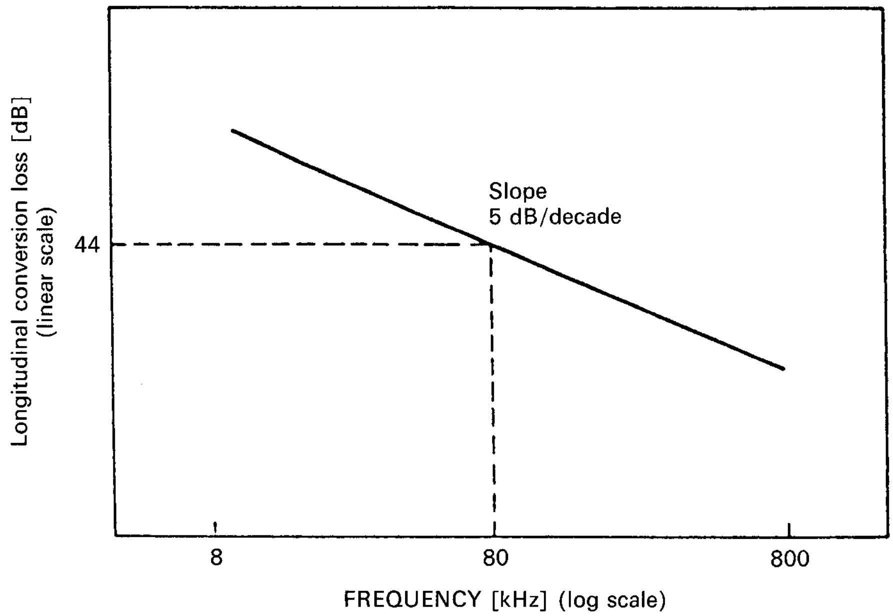


Figure 8 (T/L 05-03). Worst-Case Longitudinal Conversion Loss Versus Frequency.

3.4.6. *Impulse Noise*

The DLL will have impulse noise resulting from other systems sharing the same cables as well as from other sources.

4. SYSTEM PERFORMANCE

4.1. Performance Requirements

Performance limits for the digital section are specified in paragraph 4. of Recommendation T/L 03-13 E. The Digital Transmission System Performance must be such that these performance limits are met. For that purpose, a Digital Transmission System is required to pass specific laboratory performance tests that are defined in the next sections.

4.2. Performance Measurements

Laboratory performance measurement of a particular digital transmission system requires the following preparations:

a) Definition of a number of DLL models to represent physical and electrical characteristics encountered in local line distribution networks.

b) Simulation of the electrical environment caused by finite crosstalk coupling loss to other pairs in the same cable.

c) Simulation of the electrical environment caused by impulse noise.

d) Specification of laboratory performance tests to verify that the performance limits referred to in Section 4.1. will be met.

4.2.1. *DLL Physical Models*

For the purposes of laboratory testing of performance of a digital transmission system providing ISDN basic access, some models representative of DLLs to be encountered in a particular local line distribution network are required. The maximum loss in each model is optionally set between 37 and 42 dB at 80 kHz to satisfy requirements of the particular network. Similarly, the lengths of BTs are optionally set within the range defined in Figure 9 (T/L 05-03).

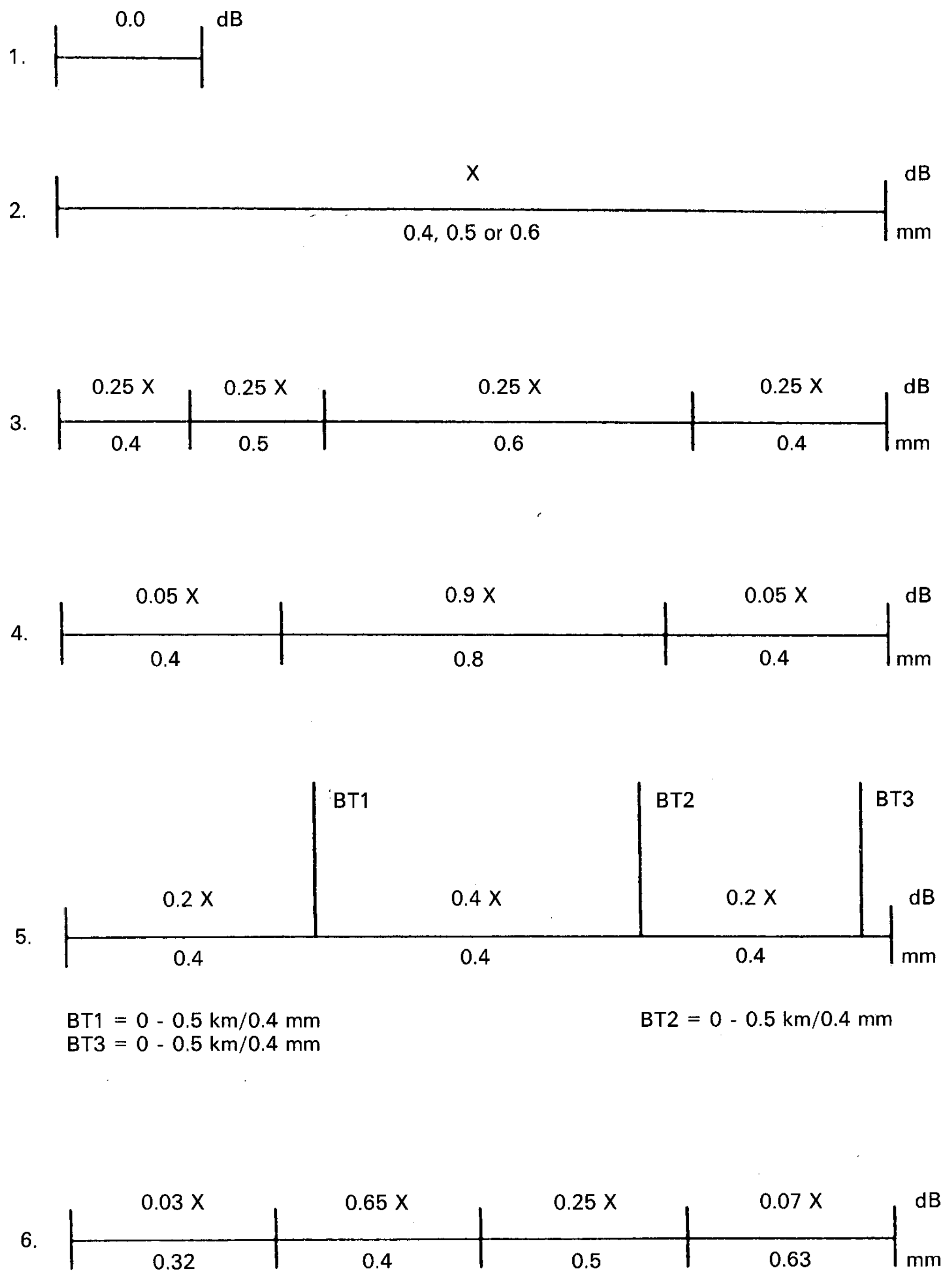


Figure 9 (T/L 05-03). DLL Physical Models for Laboratory Testing.

Note. The value of X varies from 37 to 42 dB at 80 Hz.

4.2.2. *Intrasystem Crosstalk Modelling*

4.2.2.1. Definition of Intrasystem Crosstalk

Crosstalk noise in general results from finite coupling loss between pairs sharing the same cable, especially those pairs that cause a vestige of the signal flowing on one DLL (disturber DLL) to be coupled into an adjacent DLL (disturbed DLL). This vestige is known as crosstalk noise. Near-end crosstalk (NEXT) is assumed to be the dominant type of crosstalk. Intrasystem NEXT or self NEXT results when all pairs interfering with each other in a cable carry the same digital transmission system. Intersystem NEXT results when pairs carrying different digital transmission systems interfere with each other. Definition of intersystem NEXT is not part of this Recommendation.

Intrasystem NEXT noise coupled into a disturbed DLL from a number of DLL disturbers is represented as being due to an equivalent single disturber DLL with a coupling loss versus frequency characteristic known as Power Sum Loss. Worst-Case Power Sum Loss encountered in a local line distribution network is defined in Figure 10 (T/L 05-03). All DLLs are assumed to have fixed resistance terminations of Ro ohms. The range of Ro is 110 to 150 ohms.

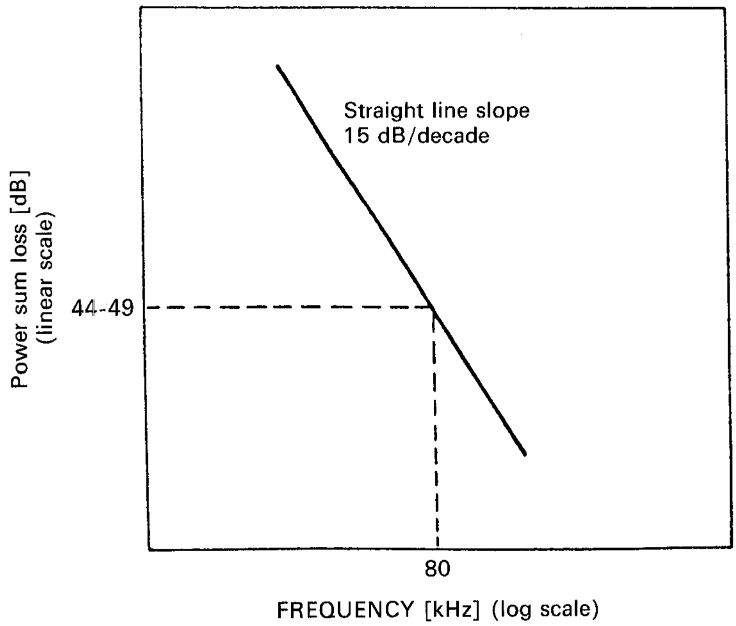


Figure 10 (T/L 05-03). Worst-Case power sum loss.

4.2.2.2. Measurement Arrangement

Simulation of intrasystem NEXT noise is necessary for performance testing of digital transmission systems. Intrasystem noise coupled into the receiver of the disturbed DLL depends on:

a) Power spectrum of the transmitted digital signal. The power spectrum is a function of the line code and the transmit filter.
b) Spectrum shaping due to the Power Sum Loss characteristic of Figure 10 (T/L 05-03).

The measurement arrangement of Figure 11 (T/L 05-03) can be used for testing of performance with intrasystem crosstalk noise.

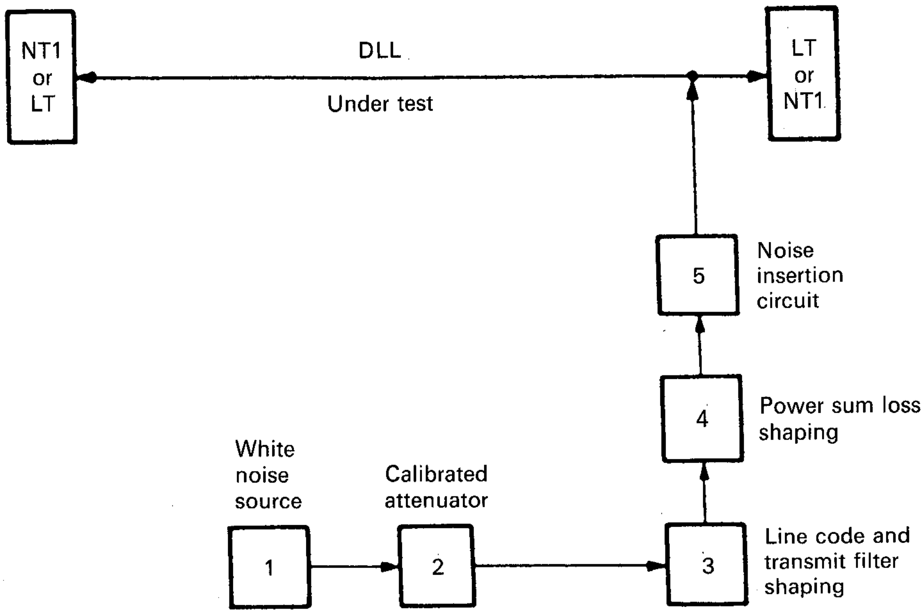


Figure 11 (T/L 05-03). Crosstalk noise simulation and testing.

The measurement arrangement in Figure 11 (T/L 05-03) is described in the following:

a) Box 1 represents a white noise source of constant spectral density. Spectrum is flat from 100 Hz to 500 kHz rolling off afterwards.
b) Box 2 is a variable attenuator.
c) Box 3 is a filter that shapes the power spectrum to correspond to the line code and the transmit filter of the system under test.
d) Box 4 is a filter that shapes the power spectrum according to the Power Sum Loss characteristic of Figure 10 (T/L 05-03).
e) Box 5 is a noise insertion circuit which couples the simulated crosstalk noise into the DLL without disturbing its performance. The insertion circuit therefore must be of sufficiently high output impedance relative to the magnitude of the characteristic impedance of the DLL under test. A value $\geqslant 4.0$ kΩ in the frequency range 0 to 1000 kHz is recommended.

Boxes 3, 4 and 5 in Figure 11 (T/L 05-03) are conceptual. Dependent on the particular realization, they could possibly be combined into one circuit. The measurement arrangement in Figure 11 (T/L 05-03) is calibrated according to the following steps:

a) By terminating the output of Box 5 with a resistor of a value of Ro/2 ohms, and measuring the true rms (root-mean-square) voltage across it in a bandwidth extending from 100 Hz to over 500 kHz. The power dissipated in the Ro/2 resistor is 3 dB higher than the power coupled into the receiver of the DLL under test.
b) The shape of the noise spectrum measured across the Ro/2 resistor should be within:
   — ± 1 dB for values within 0 dB to 10 dB down from the theoretical peak;
   — ± 3 dB for values within 10 dB to 20 dB down from the theoretical peak.

   For measurement purposes a resolution bandwidth of $\leqslant 10$ kHz is recommended.
c) The peak factor of the noise voltage across the Ro/2 resistor should be $\geqslant 4$. This in turn fixes the dynamic range requirements of the circuits used in the measured arrangement.

With the specified calibrated measurement arrangement, intrasystem crosstalk noise due to a worst-case Power Sum Loss can be injected into the DLL under test while monitoring its performance. The noise level can be increased or decreased to determine positive or negative performance margins.

4.2.3. *Impulse Noise Modelling*

4.2.3.1. Definition of Impulse Noise

Impulse noise energy appears concentrated in random short-time intervals during which it attains substantial levels. For the rest of the time impulse noise effects are negligible.

4.2.3.2. Measurement Arrangement

Figure 12 (T/L 05-03) shows a possible arrangement for impulse noise testing.

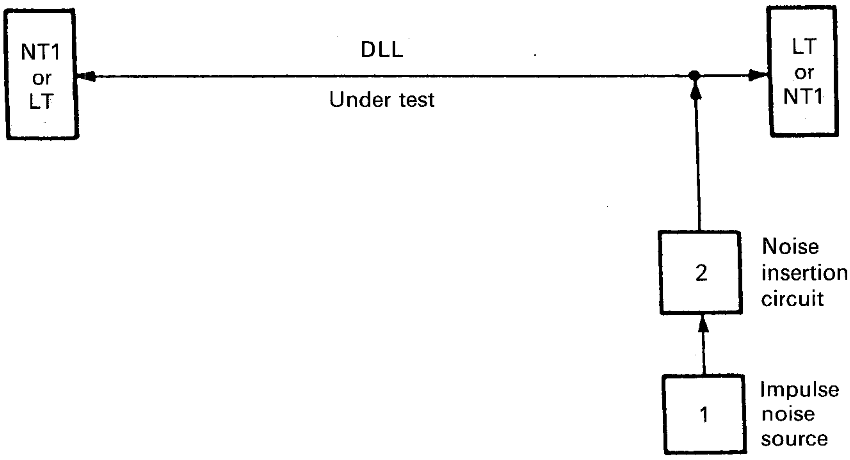
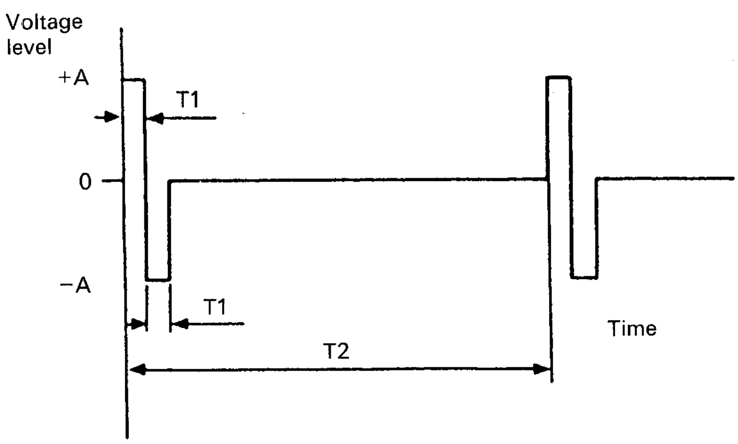


Figure 12 (T/L 05-03). Impulse noise simulation and testing.

The impulse noise source in Figure 12 (T/L 05-03) is for further study. Two possible classes of impulse noise signals are described in the following:

a) White noise of flat spectral density level of 5-10 $\mu V/\sqrt{Hz}$ and a bandwidth >4 times the Nyquist frequency of the particular system. The peak factor of the noise must be >4.

b) A particular waveform, as represented in Figure 13 (T/L 05-03).



A: Peak level, provisionally set to 100 mV.
T1: Pulse width, provisionally set to 3 baud periods.
T2: Period >T1.

Figure 13 (T/L 05-03). Possible Waveform to Simulate Impulse Noise.

4.2.4. *Performance Tests*

Five types of tests are required to describe the overall performance of a particular digital transmission system to qualify it for operation over the local line distribution network modelled in this Recommendation.

4.2.4.1. Dynamic Range

Dynamic range performance describes the ability of a particular digital transmission system to operate with received signals varying in level over a wide range. DLL models 1 and 2 in Figure 9 (T/L 05-03) have a loss varying from very low (0 dB) to very high (37-42 dB at 80 Hz).

When testing with DLL models 1 and 2 in Figure 9 (T/L 05-03), no errors should be observed.

Specification of data sequences to be used for this measurement are for further study.

Note. To verify the intrinsic quality of the system a measurement period of at least 8 days is recommended.

4.2.4.2. Immunity to Echoes

The remaining DLL models in Figure 9 (T/L 05-03) are used to test performance of digital transmission systems in the presence of BTs and/or diameter changes.

In each model, no errors should be observed in any 15-minute (provisional) measuring interval when monitoring any B channel.

Specification of data sequences to be used for this measurement are for further study.

4.2.4.3. Intrasystem Crosstalk

Using the crosstalk arrangement described in Section 4.2.2.2. with simulated crosstalk noise injected in each DLL model in Figure 9 (T/L 05-03) the observed bit error ratio (BER) should be $\leqslant 10^{-6}$ (provisional).

When BER measurements are performed in a B channel, a measuring interval of at least 15 minutes (provisional) is required.

In each DLL model, performance margins are determined. Definition of a minimum positive performance margin is left for further study. This is required to account for additional DLL loss due to splices, and environmental effects (e.g. temperature change).

Specification of data sequences to be used for this measurement are for further study.

4.2.4.4. Impulse Noise

For further study.

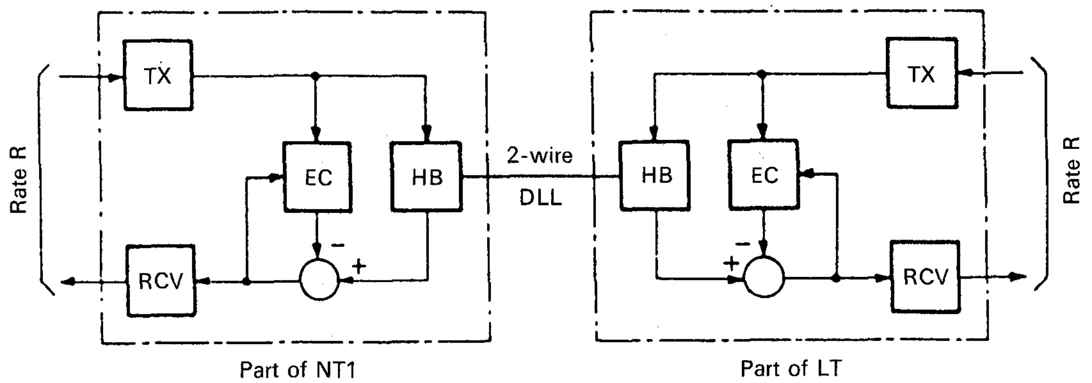
For the test in 4.2.3.2. b) (square wave) measurement of a block error ratio has been proposed to determine the maximum duration of disturbance.

4.2.4.5. Longitudinal voltages induced from power lines

For further study.

5. TRANSMISSION METHOD

The transmission system provides for duplex transmission on 2-wire metallic local lines. Duplex transmission shall be achieved through the use of ECHO CANCELLATION (ECH). With the ECH method, illustrated in Figure 14 (T/L 05-03), the echo canceller (EC) produces a replica of the echo of the transmitted signal that is subtracted from the total received signal. The echo is the result of imperfect balance of the hybrid and impedance discontinuities in the line.



TX: Transmitter
RCV: Receiver
EC: Echo Canceller
HB: Hybrid

Figure 14 (T/L 05-03). EC method functional diagram.

6. ACTIVATION/DEACTIVATION

6.1. General

The functional capabilities of the activation/deactivation procedure are specified in Recommendation T/L 03-13 E. The transmission system has to meet the requirements specified in Recommendation T/L 03-13 E. In particular, it has to make provision to convey the signals defined in Recommendation T/L 03-13 E which are required for the support of the procedures.

6.2. Physical Representation of Signals

The signals used on the digital transmission system are system dependent and can be found in Annex A and in the Appendices to this Recommendation.

7. OPERATION AND MAINTENANCE

7.1. Operation and Maintenance Functions

7.1.1. *Operation Functions*

The functions are defined in Recommendation T/L 03-13 E.

7.1.2 *Status Report Functions*

The system independent status report functions are defined in Recommendation T/L 03-13 E, paragraph 6.4.3.

Regarding FII, in addition to the causes defined in Recommendation T/L 03-13 E, the following condition shall cause an FII in the systems defined in this Recommandation: overload condition on the line.

The following system dependent status report functions apply to the systems defined in this Recommendation.

The definitive list is for further study. Some examples are given below.

Function	Location
Line test relay state	LT
LT test relay state	LT
Remote power switch state	LT
Remote power feed	LT
Induced overvoltage on line	LT
Abnormal current condition	LT
Receive eye opening	LT, Reg., NT
Echo canceller coefficient	LT, Reg., NT
Battery test	NT

7.2. CL Channel

7.2.1. *CL Channel Definition*

This channel is conveyed by the digital transmission system in both directions between LT and NT1 via a possible regenerator. It is used to transfer information concerning operation, maintenance and activation/ deactivation of the digital transmission system and of the digital section.

Even though some of these functions have an optional status the CL channel shall have the capability to convey the necessary information to perform the function.

7.2.2. *CL Channel Requirements*

The minimum number of functions to be supported by the CL channel are those defined in paragraphs 7.1.1. and 7.1.2. including those optionally implemented (see 7.2.1.).

Further requirements are for further study. The following items are a provisional list:
- minimum bit rate
- supported type of information
  - continuous
  - message
- securisation level of the information transferred in this channel

Note. The method of describing the use of the CL channel is for further study.

7.3. Transfer Mode of Operation and Maintenance Links

This is for further study. The following links need to be specified.

7.3.1. *Control Function*

- loopback control
- loopback status
- switching between normal and restricted conditions
- information request

7.3.2. *Information Function*

- FII
- line error monitoring
- power restricted conditions
- overload condition
- normal power feed fault
- restricted power feed fault

8. POWER FEEDING

8.1. General

This section deals with power feeding of the NT1, one regenerator (if required) and the provision of power to the user network interface according to Recommendation T/L 03-13 E under normal and restricted conditions.

When activation/deactivation procedures are applied, power down modes at the NT1, regenerator (if required) and the LT are defined.

8.2. **Power Feeding Options**

Power feeding options under normal and restricted conditions are considered. For this purpose, a restricted condition is entered after failure of external power at the NT1 location.

a) Power feeding of NT1 under normal conditions will be provided using one of the following options:
— External powering
— Remote powering from the network

In both cases the NT1 may provide power to the user network interface according to Recommendation T/L 03-07 E. This power is derived from AC mains or remotely from the network.

b) Power feeding of NT1 under restricted conditions, when provided, employs one of the following optional sources:
— Back-up battery
— Remote powering from the network.

In both cases the NT1 provides power to the user-network interface according to Recommendation T/L 03-07 E.

Power feeding options are chosen to satisfy national regulations.

8.3. **Power Feeding and Recovery Methods**

Two power feeding and recovery methods are possible and are described in Figure 15 (T/L 05-03).

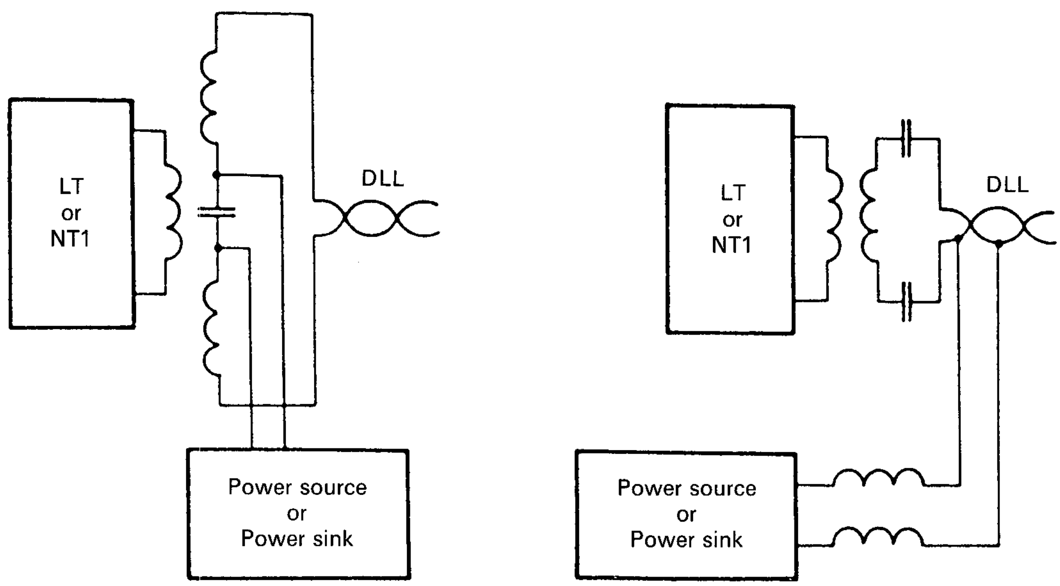


Figure 15 (T/L 05-03). Power Feeding and Recovery Methods.

When no regenerator is present on the DLL connecting the LT and the NT1, for each case in Figure 16 (T/L 05-03) the power source shall be a constant voltage source with current limiting.
When a regenerator is present, both methods of power feeding and recovery in Figure 16 (T/L 05-03) remain applicable.

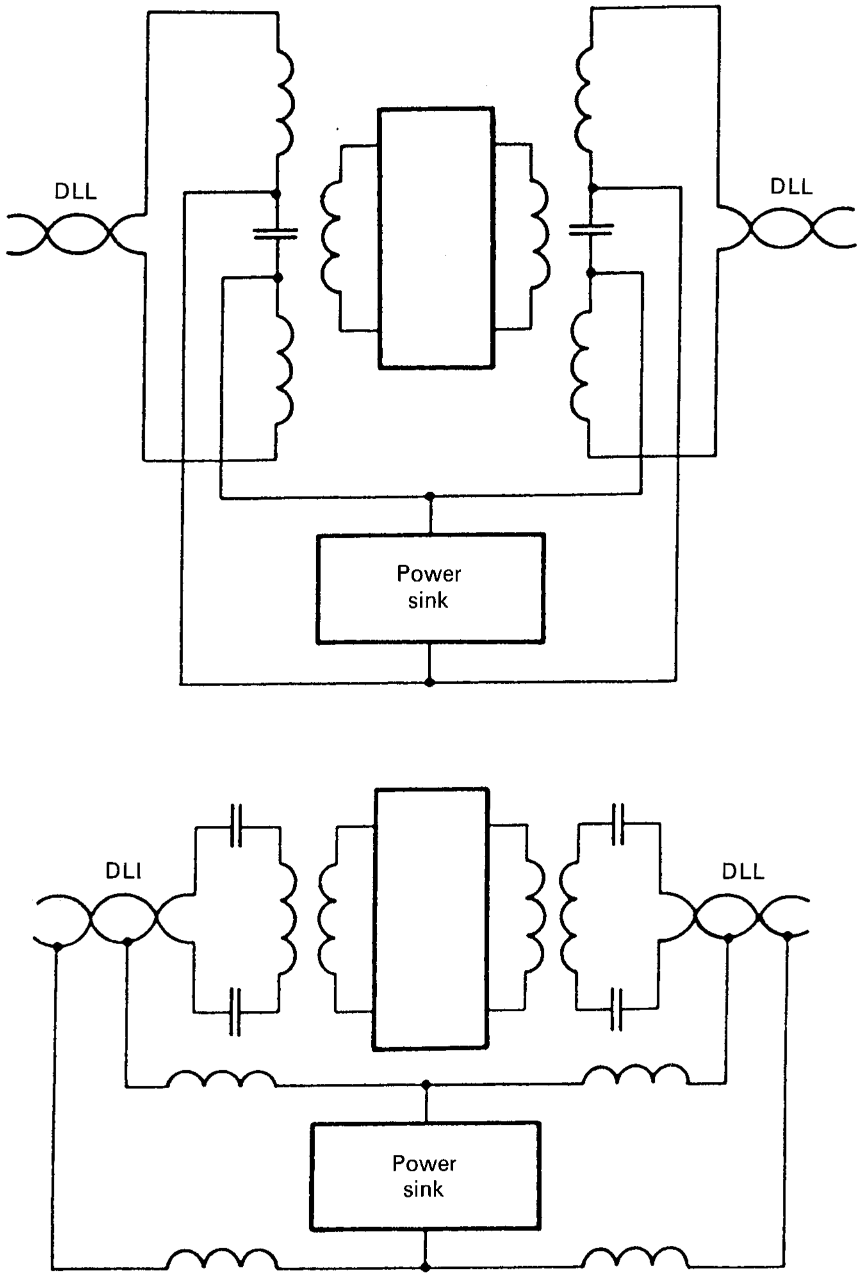


Figure 16 (T/L 05-03). Regenerator Powering from Constant Voltage Source at LT.

8.4. **DLL Resistance**

This parameter is a particular subject of the individual local network and therefore out of the scope of this Recommendation. Its maximum value depends on the LT output voltage, the power consumption of the NT1 and regenerator (if required) and the power feeding arrangement of the user-network interface.

8.5. **Wetting Current**

The NT1 shall provide a DC termination to allow a minimum wetting current to flow (the value has to be defined) including the power down mode or in case of local power feeding of the NT1.

8.6. **LT Aspects**

A current limitation for voltage source configuration is required. The value shall take into account the relevant IEC Publications and national safety regulations.
Short-term overload of the feeding current may be tolerated (charging condition of the capacitor of DC/DC converter in NT1).

8.7. **Power Requirements of NT1 and Regenerator**

8.7.1. *Power Requirements of NT1*

a) Active state without powering of user-network interface:
to be defined

b) Active state including restricted powering of the user-network interface as defined in Recommendation T/L 03-07 E:
to be defined

c) Active state including normal powering of user-network interface as defined in Recommendation T/L 03-07 E:
to be defined

d) Power down mode:
to be defined

8.7.2. *Power Requirement of Regenerator*

For further study.

8.8. **Current Transient Limitation**

The rate of change of current drawn by the NT1 or regenerator from the network shall not exceed x mA/µs. The value of x is to be defined.

9. **ENVIRONMENTAL CONDITIONS**

9.1. **Climatic Conditions**

Climatograms applicable to the operation of NT1 and LT equipment in weather protected and non-weather protected locations can be found in IEC Publication 721-3. The choice of classes is under national responsibility.

9.2. **Protection**

9.2.1. *Isolation*

Isolation between various points at the NT1 can be identified:
— between line interface and T reference point
— between line interface or T reference point and AC mains (this is generally defined in IEC Guide 105 and IEC Publication 950 but the test requirements may be different in various countries)
— between line interface and the protective ground of AC mains

The isolation specification is under national responsibility.

9.2.2. *Overvoltage Protection*

To conform with CCITT Recommendations K.12 and K.20 for LT.

To conform with CCITT Recommendations K.12 and K.21 for NT1.

Additional overvoltage protection specifications are under national responsibility.

9.3. **Electromagnetic Compatibility**

9.3.1. *Susceptibility Radiated and Conducted Emission Levels for LT or NT1 Equipment*

This is outside of the scope of this Recommendation. CISPR Publication 22 and national regulations have to be considered.

9.3.2. *Limitation of the Output Power to the Line*

Due to limited longitudinal conversion loss of the line at high frequencies and the limitation of radiating according to CISPR Publication 22 and national regulations, the output power shall be limited. The specific values are outside the scope of this Recommendation.

Annex A

GENERAL STRUCTURE FOR AN APPENDIX ON ELECTRICAL CHARACTERISTICS

A. ELECTRICAL CHARACTERISTICS

Short general characterization of the digital transmission system.

Note. The content of this Annex is a guideline for the presentation of the description of the digital transmission systems and is not intended to constrain any of the systems which will be included.

A.1. LINE CODE

For both directions of the transmission the line code is ....
And the coding scheme will be ....

A.2. Symbol Rate

The line baud rate is determined by the line code, the bit rate of the information stream and the frame structure. The symbol rate is .... kbaud.

A.2.1. Clock Requirements

A.2.1.1. *NT1 free running clock accuracy*

The accuracy of the free running clock in the NT1 shall be ± .... ppm.

A.2.1.2. *LT clock tolerance*

The NT1 and LT shall accept a clock accuracy from the ET of ± .... ppm.

A.3. FRAME STRUCTURE

The frame structure contains a frame word, N times (2 B+D) and a CL channel.

Frame word	N times (2 B+D)	CL channel

A.3.1. Frame Length

The number N of (2 B+D) slots in one frame is ....

A.3.2. Bit Allocation in Direction LT-NT1

In Figure A.1 (T/L 05-03) the bit allocation is given.

Figure A.1 (T/L 05-03). Bit allocation in direction LT-NT1.

A.3.3. Bit Allocation in Direction NT1-LT

In Figure A.2 (T/L 05-03) the bit allocation is given.

Figure A.2 (T/L 05-03). Bit allocation in direction NT1-LT.

A.4. FRAME WORD

The frame word is used to allocate bit positions to the 2 B+D+CL channels. It may, however, also be used for other functions.

A.4.1. Frame Word in Direction LT-NT1

The code for the frame word will be ....

A.4.2. Frame Word in Direction NT1-LT

The code for the frame word will be ....

A.5. FRAME ALIGNMENT PROCEDURE

A.6. MULTIFRAME

To enable bit allocation of the CL channel in more frames next to each other a multiframe structure may be used. The start of the multiframe is determined by the frame word. The total number of frames in a multiframe is ....

A.6.1. Multiframe Word in Direction LT-NT1

The multiframe will be identified by ....

A.6.2. Multiframe Word in Direction NT1-LT

The multiframe will be identified by ....

A.7. FRAME OFFSET BETWEEN LT-NT1 AND NT1-LT FRAMES

The NT shall synchronise its frame on the frame received in the direction LT to NT and will transmit its frame with an offset.

A.8. CL Channel

A.8.1. Bit Rate

A.8.2. Structure

A.8.3. Protocols and Procedures

A.9. SCRAMBLING

Scrambling will be applied on (2 B+D) channels and the scrambling algorithm shall be as follows.
In direction LT to NT1.
In direction NT1 to LT.

A.10. ACTIVATION/DEACTIVATION

Description of system activation/deactivation procedure including options that are supported and options that are not supported.
See also: Recommandation T/L 05-03, Section 5.

A.10.1 Signals Used for Activation

A list and definition of the signals used for activation/deactivation (SIGs)
— effective signal (CL not available)
— bits in CL channel or elsewhere in an already established frame

A.10.2 Definition of Internal Timers

A.10.3. Description of the Activation Procedure

(Based on arrow sequence for the error-free case)

— Activation from the network side
— Activation from the user side

A.10.4. State Transition Table NT as a Function of INFOs, SIGs, Internal Timers

The description of loopbacks and options supported is given in such a way that the minimum implementation may be clearly identified.

A.10.5. State Transition Table LT as a Function of FEs, SIGs, Internal Timers

The description of loopbacks and options supported is given in such a way that the minimum implementation may be clearly identified.

A.10.6. Activation Times

See Recommendation T/L 05-03 E, paragraphs 5.5.1. and 5.5.2.

A.11. JITTER

Jitter tolerances are intended to ensure that the limits of Recommendation T/L 03-07 E are supported by the jitter limits of the transmission system on local lines. The jitter limits given below must be satisfied regardless of the length of the local line and the inclusion of one regenerator, provided that they are covered by the transmission media characteristics (see Section 3.). The limits must be met regardless of the bit patterns in the B, D and CL Channels.

A.11.1 NT1 Input Signal Jitter Tolerance

The NT shall meet the performance objectives with wander/jitter at the maximum magnitudes (J1, J2) indicated in Figure A.3. (T/L 05-03), for single jitter frequencies in the range of F_1 Hz to F_3 kHz (F_3 = 1/4 F_b, F_b = SYMBOL RATE FREQUENCY), superimposed on the test signal source. The NT1 shall also meet the performance objectives with wander per day of up to UI peak-to-peak where the maximum rate of change of phase is UI/hour.

A.11.2. NT1 Output Jitter Limitations

With the wander/jitter as specified in A.11.1., superimposed on the NT1 input signal, the jitter on the transmitted signal on the NT1 towards the network shall conform to the following:

a) The jitter shall be equal to or less than UI peak-to-peak and lesser than .... UI rms when measured with a high-pass filter having a 20 dB/decade roll-off below $M \cdot F_2$ Hz ($M \geq 1$).

b) The jitter in the phase of the output signal relative to the phase of the input signal (from the network) shall not exceed .... UI peak-to-peak or .... UI rms when measured with a band-pass filter having a 20 dB/decade roll-off above $N \cdot F_2$ Hz ($N \geqslant 2$) and a 20 dB/decade roll-off below $K \cdot F_1$ Hz ($K < 1$). This requirement applies with superimposed jitter in the phase of the input signal as specified in A.11.1. for single frequencies up to F_2Hz.

A.11.3. **Test Conditions for Jitter Measurements**

Due to bidirectional transmission on the 2-wire and due to severe intersymbol interference no well defined signal transitions are available at the NT1 2-wire point.

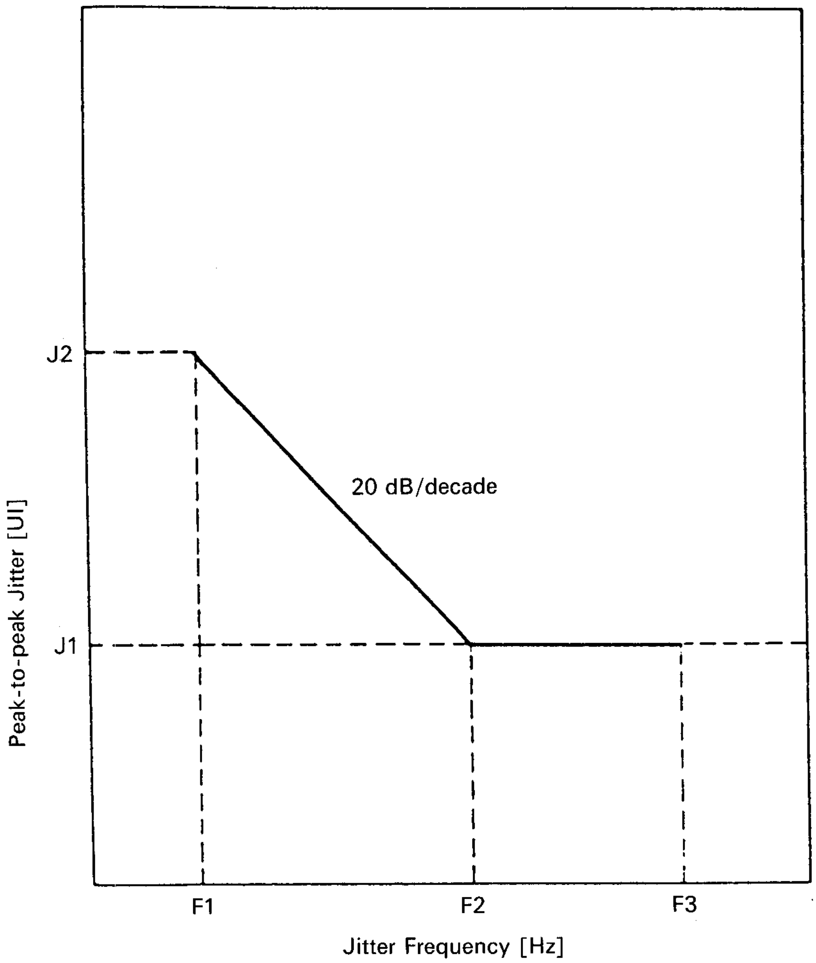


Figure A.3 (T/L 05-03). Tolerable Jitter on NT Input Signal.

Note. Two possible solutions are proposed:

1. A test point in the NT1 is provided to measure jitter with an undisturbed signal.
2. A standard LT transceiver including an artificial local line is defined as a test instrument.

A.12. **TRANSMITTER OUTPUT CHARACTERISTICS OF NT1 AND LT**

The following specifications apply with a load impedance of ....

A.12.1. **Pulse Amplitude**

The zero-to-peak nominal amplitude of the largest pulse shall be .... V and the tolerance shall be ± ....%.

A.12.2. **Pulse Shape**

The pulse shape shall meet the pulse mask of Figure ....

A.12.3. **Signal Power**

The average signal power shall be between .... dBm and .... dBm.

A.12.4. **Power Spectrum**

The upper bound of the power spectral density shall be within the template in Figure ....

A.12.5. **Transmitter Signal Non-linearity**

This is a measure of the deviations from ideal pulse heights and the individual pulse non-linearity. The measurement method is for further study.

A.13. **TRANSMITTER/RECEIVER TERMINATION**

A.13.1. **Impedance**

The nominal input/output impedance looking toward the NT1 or LT respectively shall be ....

A.13.2. **Return Loss**

The return loss of the impedance shall be greater than shown in the template Figure ....

A.13.3. **Longitudinal Conversion Loss**

The minimum longitudinal conversion loss shall be as follows:

.... kHz	.... dB
.... kHz	.... dB

The five Appendices to Recommendation T/L 05-03 E correspond to the following Appendices of CCITT Recommendation G.961:

Appendix of T/L 05-03	Appendix of G.961
I	I
II	II
III	III
IV	IV
V	V