Recommendation T/CD 01-13 (Odense 1986)

ENGINEERING REQUIREMENTS FOR A VOICE PLUS DATA SYSTEM

Recommendation proposed by Working Group T/WG 10 "Data communications" (CD)

Text of the Recommendation adopted by the "Telecommunications" Commission:

"The Conference of European Post and Telecommunications Administrations,

considering

— that the Working Group CD has studied under the auspices of Question CD 1 the harmonization of Data Circuit Terminating Equipment,

recommends

— that the attached specification of engineering requirements for a voice plus data system as contained in Annex to this Recommendation should be taken into account by all CEPT members Administrations when the implementation of a relevant piece of equipment is being planned by Administrations."

Administrations are free to stipulate additional requirements, and also which of the optional requirements, if any, are to be provided.

Note 1: It should be noted that this Recommendation may be revised from time to time.

Annex. Index

1. SCOPE

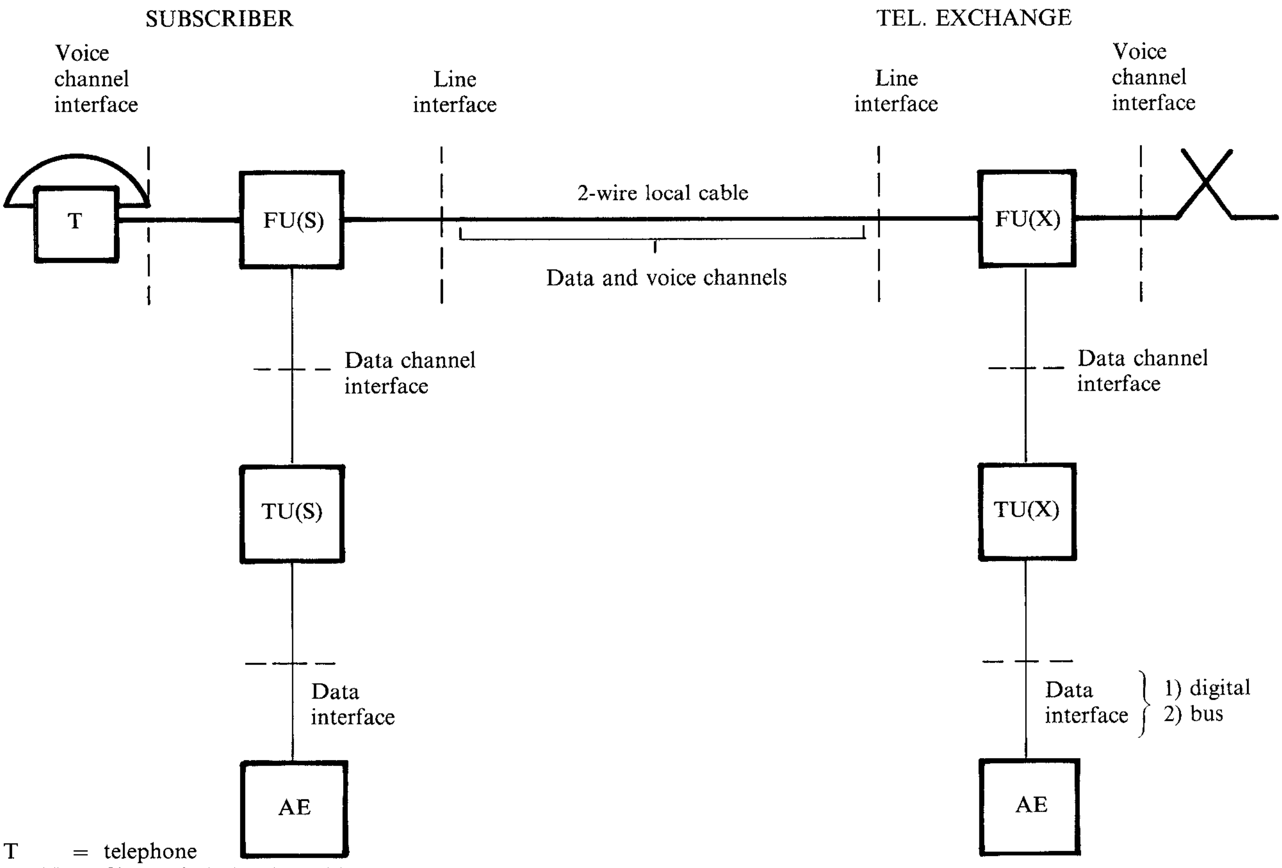
This document specifies equipment which allows simultaneous and independent transmission of voiceband signals and data or other digital signals over a two-wire line between a customer's premises and his telephone exchange as shown in Figure 1 (T/CD 01-13).

For applications where relatively low signalling rates are sufficient (e.g. telemetry), this specification does not necessarily apply.

The voice channel is provided using the normal voiceband while the data channel is provided using the frequency spectrum above the voiceband.

It is intended that at the customer's premises the line shall terminate on equipment designated filter unit FU(S) and transmission unit TU(S) (or equivalent). At the telephone exchange the line shall terminate on equipment designated FU(X) and TU(X) (or equivalent).

The characteristics of various kinds of the line are given in Section B. Other possible configurations for the voice plus data systems are given in Appendix 1.



T = telephone
FU(S) = filter unit (subscriber side)
FU(X) = filter unit (exchange side)
TU(S) = transmission unit (subscriber side)
TU(X) = transmission unit (exchange side)
AE = associated equipment (e.g. DTE, DCE, MUX)

Figure 1 (T/CD 01-13).

The transmission units (TU) may be accommodated within various other equipments e.g. a DCE, a multiplexer etc. (Associated equipment AE).

The data interface as described in item A-1.3. below may be
— a digital interface (item A-1.3.1.) or
— a bus interface (item A-1.3.2.)

The filter unit (FU) for combination and separation of the voice and data channels may be integrated in the transmission unit (TU) or may be a separate physical unit.

Section A. *Common requirements*

A-1. TRANSMISSION UNIT (TU)

A-1.1. General

Simplex, half-duplex and duplex modes of operation using the frequency spectrum above the normal voice channel (including charging systems whose signals are transmitted at 12 kHz or 16 kHz) shall be possible.

For the TU channel separation by frequency division multiplexing (FDM) is used where necessary.

Depending on the user data signalling rates (see item A-1.2.)
— only synchronous or
— synchronous and/or asynchronous
mode of operation is required.

A-1.2. Data signalling rates

The user data signalling rates are given in Table A-1 (T/CD 01-13). The provision of all these rates may not be required by each Administration.

The signalling rate on the line should be equal to the highest bitrate (i.e. 12 or 19.2 kbit/s).

User rates are derived by dividing this rate.

The inherent redundancy for user data signalling rates lower than 19.2 kbit/s or 12 kbit/s offers the possibility of a forward error correction. This is not part of the Recommendation.

Examples of error correction methods are given in Appendices 8 and 9.

User data signalling rate (bit/s)	Signalling rate in bit/s on the line in case of:		
	Synchronous operation no envelope str.	Synchronous operation 8+2 envelopes	Asynchronous operation (*Note 1*)
600 (*Note 2*)	Not applicable	12,000	Not applicable
1,200	19,200	12,000	19,200 synchr.
2,400 (*Note 2*)	19,200	12,000	19,200 synchr.
4,800 (*Note 2*)	19,200	12,000	19,200 synchr.
9,600 (*Note 2*)	19,200	12,000	9,600 asynchr.
19,200	19,200	Not applicable	19,200 asynchr.

Table A-1 (T/CD 01-13).

Note 1. Asynchronous operation with a user data signalling rate of up to 19.2 kbit/s can be achieved in the case of Alternative A (as described in item A-1.4.1.) by direct FSK modulation of the user data. It may be necessary to reduce the transmit power to avoid unacceptable cross talk, otherwise a synchronous-asynchronous conversion (e.g. according to CCITT Recommendation V.22) at the data signalling rate on the line is needed. This conversion is not subject of the Recommendation.

Note 2. The data signalling rate appearing at the data interface is 25% higher than the user signalling rate when 8+2 envelope transmission is employed.

A-1.3. Data interface

The TU is defined between the
— data interface and the
— data channel interface, as shown in Figure 1 (T/CD 01-13).

A-1.3.1. *Digital data interface*

(a) Interchange circuits

In the case where a physical interface exists between a TU and any associated equipment (AE), Table A-2 (T/CD 01-13) gives a list of mandatory and optional interchange circuits.

Interchange circuit designation	Interchange circuit name	Access point designation AE TU
G	Signal ground or common return	G G
DT	Transmitted data	Do → Di
DR	Received data	Di ← Do
RS1	Receiver signal element timing	RS1i ← RS1o
RS2	8 × clock of RS1 (*Note 1*)	RS2i ← RS2o
TS1	Ext. transmit signal element timing	TS1o → TS1i
TS2	Transmit signal element timing	TS2i ← TS2o
TS3	8 × clock of TS2 (*Note 1*)	TS3i ← TS3o
A	Received line signal detector	Ai ← Ao
"105"	Request to send (optional)	→
"106"	Ready for sending (optional)	←
"107"	Data set ready (optional)	←
"142"	Test indicator (optional)	←
DEB1 DEB2	Bit rate selection (*Note 2*)	←
ID1 ID2	Modem type selection (*Note 2*)	←

Table A-2 (T/CD 01-13).

Note 1. This circuit is mandatory if the transmission of envelope structured data (8+2) is required, otherwise it is optional.

Note 2. These circuits are optional and might be applicable if the TU is a plug-in unit.

(b) Definitions of the interchange circuits

Circuit G – Signal ground or common return

This conductor establishes the signal common return for unbalanced interchange circuits.

Circuit DT – Transmitted data

The data signals to be transmitted via data channel to the remote AE are transferred on this circuit to the TU.

Circuit DR – Received data

The data signals generated by the TU, in response to data channel line signals received from the remote AE are transferred on this circuit to the AE.

Circuit RS1 – Receiver signal element timing

Signals on this circuit provide the AE with signal element timing information. The condition of this circuit shall be ON and OFF for nominal equal periods of time, and a transition from the ON to the OFF condition shall nominally indicate the centre of each signal element on circuit DR.

Circuit RS2 – 8 × clock of RS1

The number of transitions from ON to OFF on this circuit should be 8 times higher than on circuit RS for a 10 bit envelope structure. Each transition from ON to OFF of RS1 corresponds also with an ON to OFF transition of RS2.

Circuit A – Received line signal detector

Signals on this circuit indicate whether the received data channel line signal is within appropriate limits. The ON condition indicates that the received signal is within appropriate limits. The OFF condition indicates that the received signal is not within appropriate limits.

(c) Electrical characteristics and significant levels

In accordance with CCITT Recommendation V.24/V.28 and/or CEPT Recommendation T/CD 01-12 (Part I, Section A, Item 3.2.3.).

A-1.3.2. *Bus interface*

If a bus interface is to be used reference is made to the Recommendation T/CDxx (bus interface specification). An application of a bus interface in the TU(S) is not foreseen.

A-1.4. **Modulation and coding**

At present two alternatives are under consideration.

A-1.4.1. *Alternative A: Frequency shift keying (FSK)*

	Carrier frequency	Mark	Space
TU(S) → TU(X):	100 kHz ± 0.2%	95 kHz	105 kHz
TU(X) → TU(S):	55 kHz ± 0.2%	50 kHz	60 kHz

A-1.4.2. *Alternative B: 4 Phase differential modulation for 19.2 kbit/s and 12 kbit/s*

Carrier frequencies:

TU(S) → TU(X): 76.8 kHz ± 0.01%

TU(X) → TU(S): 38.4 kHz ± 0.01%

The data rate transmitteed to line shall be 19.2 kbit/s or 12 kbit/s ± 0.01% with a modulation rate of 9.6 kbauds and 6 kbauds ± 0.01%.

The data stream to be transmitted shall be divided into pairs of consecutive bits (dibits). Each dibit is encoded as a phase change relative to the phase of the immediately preceding signal element.

At the receiver the dibits are decoded and the bits are reassembled in correct order. The coding is given in Table A-3 (T/CD 01-13). The left-hand bit of the dibit is the one occurring first in the data stream.

Dibit	Phase change (see *Note*)
00	+ 0°
01	+ 90°
11	+180°
10	+270°

Table A-3 (T/CD 01-13).

Note. The phase change is the actual on-line phase shift in the transition region from the centre of one signalling element to the centre of the following signalling element.

A-1.5. **Scrambler**

The scrambler to be used shall be according to CEPT Recommendation T/CD 01-12, Section A, Item 2.1.4., including the guard circuitry.

A-1.6. **Timing**

For the synchronous mode of operation the TU(S) has an internal clock source which under normal conditions is synchronized by the received data signal.

The free running accuracy of the internal clock shall be at least ± 0.01%.

The signal which is given to the interchange circuit RS1 (receiver signal element timing, circuit "115") is a square wave signal with a frequency in Hz with the same value as the selected data signalling rate in bit/s.

A deviation from the nominal value of the transition of the timing signals shall not exceed $4 \times T/100$ where T is the duration of one cycle of RS1.

The phase relationship between transmitted and received data (DT, DR) and the signal element timing RS1 (= 115) and for TU(X) "113" or "114" (114 is optional) is given in Appendix 2.

A-1.7. **Data channel interface**

To ease the installation at the subscriber's premises and at the telephone exchange the TU and the FU can be separate physical units. In this case the data channel interface is a 2-wire interface.

The length of the interchange cable should not exceed 300 m.

A-1.7.1. *Transmit side*

(a) Transmit level

TU(X): Reference level x dBm (nationally dependent)

TU(S) : Two alternatives are possible:

A) A fixed transmit level (nationally dependent).

B) Transmit level depending on the receive level, implemented as continuous variations or as shown in Table A-4 (T/CD 01-13) where x is national dependent.

Receive level	Transmit level
x to x−11 dB	x−12 dBm
x−11 dB to x−22 dB	x− 6 dBm
x−22 dB to x−33 dB	x− 0 dBm
x−33 dB to x−44 dB	x+ 6 dBm

Table A-4 (T/CD 01-13).

In case of an automatic adjustment a hysteresis of 3 dB (±1 dB) and an integration time for one level to another of 1 s (± 200 ms) should be met.

(b) Spectrum

Alternative A:

The spectrum of the transmit side of TU(X) and TU(S) should be within the limits of Figure A-1 (T/CD 01-13) (measured with a bandwidth of 300 Hz).

Example for a reference level x= −6 dBm and a receive level in the range of −39 to −50 dBm.

In addition, for frequencies above 160 kHz the energy of the spectral components should be below −70 dBm.

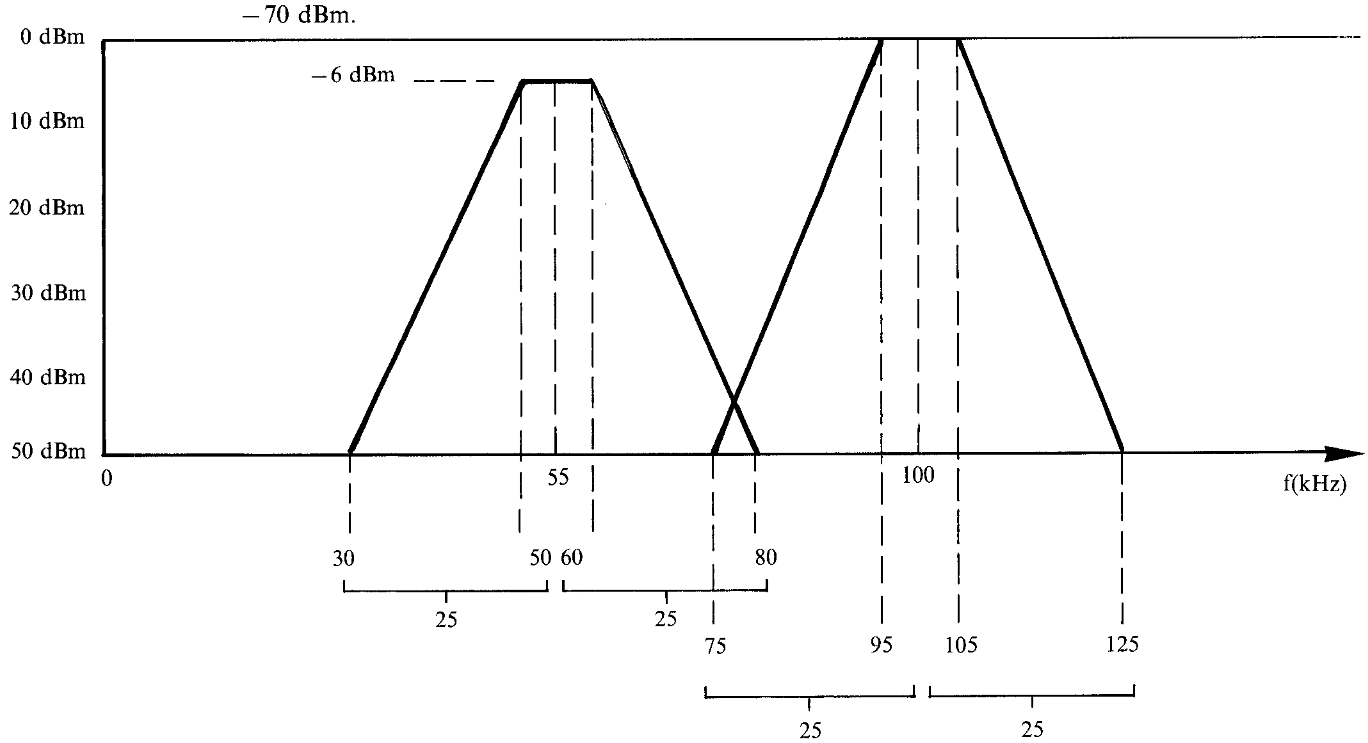


Figure A-1 (T/CD 01-13).

A-1.7.2. *Receive side*

Treshold of received line signal detector:

TU(X): greater than X −44 dB, circuit A (= 109) "ON"
less than X −49 dB, circuit A (= 109) "OFF"

TU(S) : greater than X −44 dB, circuit A (= 109) "ON"
less than X −49 dB, circuit A (= 109) "OFF"

The condition of circuit A for values between the above-mentioned levels is not specified except that the signal detector shall exhibit a hysteresis such that the level at which the OFF-to-ON transition occurs is at least 2 dB greater than that for the ON-to-OFF transition.

A-1.7.3. *Equalisation*

An automatic distorsion equalisation may be provided in the TU(S).

A-1.8. **Power consumption**

The maximum power consumption should not exceed 4 Watts for one TU. The current consumption and the voltage levels for plug-in units should be within the limits specified below:

+12 V±5%	. . . .	max. 90 mA
−12 V±5%	. . . .	max. 90 mA
+ 5 V±5%	. . . .	max. 400 mA

A-2. **FILTER UNIT (FU)**

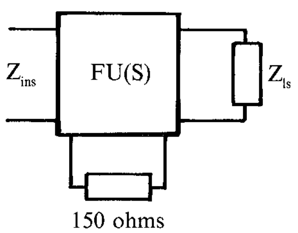
A-2.1. **Voice channel interface**

This interface is a 2-wire interface.

A-2.1.1. *Return loss*

The mean input impedance of the telephone network seen from the subscriber side shall not change excessively after the insertion of the FU's, since the balancing network in the telephone set is designed for optimum sidetone attenuation.

As it is not possible to design impedance transparent filters a return loss is specified in Figure A-2 (T/CD 01-13) as a first design objective.



Z_{ins}: Input impedance of the FU(S) at the voice channel interface.
Z_{ls}: Mean input impedance of the telephone network seen from the subscriber side.

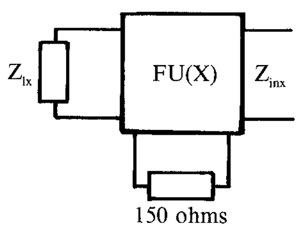
Figure A-2 (T/CD 01-13). Impedance of the FU(S).

Return loss:

$$a_{RS} = 20 \log \left| \frac{Z_{ins} + Z_{ls}}{Z_{ins} - Z_{ls}} \right|$$

The mean input impedance of the subscriber's telephone network seen from the exchange side shall not change excessively after the insertion of the FU's since the balance impedance of the hybrid in digital exchanges is equal to this mean input impedance in order to have optimum balance return loss.

Similarly to the subscriber side a return loss is specified in Figure A-3 (T/CD 01-13).



Z_{inx}: Input impedance of the FU(X) at the voice channel input.
Z_{lx}: Mean input impedance of the subscriber's telephone network seen from the exchange.

Figure A-3 (T/CD 01-13). Impedance of the FU(X).

Return loss:

$$a_{RX} = 20 \log \left| \frac{Z_{inx} + Z_{lx}}{Z_{inx} - Z_{lx}} \right|$$

For the filter design Z_{lx} shall be equal or similar to Z_{ls}; Z_{lx} and Z_{ls} shall be substituted by reference networks. Details of such reference networks together with values a_{RS} and a_{RX} to be found in Section B (depending on national requirements).

A-2.1.2. *Balance to earth*

The balance to earth shall be greater than the limits shown in Appendix 3. It will be measured selectively.

$a_u = P_s - P_E$; a_u in dB

A-2.1.3. *Insertion loss*

The insertion loss should be less than 0.5 dB between the voice interfaces a_1/b_1 and a_2/b_2 in the following frequency ranges.

Range	= ZG (generator) ZE (receiver)	P_1
300 ... 3,400 Hz	600 ohms	−10 dBm
6 kHz	200 ohms	
8 kHz	200 ohms	
10 kHz	200 ohms	
12 kHz ±72 Hz	200 ohms	+10 dBm
16 kHz ±80 Hz	200 ohms	−27 ... +22 dBm (775 mV)

Measurement set-up in Appendix 4.

$a_I = P_1 - P_2$; a_i in dB

The value of insertion loss above 3.4 kHz and outside of the range from 12 kHz to 16 kHz is not specified.

A-2.1.4. *Interference signals*

The noise shall meet the following requirements at the voice input terminals to the telephone set or to the line circuits in the telephone exchange when data transmission is in progress.

Measurement set-up in Appendix 5.

RV: 0 ... 1,600 ohms

A-2.1.4.1. Psophometric weighted noise

The average psophometric weighted (speech) noise should be less than −72 dBmp (0.2 mV).

A-2.1.4.2. Unweighted noise

The unweighted noise shall be less than the indicated values. It will be measured with a bandwidth of 80 or 100 Hz.

Frequency/kHz	ZA (ohms)	V_{rms} converted to absolute level
> 0.05 ... 0.3	600	−47 dBm
> 0.3 ... 3.4	600	−72 dBm
> 3.4 ... 8	200	−64 dBm
> 8 ... 16	200	−50 dBm
> 16 ... 240	150	−35 dBm

A-2.1.5. *Non linear distortion*

A-2.1.5.1. The influence of the transmit level on insertion loss

For each frequency component between 300 Hz and 3,400 Hz the value of the insertion loss should not deviate more than 0.2 dB from the nominal value, when the transmit power will be increased from −40 dBm to +3.5 dBm.

A-2.1.5.2. Harmonic distortion

The total harmonic distortion (d_{tot}) is expressed by the following formula:

$$d_{tot} = \sqrt{\frac{d_2^2 + d_3^2 + d_4^2 + \text{———} + d_n^2}{d_1^2}}$$

The term d_1 represents the relative value of the sinusoidal wave, d_2 represents the relative value of the second harmonic of the original sinusoidal wave, etc.

The measurements should be carried out with a nominal transmit level of 0 dBm in the frequency band of 300 Hz-3,400 Hz.

The total harmonic distortion should be less than 0.01.

A-2.1.5.3. Group delay distorsion

The group delay distortion between both voice channel interfaces must not exceed a value of 10 µs in the range 300 to 3,400 Hz. The measurement should be carried out with a transmit level of 0 dBm.

A-2.1.6. *Electrical conditions*

A-2.1.6.1. D.C. load

Currents of up to 100 mA shall not change the transmission and the performance requirements specified in Chapters A-2 and A-3.

A-2.1.6.2. Polarity independence

The channel filters shall operate independently of the subscriber line polarity. The required transmission values are to be met irrespective of the polarity.

A-2.1.6.3. D.C. resistance

The d.c. loop resistance of both FU's in tandem shall not exceed a value of 20 ohms at a loop current of 14 ... 60 mA.

A-2.2. **Data channel interface** (see item A-1.7.)

A-2.3. **Line interface**

This interface is a 2-wire interface.

The requirements of Recommendation T/CD 01-01 shall apply (for further study). The balance to earth requirements of the input transformer, together with a measurement set-up, are given in Appendix 6.

A-3. PERFORMANCE REQUIREMENTS

A-3.1. Data channel performance

The performance of the data channel of a voice plus data system [TU(S), FU(S), line FU(X), TU(X)] shall be measured from the data interface of the TU(S) to the data interface of the TU(X) and vice versa.

An error-free performance is required at any specified bit rate when no noise is injected into the system.

The equipment is required to work satisfactorily over a length of cable the attenuation of which is less than 50 dB at 100 kHz. However, Administrations may specify a lower value of the attenuation, e.g. 40 dB. An error rate better than 10^{-6} is required for any specified bit rate for the data channel when noise is injected such that the signal to noise ratio is 20 dB. An appropriate measurement set-up is given in Appendix 7.

For the asynchronous mode of operation up to 19.2 kbit/s a maximum start-stop distortion of 20% is allowed.

A-3.2. Line condition influence

While data signals are transmitted (511 bit pseudo-random test sequence) in the overvoice band, a simulator performs a main sequence consisting of 20 times the sequence described in Figure A-4 (T/CD 01-13) and a main sequence consisting of 20 times a sequence of two ringing signals each with a duration of 750 ms and with a 5 s interval.

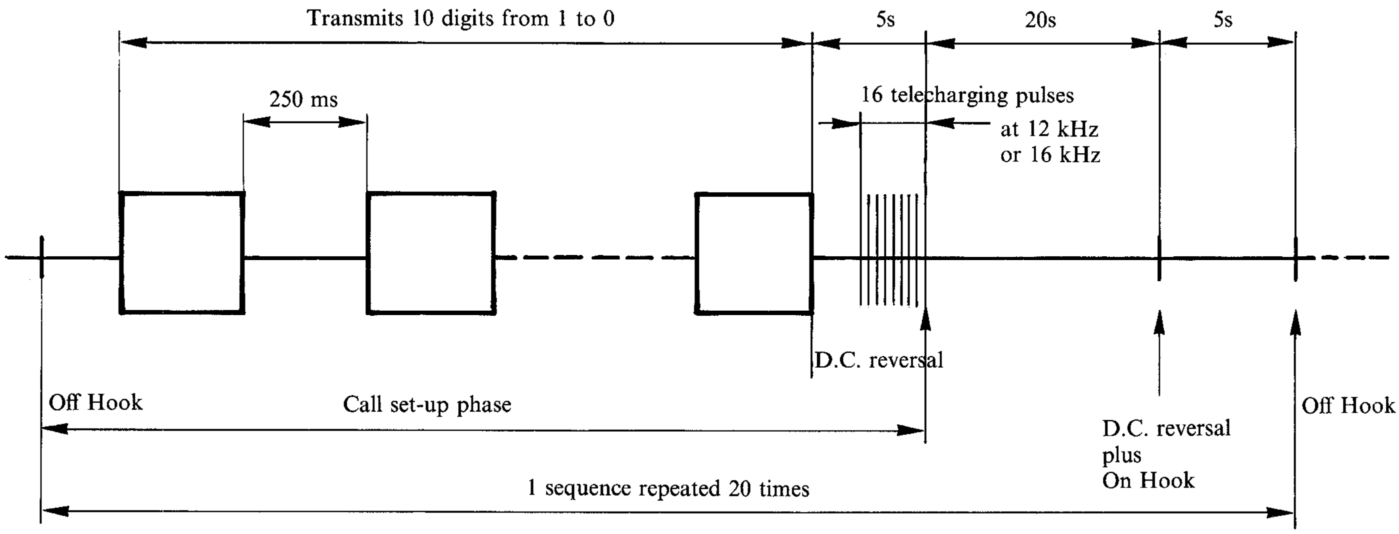


Figure A-4 (T/CD 01-13).

For each main sequence the number of erroneous blocks shall not exceed 2.
When the OFF hook condition is established while receiving a ringing signal erroneous blocks may occur in 10% of the incidents.

Administrations may impose additional requirements depending on their network conditions.

A-3.3. Additional requirements

A-3.3.1. *Electromagnetic compatibility*

See Appendix 10 (provisional values from the Nordic Countries).

A-4. TEST AND MAINTENANCE FEATURES

(for further study)

A-5. CONSTRUCTION

A-5.1. Subscriber side

The equipment practice Type IA or IB or Type IIA shall conform in size to CEPT Recommendation T/CD 01-14.

The FU shall be contained within the TU(S)-module or shall be a separate physical unit to ease the installation at the subscriber's premises. In this case the maximum distance between TU(S) and FU can be 300 m.

A-5.2. Exchange side

The equipment practice of the TU(X) may e.g. conform to Type I, II or III of the CEPT Specification of Equipment Practice for Data Circuit Terminating Equipment. More than one TU(X) may be accommodated on a single card.

For the FU the same situation occurs as under item A-5.1.

Section B. ***Network dependent requirements***

B-1. **POWER-OFF SIGNAL** (required for the NPDN)

The TU(S) shall be provided with a "power-off" generator which shall be connected to the line, if one or more of the power supply voltages to the TU(S) fail(s).

When the power-off generator is activated a signal shall be transmitted to the TU(X), consisting of an ON-OFF modulated carrier with a frequency of 95 kHz. The duty cycle of the signal may be depending on the energy available in the TU(S). The transmit level shall be the same as for the data signals.

The power-off generator may be powered from either an accumulator in the TU(S) or from the line.

If an accumulator is used for the power-off generator it shall be able to supply the power-off generator for at least 72 hours continuously.

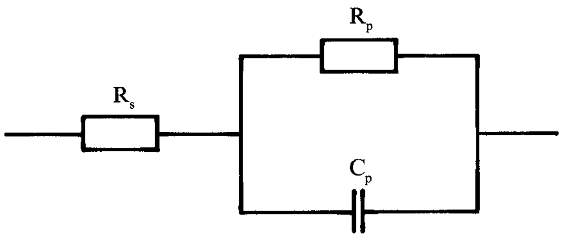
If DC-power is obtained from the line, the power consumption shall not exceed 200 μA.

When the TU(X) receives a power-off signal from the TU(S) a signal shall be generated towards the network, indicating the power-off condition. This signal shall be a square wave signal of the frequency from 1.7-3 Hz, so that the signal is ON 35-65% of the time and OFF 35-65% of the time. The signal shall always start with an OFF-period longer than 100 ms.

B-2. **REFERENCE NETWORKS AND RETURN LOSS VALUES**

The principle requirements concerning the terminating impedance, return loss and the earth unbalance ratio of the line interface applicable within the various CEPT Administrations are summarized in the following Table.

The components R_s, R_p and C_p, referred to in the Table, are parts of a complex terminating impedance as depicted in the following Figure.



Complex terminating impedance.

Country	Terminating impedance			Return loss dB	Unbalance ratio dB
	R_s/Ω	R_p/Ω	C_p/nF		
Austria (*Note 1*)	220 88.9	820 711	115 63.8	⩾14 ⩾14 (*Note 2*)	46
Belgium	150	830	72	⩾14	48
Denmark	600	—	—	10	50 in 50- 600 Hz 56 in 600-3,400 Hz –6 dB/octave above 3,400 Hz
Finland	270	910	120	10	
France	180	910	150	⩾14	
Fed. Rep. of Germany	220	820	115	⩾18	46
Greece	600	—	—	15	50
Italy	600	—	—	14	50
Netherlands	600	—	—	⩾14	50
Norway	120	820	110	9	40 in 40- 300 Hz 50 in 300- 600 Hz 55 in 600-3,400 Hz
Portugal	230	820	103	⩾14	55
Spain	600	—	—	⩾14	40 in 40- 300 Hz 50 in 300- 600 Hz 55 in 600-3,400 Hz
Sweden	—	900	30	⩾ 6	40 in 300- 600 Hz 46 in 600-3,400 Hz
Switzerland	600 220	— 820	— 115	⩾14 ⩾14	57 (*Note 3*) 57 (*Note 4*)
United Kingdom	600	—	—	15	46

Section I. Table B-1 (T/CD 01-13).

Note 1. Two different terminating impedances are used. The requirement of −14 dB must be met for both.

Note 2. In some cases the national requirements cannot be met by using only the reference networks for the measurement of the return loss values. It is therefore recommended for extreme subscriber lines to use these "real" subscriber lines for the above measurements, and then a value of ⩾ 8.5 dB is required.

Note 3. For electromechanical switches.

Note 4. For digital switches, Figures indicated by Austria and the Fed. Rep. of Germany could also be accepted for future developments.

Appendix 1

Applications

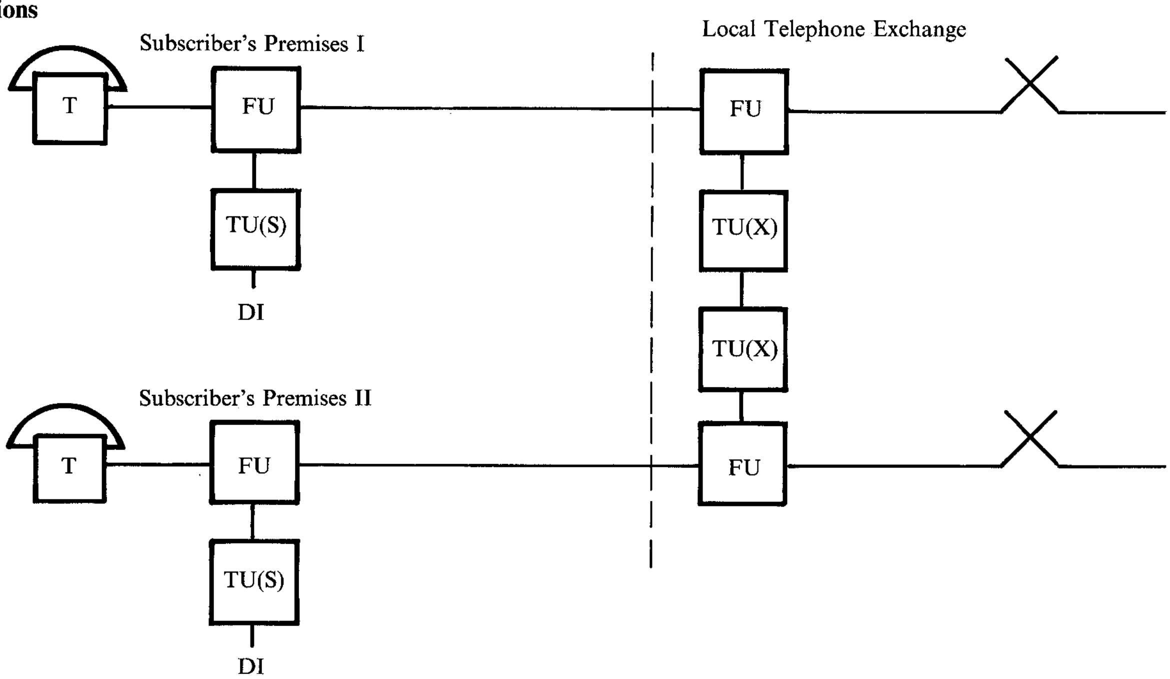


Figure a

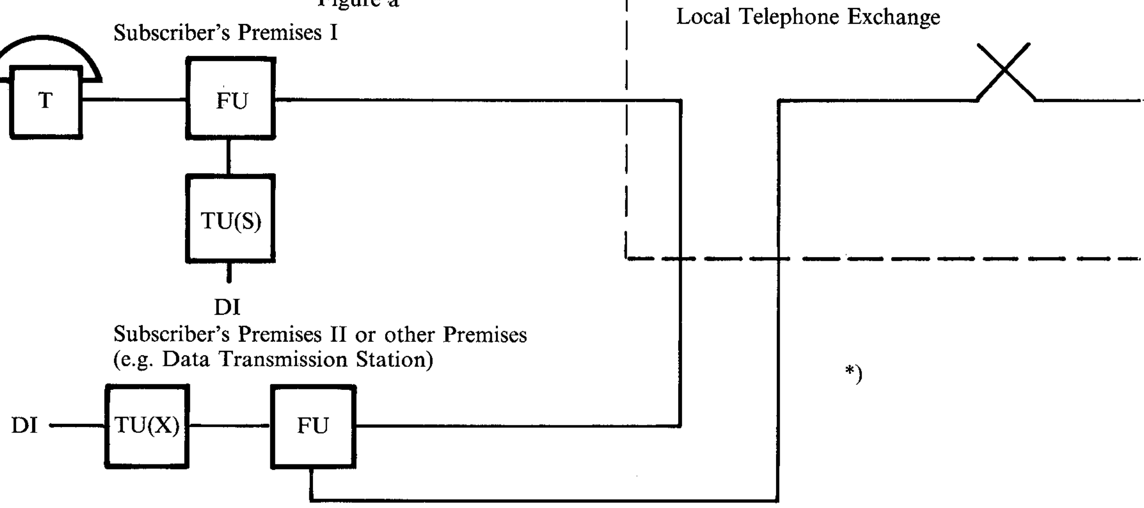


Figure b

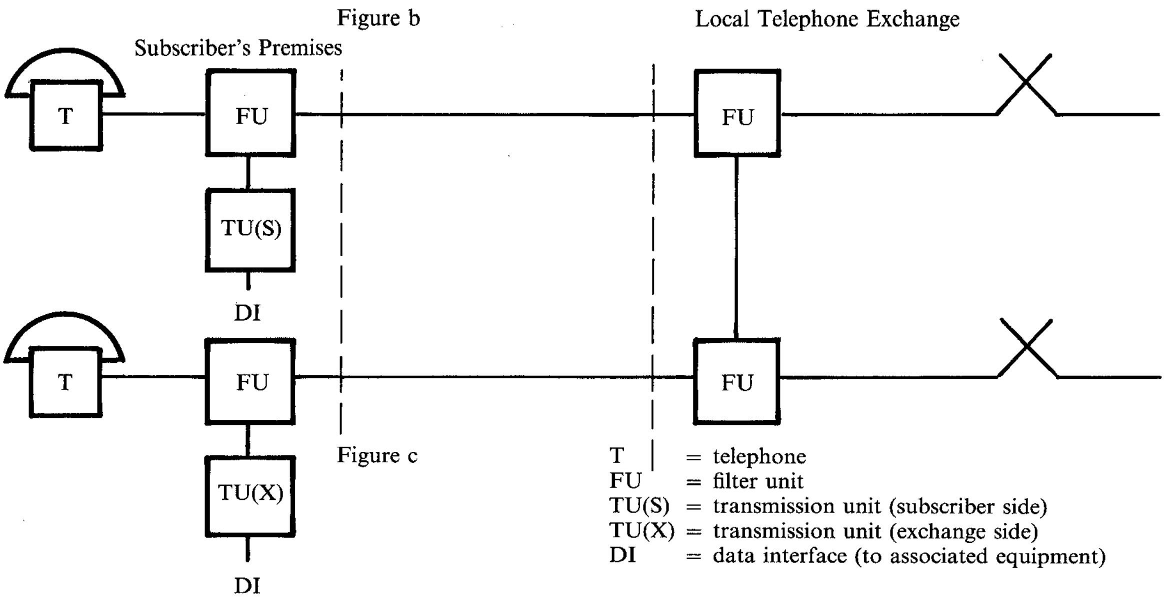


Figure c

T = telephone
FU = filter unit
TU(S) = transmission unit (subscriber side)
TU(X) = transmission unit (exchange side)
DI = data interface (to associated equipment)

*) In this configuration the risks to the privacy of the subscriber should be noted

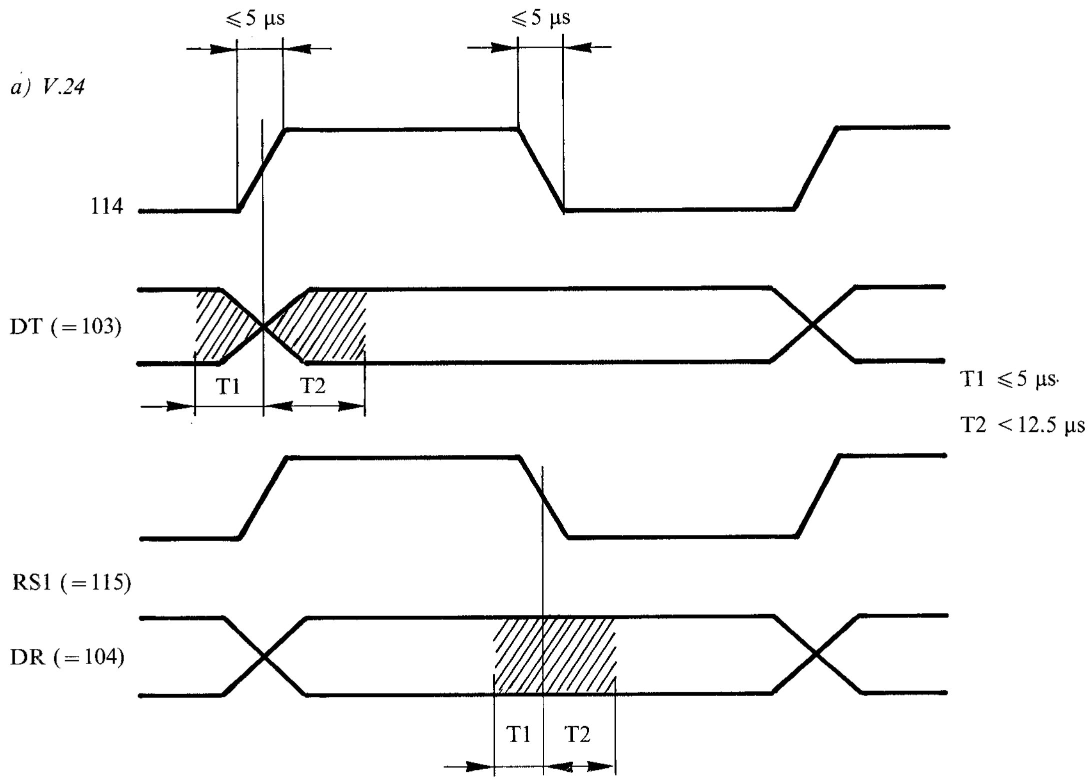
Appendix 2

Phase relationship between data and clock signals

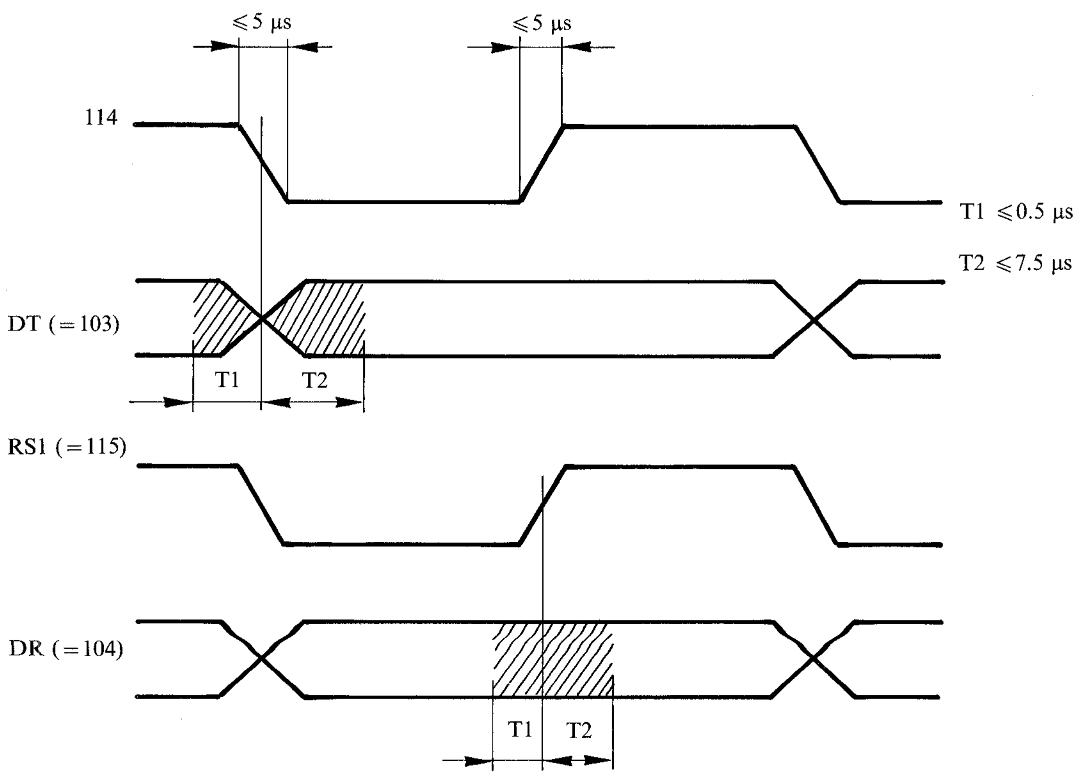
Values for a user data signalling rate up to 19.2 kbit/s.

Timing

a) V.24

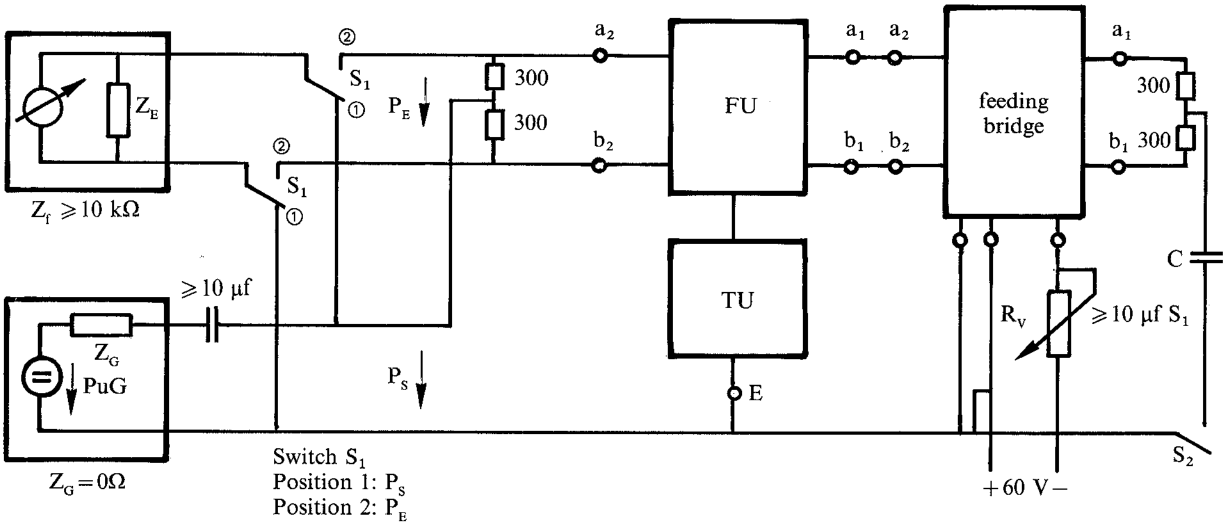


b) CMOS-TTL-compatible interface



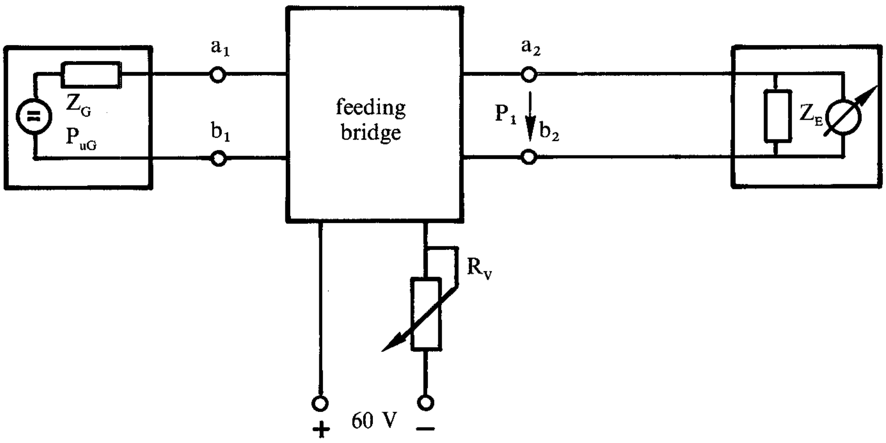
Appendix 3

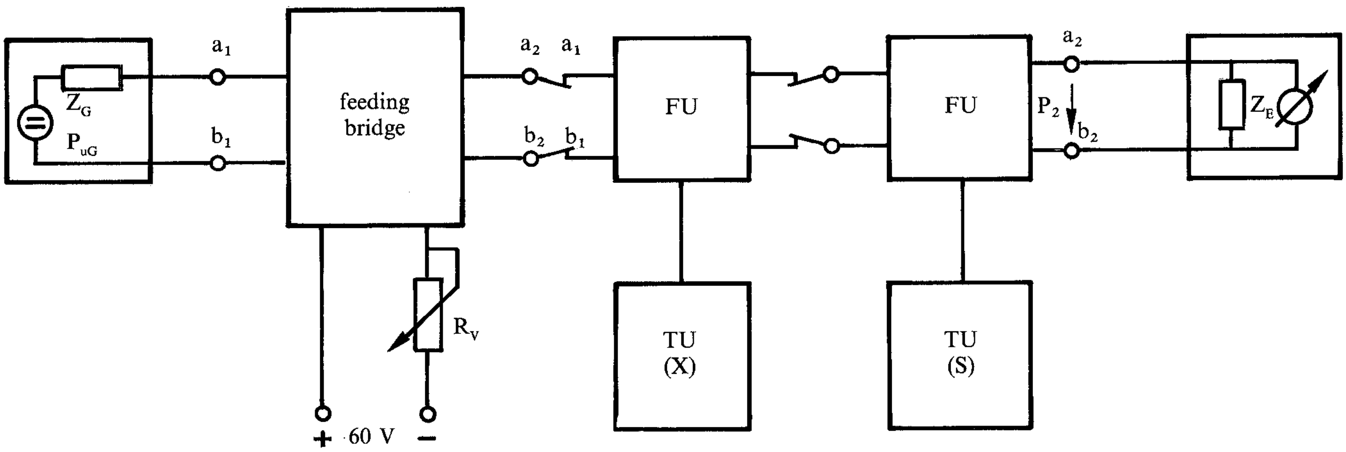
Balance to earth



Appendix 4

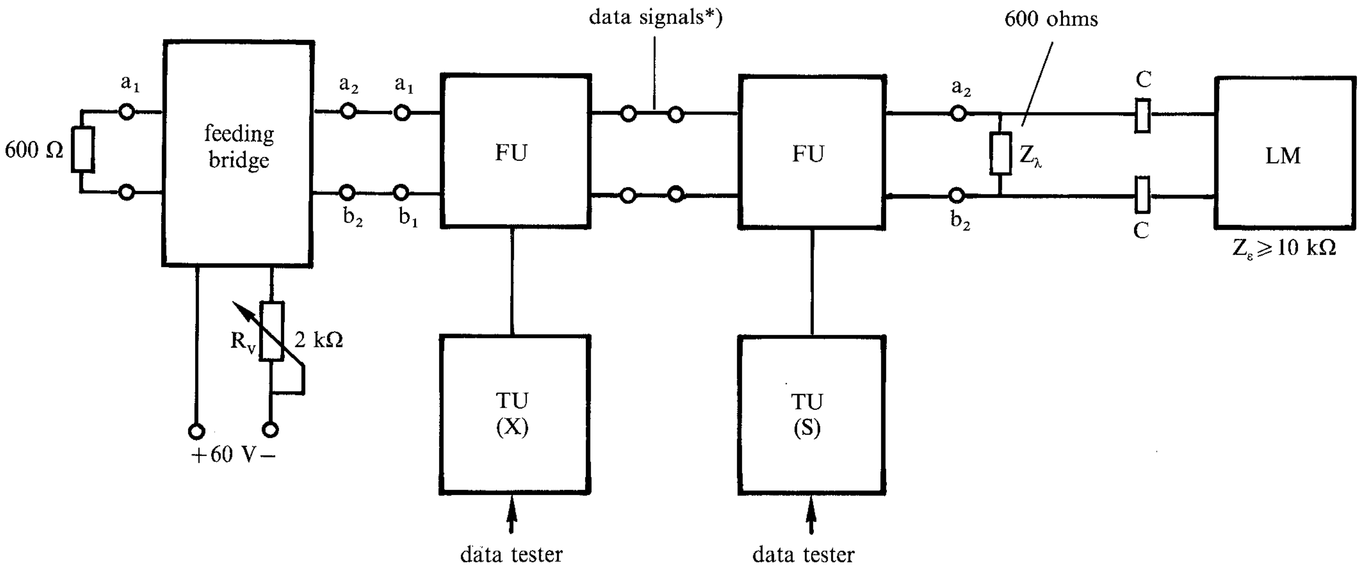
Insertion loss





Appendix 5

Interference signals

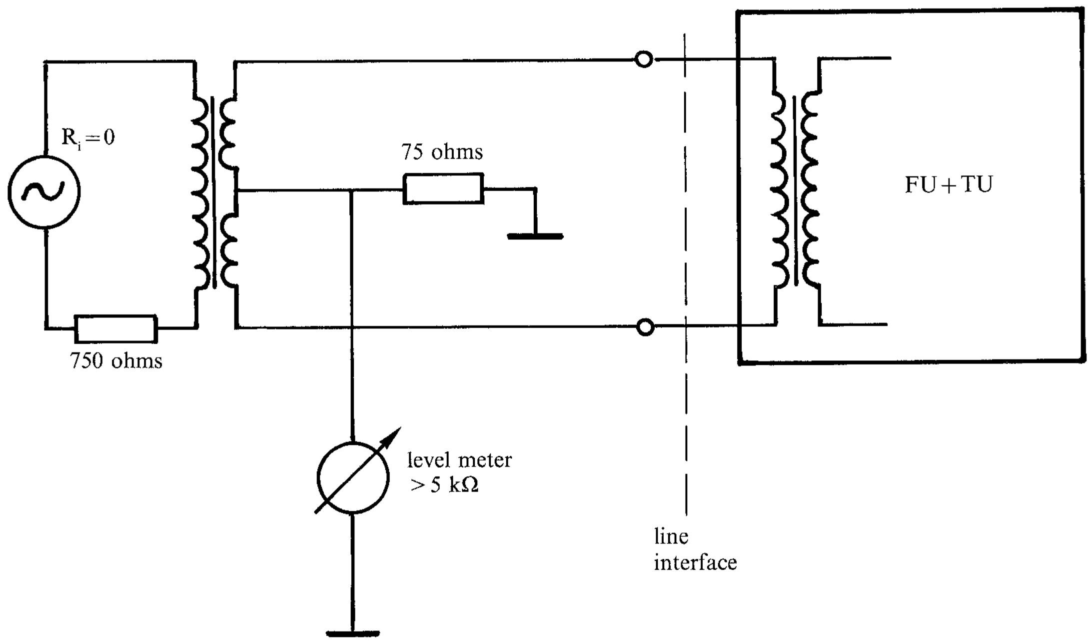


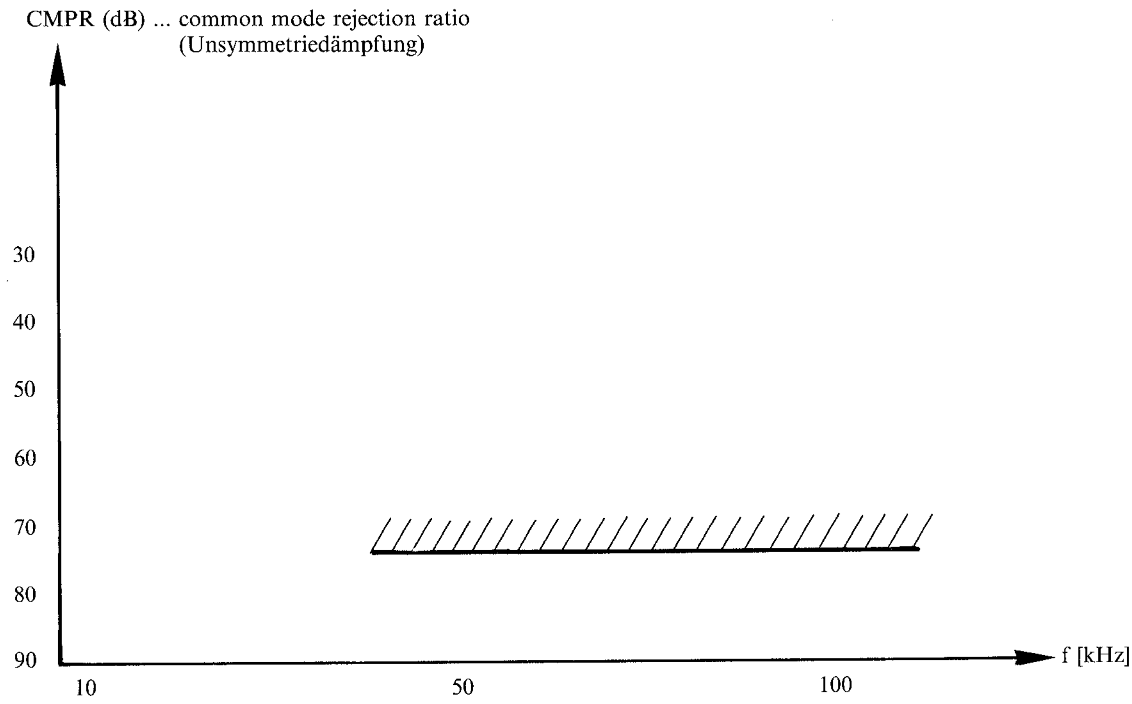
LM in measurement A-2.1.4.1. = psophometer
LM in measurement A-2.1.4.2. = selective level meter

*) with scrambler switched on

Appendix 6

Balance to earth measurement set-up

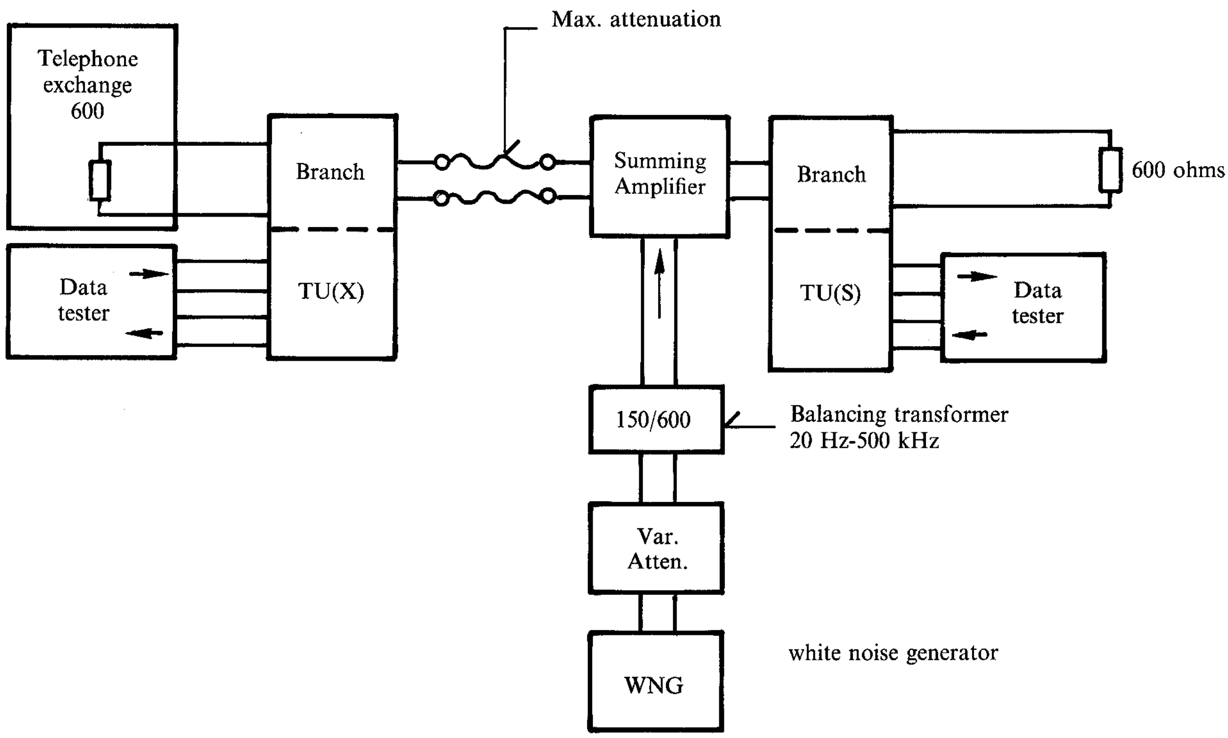




Appendix 7

Measurement set-up for the data channel

Measurement set-up:



Correction factor for the signal to noise ratio at different bandwidths:

$$\Delta\ (\mathrm{dB}) = 10\ \lg \frac{B_1}{B_2}$$

B_1 ... data signalling rate in bit/s

B_2 ... Alternative A: 100 kHz
Alternative B: 100 kHz

$$\frac{S}{N} + \Delta\ (\mathrm{dB}) = \left(\frac{S}{N}\right)_{min}$$

Appendix 8

Error detection and correction

Any transition in the low bit rate period indicates the occurrence of a transmission error.

Since there is a fixed relation between the first detected error and the errors due to the selfsynchronizing descrambler process (see Figure AP8-1 (T/CD 01-13)), only the first bit in error has to be located.

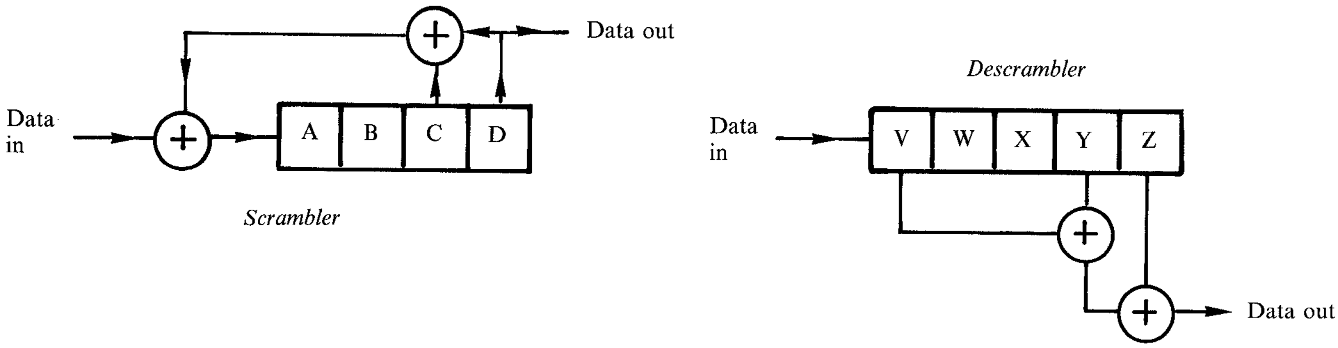
Localisation of the first bit in error

In paragraph A-2., a method for localisation of the first bit in error is described. This method has the limitation that for 9,600 bit/s only single bit errors can be detected (not all dibits in error can be corrected). For the lower user bit rates 4.8, 2.4 and 1.2 kbit/s this method has the capability also to detect adjacent bit in errors.
Further study on this subject is recommended.

Summary

This appendix presents some suggestions for improving the performance at low user bit rates; inclusion of such a technique is only justified if an improvement is required. Study of the behavior of errors (burst or single errors) is required before a particular method can be recommended.

Remark: If this technique is used in combination with an ARQ technique it will increase the throughput considerably. Bursts of errors are corrected by "ARQ", and correction of single errors will reduce the number of retransmissions.



Input signal	A	B	C	D	V	W	X	Y	Z								
0	1	1	1	1	1												
0	0	1	1	1	1	1											
0	0	0	1	1	1	1	1										
0	0	0	0	1	1	1	1	1									
1	1	0	0	0	0	1	1	1	1	0	0	0	1	1	1	1	0
1	1	1	0	0	0	0	1	1	1	0	0	0	0	1	1	1	0
1	1	1	1	0	0	0	0	1	1	0	0	0	0	0	1	1	0
1	0	1	1	1	1	0	0	0	1	0	1	1	0	0	0	1	0
1	1	0	1	1	1	1	0	0	0	1 error →	0	0	1	0	0	0	0x
1	1	1	0	1	1	1	1	0	0	1	1	1	0	1	0	0	1
1	0	1	1	0	0	1	1	1	0	1	0	0	1	0	1	0	1
1	0	0	1	1	1	0	1	1	1	1	1	1	0	1	0	1	0x
0	1	0	0	1	1	1	0	1	1	1	1	1	1	0	1	0	0x
0	1	1	0	0	0	1	1	0	1	1	0	0	1	1	0	1	1
0	0	1	1	0	0	0	1	1	0	1	0	0	0	1	1	0	1
0	1	0	1	1	1	0	0	1	1	1	1	1	0	0	1	1	1
0	0	1	0	1	1	1	0	0	1	0	1	1	1	0	0	1	0
0	1	0	1	0	0	1	1	0	0	0	0	0	1	1	0	0	0
0	1	1	0	1	1	0	1	1	0	0	1	1	0	1	1	0	0

x = changing of the output by more than a single edge per bit period is an indication for the occurrence of a bit error.

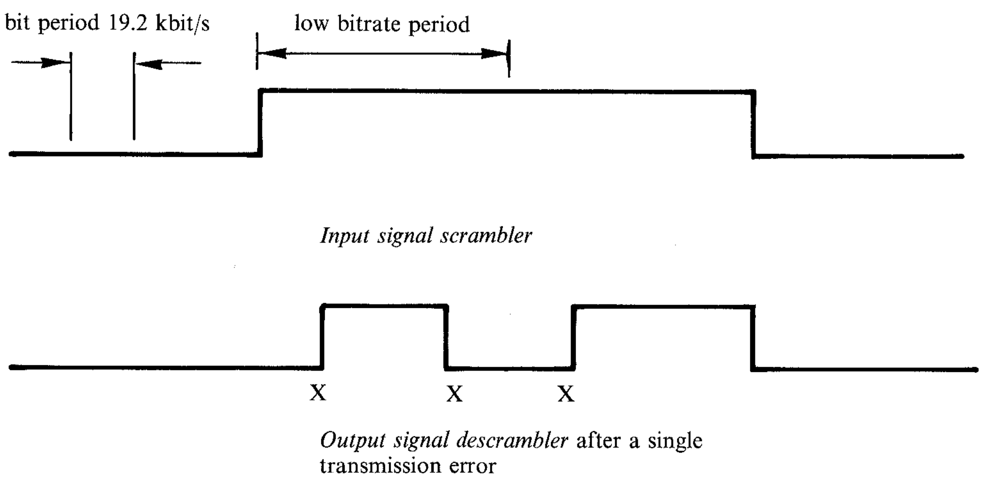


Figure AP8-1 (T/CD 01-13).

2. *Example of the localisation of the first bit in error for 9,600 bit/s*

Figure AP8-2 (T/CD 01-13) = transmitted signal
Figure AP8-3 (T/CD 01-13) = received signal with errors (case 1)
Figure AP8-4 (T/CD 01-13) = received signal with errors (case 2)

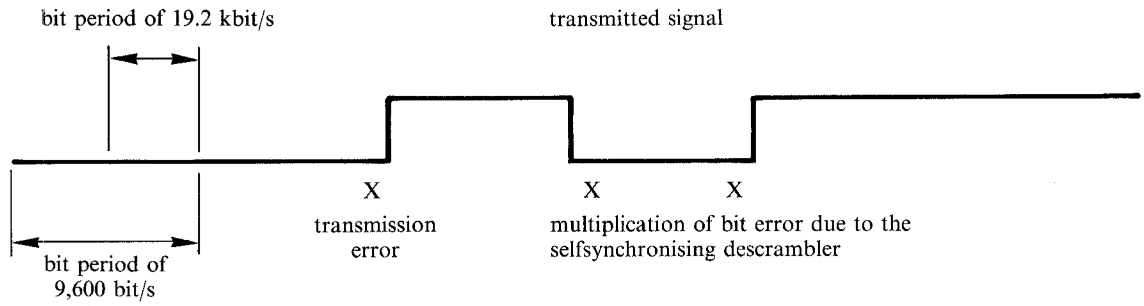


Figure AP8-2 (T/CD 01-13).

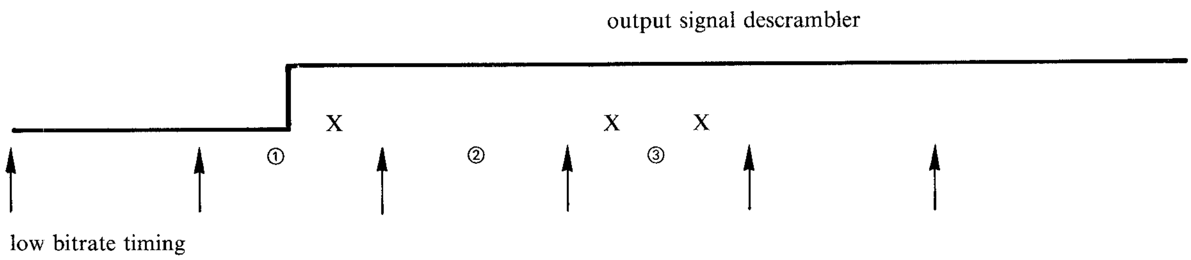


Figure AP8-3 (T/CD 01-13).

① Criterium for an error is an edge in the middle of a low bit rate period.

② Location of the first bit in error
If there is no edge in the third low bit rate period the last bit of ① is affected (see Figure AP8-3 (T/CD 01-13)).
If there is an edge in the ③ (the third low bit rate period) the first bit is affected (see Figure AP8-4 (T/CD 01-13)).

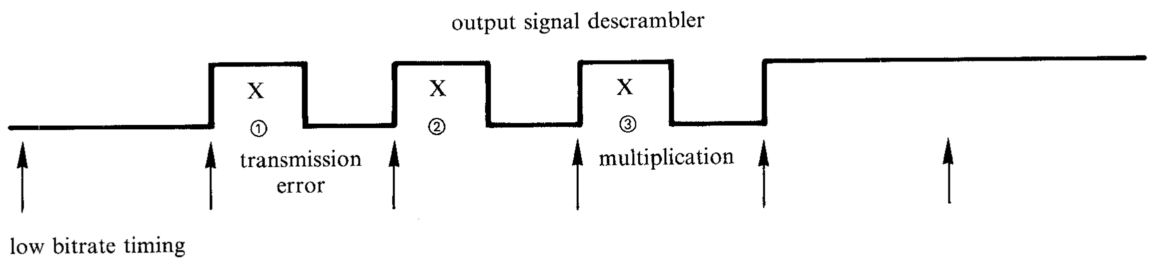


Figure AP8-4 (T/CD 01-13).

Appendix 9

Forward error correction for 2.4 kbit/s

Figure AP9-1 (T/CD 01-13) shows a simplified block diagram for the TU(S) including FU(S) and the additional components for dividing of the signalling rate on the line and the forward error correction.

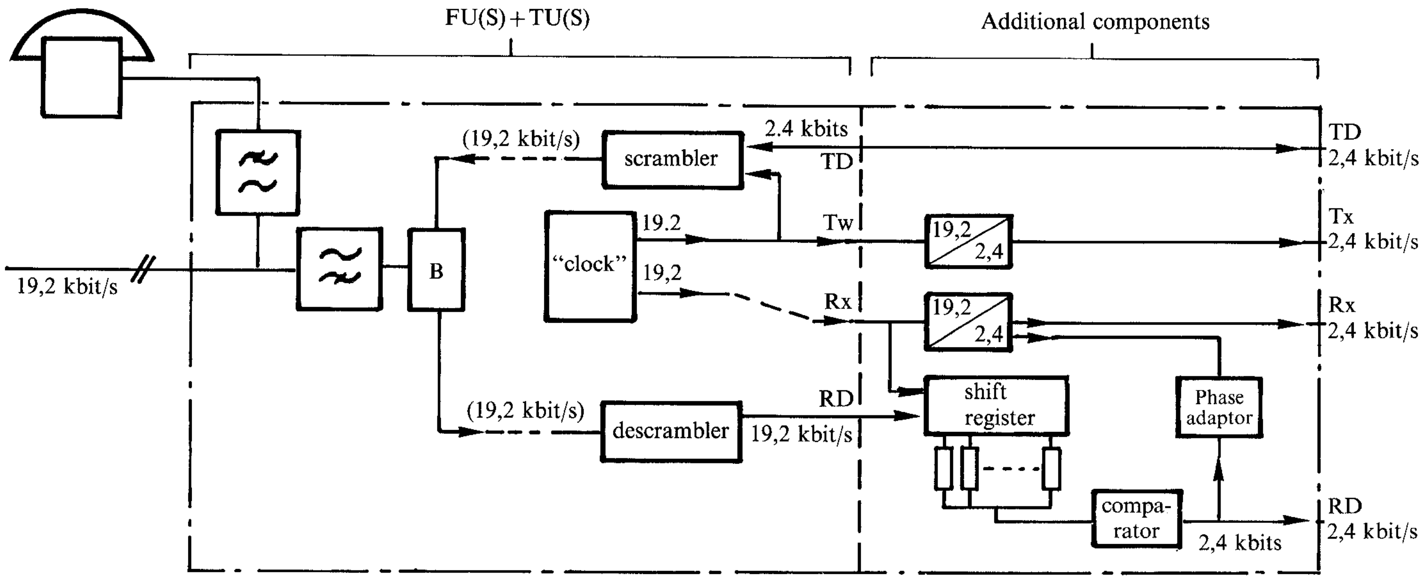


Figure AP9-1 (T/CD 01-13).

The forward error correction uses a majority decision of 5 to 3, i.e. if 1 bit error at 19.2 kbit/s occurs and will be increased by the descrambler in the TU(S) to 3 bit errors, this situation will be corrected.

Figure AP9-2 (T/CD 01-13) gives an example of 2 bits of a 2.4 kbit/s data stream, which are disturbed. This signal will be transmitted to the shift register with 19.2 kbit/s. After the comparator the 2 bits are correct again.

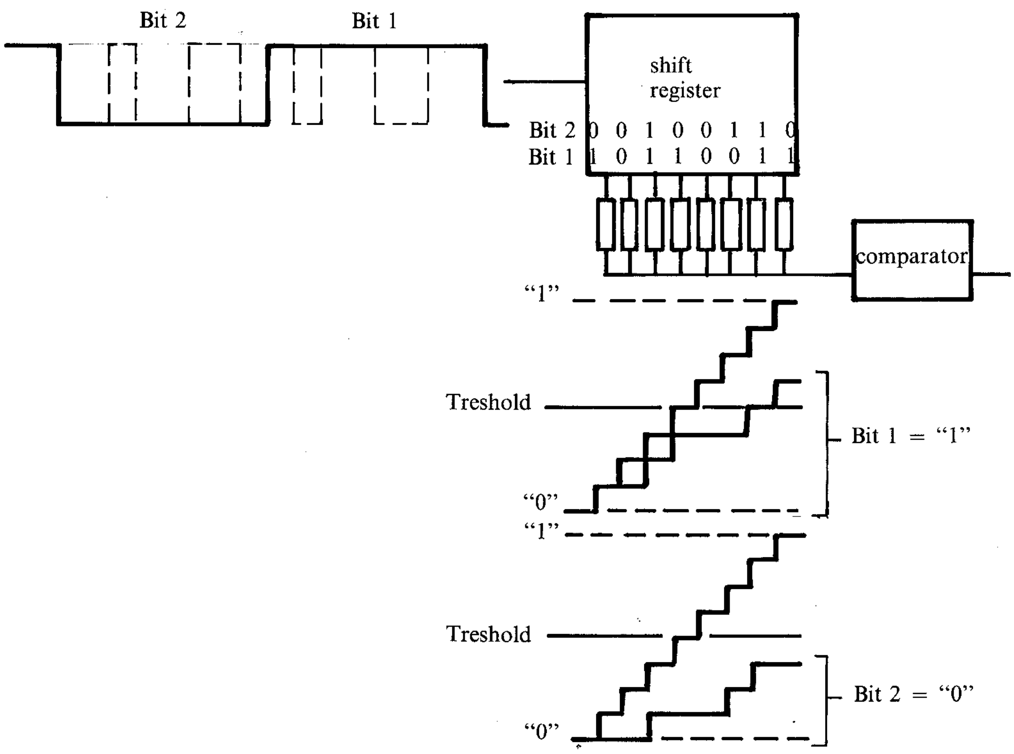


Figure AP9-2 (T/CD 01-13).

Appendix 10

Electromagnetic compatibility
(provisional values; submitted by the Nordic Countries)

1. INTRODUCTION

In an electromagnetically quiescent environment only thermal noise would impose limitations on the attainable signal-to-noise ratio in communication. In reality the electrical activity of the atmosphere and the activities of man give rise to disturbance factors of continuous and transient nature.

In order to ensure that communication equipment performs satisfactorily in its electromagnetic environment, i.e. possesses adequate Electro Magnetic Compatibility (EMC) properties, four conditions must be satisfied.
- The electromagnetic environment on the installation site must be known.
- Severities of testing must be stated which ensure that the equipment has sufficient immunity to the disturbances occurring in its environment.
- Limits must be imposed on the electromagnetic emission from the equipment in order to prevent impairment of the proper function of other equipment or systems.
- Methods of testing must be prescribed by means of which it may be ascertained whether the equipment complies with the requirements.

2. ENVIRONMENTAL CONDITIONS

The transmission unit and filter units of the voice plus data system are installed on subscriber's premises (subscriber side) as well as on switching centers (exchange side).

The electromagnetic environmental conditions are different on these locations. Subscriber's premises exhibit particularly varied environments being in urban or rural domestic areas or in areas of concentrated industry.

It is favourable to operate with one version of equipment regarding EMC performance. Expecting that a sizeable fraction of voice + data systems are installed on industrial sites—even switching centers (PABX) may be located on such sites—the present EMC specification shall be based upon the electromagnetic conditions in an industrial environment.

The electromagnetic environment is characterized by a number of parameters and their severities. Only parameters which are important for the performance are included, the parameters are treated as independent factors, and the severities stated for each parameter define levels of exposure which are rarely exceeded [1]. These "maximum" levels of exposure are designated characteristic severities in the tables below.

3. EMC SPECIFICATIONS. IMMUNITY [2]

Immunity to every conceivable disturbance irrespective of its severity leads to overspecification. Hence, the immunity tests are graded taking the probability of occurrence of the severities into account. It is recommended that tests are made according to the following graded performance requirements.

In order of increasing exposures the performance requirements are:
- *Normal performance* means that all specified performance requirements shall be fulfilled. The severity of testing is identical to the characteristic severity of the environment knowing that more severe conditions may occur in practice.
- *Intermittent function* means functional failure of short duration. Automatic recovery to normal performance is required following cease of exposure unless otherwise specified. Recalling the statistical nature of the environmental conditions it is clear that intermittent function must be expected and accepted in few cases.
- *Cease of function* means irreversible functional failure. Equipment or components may suffer permanent breakdown. Any damage or permanent malfunction must be confined to the exposed parts of the equipment [3].

The tables below state the environmental parameters arranged according to coupling path, their characteristic severities, the graded severities of testing, reference to test methods, remarks, and reference to related national or international standards.

4. EMC SPECIFICATIONS. EMISSION [4]

Emission from equipment must be limited in order to
— comply with national radio frequency interference regulations
— conserve the environmental conditions on which immunity requirements are based.

In both cases the limits depend on the general character of the installation site, being e.g. a dominantly domestic area or an area of industrial activity, depending on typical neighbour-to-neighbour distances and to the background noise level of the site.

The more severe limits apply to installation in domestic areas. The voice plus data system must comply with these limits since a large proportion of the systems will be used in such areas.

The tables below state the emission limits for the important parameters, refer to a test method, and refer to related standards. These references apply to test methods, not to limits.

Immunity requirements, conducted interference [2]

SIGNAL LINE TERMINALS

Environmental parameter		Unit	Charact. severity	Severities of testing			Test No.	Remarks	Ref. S
				Normal perf.	Interm. func.	Cease of func.			
DC common mode	Amplitude Impedance Duration	V ohm s	10; 500 100; 1M —	10 100 1 × 60	500 1 M 1 × 10	—	TE-1/1		TE 18 (DK)
$16\frac{2}{3}$ Hz (a common mode	Amplitude (rms)	V	50	50	100	—	TE-1/2	(a: Only applicable in N and S	
50 Hz common mode	Amplitude (rms) Impedance Duration	V ohm s	230; 650 (b — 600; 0.5	—	650 200 2 × 0.5/0.5	230 600; 10 1 × 900	TE-1/3	(b: 1,200 V/.2 s and 900 V/.35 s is accepted in SF	CCITT KY CCITT K20 TE 25 (DK)
50 Hz diff. mode	Amplitude (rms) Impedance Duration	V ohm s	230 — 600	—	—	230 600; 10 1 × 900	TE-1/4		TE 17 (DK)
Audio frequency common mode	Frequency Amplitude (rms)	kHz V	0.05 - 1 - 20 50 - 1.5 - 0.5	0.05 - 1 - 20 50 - 1.5 - 0.5	—	—	TE-1/5		TE 12 (DK)
Radio frequency common mode	Frequency Amplitude (rms) Modulation	MHz V —	0.02 - 1,000 5 —	0.02 - 300 5 80% at 1 kHz	0.02 - 300 20 80% at 1 kHz	—	TE-1/6		TE 05X (DK) CISPR/E (Secr) 27+28
Radio frequency bursts. Common & diff. mode	Amplitude (p) Frequency Repetition	kV MHz —	0.4 0.1 to 10 —	0.4 1.0 400 Hz in 2 s/2 s	1.0 1.0 400 Hz in 2 s/2 s	—	TE-1/7	Schaffner NSG 505 Haefely P3	8S 436 15 03 (S)
Transients commom mode	Amplitude (p) T_1/T_2 Repetition	kV μs/μs —	3; 1; 0.1 5 to 50/1,000 —	—	1 to 4 (c 10/700 5 × (+)+ 5 × (−)/10 s	4 (d 10/700 5 × (+)+ 5 × (−)/10 s	TE-1/8	(c: With agreed primary protection at 1 kV (d: Unprotected	CCITT KY CCITT K20 CCITT K17 TE 19 (DK)

Immunity requirements, conducted interference [2]

AC POWER LINE TERMINALS (230 V)

Environmental parameter		Unit	Charact. severity	Severities of testing			Test No.	Remarks	Ref. S
				Normal perf.	Interm. func.	Cease of func.			
Voltage variation	100 $\Delta U_o/U_n$	%	−10 to +10	−10 to +10	−20 to +20	—	TE-2/1	Veriac	TE 16 (DK)
Voltage deviation	100 $\Delta U/U_o$ Duration Rate of occur	% ms Per d	10; 25; >50 200; 100; 10 0.1; .05; .01	−25; +25 10×100 —	−50; +50 10×40 —	—	TE-2/2	Schaffner gen. NSG 203A	TE 08 (DK) 8S 436 15 03 (S)
Voltage interruption	Duration Rate of occur	ms Per d	10; 20; 100 50; 5; 0.5	10×20 —	10×200 —	—			
Radio frequency common mode	Frequency Amplitude (rms) Modulation	MHz V —	0.02 - 1,000 5 —	0.02 - 300 5 80% at 1 kHz	0.02 - 300 20 80% at 1 kHz	—	TE-2/3	RF-LISN	TE 06 (DK) CISPR/E (Secr) 27+28
Transient bursts common & diff. mode	Amplitude (p) T_1/T_2 Rep. freq. Duration Repetition	kV ns/ns kHz ms —	>0.5; 0.3; 0.2 10/50 — — —	2 5/50 5.0 15 ms/300 ms 10 s (+) +10 s (−)	4 5/50 2.5 15 ms/300 ms 10 s (+) +10 s (−)	—	TE-2/4	Schaffner gen. NSG 225 Haefely PB4	8S 436 15 03 (S) IEC 801-4
Transients common mode	Amplitude (p) T_1/T_2 Repetition	kV µs/µs —	10; 2 1/50 —	2 1/50 5×(+)+5 ×(−)/10 s	4 1/50 5×(+)+5 ×(−)/10 s	6 1/50 5×(+)+5 ×(−)/10 s	TE-2/5	Hybrid-generat. 1/50 open circ. 8/20 short circ.	IEC 801-5

Immunity requirements, conducted interference [2] [5]

DC POWER SUPPLY TERMINALS (48 V)

Environmental parameter		Unit	Charact. severity	Severities of testing			Test No.	Remarks	Ref. S
				Normal perf.	Interm. func.	Cease of func.			
Voltage variation	Voltage	V	40.5 to 57	40.5 to 57	—	—	TE-3/1	Variable DC-supply	CEPT T/TR 02-02 TE 20 (DK)
Voltage deviation	Voltage Duration Rate of occur	V ms Per y	0 to 40.5; 57 to 60 50 3	—	0 to 40.5; 57 to 60 1 × 50 —	—	TE-3/2	Schaffner gen. NSG 204	CEPT T/TR 02-02 TE 21 (DK)
Audio frequency common & diff. mode	Frequency Amplitude (rms)	kHz mV	0.025 - 0.1 - 1 - 20 200 - 200 - 7 - 7	0.025 - 0.1 - 1 - 20 200 - 200 - 7 - 7	0.025 - 0.1 - 1 - 20 800 - 800 - 30 - 30	—	TE-3/3	Generator impedance: 50 ohms in parallel with .3 ohms + 56 μH	CEPT T/TR 02-02 TE 22 (DK)
Radio frequency common & diff. mode	Frequency Amplitude (rms) Modulation	MHz mV —	0.02 - 0.15 - 100 7 - 50 - 50 —	0.02 - 0.15 - 100 7 - 50 - 50 80% at 1 kHz	0.02 - 0.15 - 100 150 - 1,000 - 1,000 80% at 1 kHz	—	TE-3/4	Generator impedance: 50 ohms in parallel with .3 ohms + 56 μH	CEPT T/TR 02-02 TE 23 (DK)
Radio frequency bursts. Common & diff. mode	Amplitude (p) Frequency Repetition	V MHz —	500 0.1 to 10 —	300 1 400 Hz in 2 s/2 s	1,000 1 400 Hz in 2 s/2 s	—	TE-3/5	Schaffner gen. NSG 505 Haefely P3	8S 436 15 03 (S)
Transients common & diff. mode	Amplitude (p) T_1/T_2 Rate of occur	V μs/μs Per y	200 5/100 < 3	100 1/50 —	400 1/50 —	—	TE-3/6	Schaffner gen. NSG 504	CEPT T/TR 02-02 TE 24 (DK)

Immunity requirements [2], radiated interference [6] and ESD

RADIATED INTERFERENCE

Environmental parameter		Unit	Charact. severity	Severities of testing			Test No.	Remarks	Ref. S
				Normal perf.	Interm. func.	Cease of func.			
Audio frequency magnetic field	Frequency Amplitude (rms)	kHz A/m	.05; .1 - 5 - 20 150 (a; 50 - .5 - .5	.05; 1 - 5 - 20 150; 50 - .5 - .5	0.05 350	—	TE-4/1	(a: May rise to 350 A/m for .1 s	KT-SCH-03 (SF) TE 01 (DK)
Audio frequency electric field	Frequency Amplitude (rms)	kHz V/m	0.05; 0.1 - 20 1,000; 50 - 2	0.05; 0.1 - 20 1,000; 50 - 2	—	—	TE-4/2		TE 02 (DK)
Radio frequency electromagnetic field, AM	Frequency Amplitude (p) Modulation	MHz V/m —	0.15 - 1,000 5 —	0.15 - 300 5 80% at 1 kHz	0.15 - 300 20 80% at 1 kHz	—	TE-4/3		KT-SCH-06 (SF) TE 01 (DK) IEC 801-3 CISPR/E (sec) 27
Radio frequency electromagnetic field, PM	Frequency Amplitude (p) Modulation	GHz V/m —	1 - 20 20 —	2.45 20 1 μs per ms	—	—	TE-4/4		TE 15 (DK)
Transient field	Amplitude (p) T_1/T_2 Repetition	A/m μs/μs —	50 5 to 50/50 to 500 —	25 5/50 5×(+)+5×(−)/10 s	50 5/50 5×(+)+5×(−)/10 s	—	TE-4/5		TVT 1025 202 (S)

ELECTROSTATIC DISCHARGE

Electrostatic discharge	Amplitude (p) Repetition	kV —	15	8 10×/1 s	15 1 0×/1s	20 10×/1s	TE-5/1		IEC 801-2

Emission requirements [4], **conducted and radiated** [6] interference

RADIATED EMISSION

Environmental parameter		Unit	Limit	Remarks	Ref. S
Audio frequency Magnetic field	Frequency Amplitude (rms) Distance	Hz mA/m m	50 - 500 - 20 000 10 - 1 - 1 1	Pick-up coll	DIN 45410
Radio frequency Electromagnetic field, broad band	Frequency Amplitude (rms) Bandwidth Distance	MHz dBµV/m kHz m	30 - 1000 25 120 10	Open air meas. site Half-wave dipole	CISPR publ. 14
Radio frequency Electromagnetic field, narrow band	Frequency Amplitude (rms) Bandwidth Distance	MHz dBµV/m kHz m	30 - 88 - 230 - 1000 15 - 15/20 - 20/30 - 30 <9 10	Open air meas. site Half-wave dpole	CISPR/B (c.o.) 16

CONDUCTED EMISSION, ALL LINES

Environmental parameter		Unit	Limit	Remarks	Ref. S
Radio frequency Common mode volt. Broad band	Frequency Amplitude (qp) Bandwidth	MHz — kHz	0.009 - 0.15 - 30; 30 - 300 52 - 28/44 - 44 dBµ; V; 35 - 45 dBpW 02; 9; 120	AMN and MDS-clamp	CISPR publ. 14 & 16
Radio frequency Common mode volt. Narrow band	Frequency Amplitude (qp) Bandwidth	MHz — kHz	0.15 - 0.5 - 5 - 30; 30 - 300 56 - 46 - 46/50-50 dBµV; 35 dBpW <9	AMN and MDS-clamp	CISPR/B (c.o.) 16 CISPR publ. 16

5. TEST METHODS

The purpose of testing is to provoke malfunction and reveal potential error mechanisms under controlled laboratory conditions. This is generally different from reproducing the actual environmental conditions.

In most cases test methods are under consideration (applies to refered test methods TE-1/1, TE-1/2, ... [2]. In cases where internationally recommended methods exist reference is made in the tables. The tables also suggest relevant test equipment. Here, a few general comments on the testing procedures shall be given.

In cases of common mode cw exposures measurements are made using a ground plane. The units are placed on insulating supports elevated 0.1 m above the groundbd plane. Units installed at great distance are tested with separate ground planes and with local earth connections. If units are tested on a single ground plane the inter connecting wires are also kept 0.1 m above the ground plane. The duration of CW tests must be sufficient to allow check of appropriate funcitons.

Coupling of disturbances into the data channel may be conveniently made by measures of the coupling "Tee" shown in Figure AP 10.1 (T/CD 01-13). Common or differential mode transient as well as cw voltages may be injected. With a generator impedance of 50 ohm the circuit maintains the filter termination impedance of 150 ohm at the data channel interface.

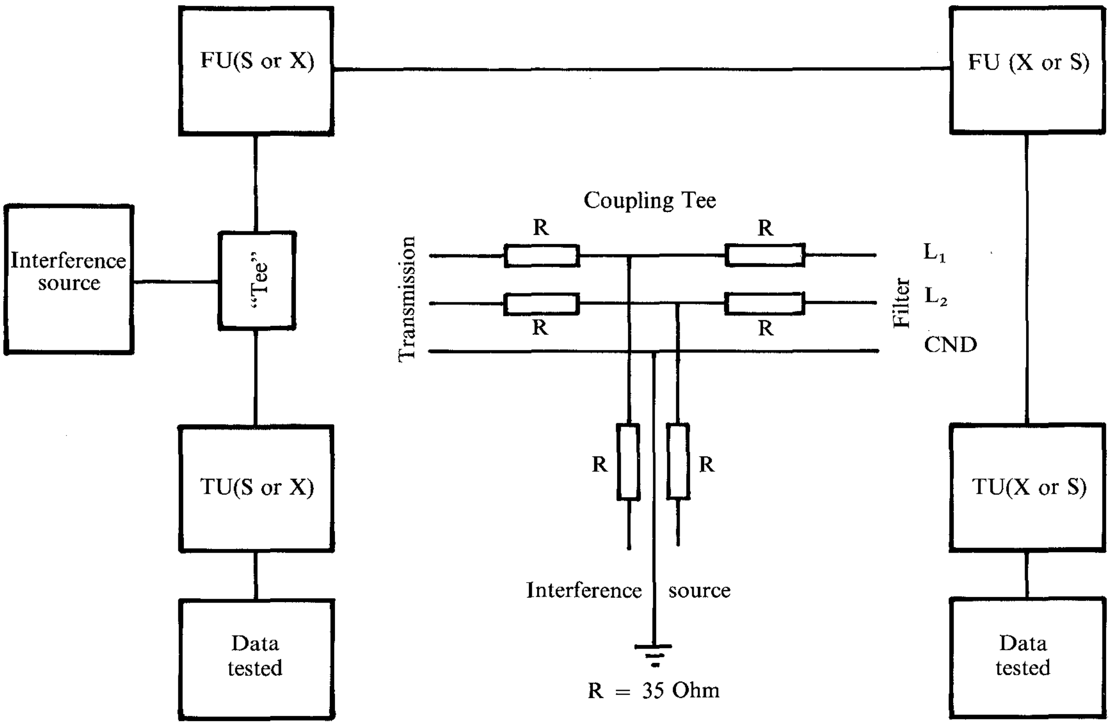


Figure AP10.1 (T/CD 01-13). Coupling to signal lines.

Coupling of disturbances into the line interface — typically common mode Radio Frequency interference picked up along the line — requires an LISN unit (LISN — Line Impedance Stabilization Network wich
— allows injection of a common mode disturbance
— has pass band(s) at the voice and data channels
— terminates the filter units with the appropriate impedance

The LISN unit has not yet been developed.

Coupling of disturbances via the live power supply terminals must be possible whether power being derived from the 230 V mains or the exchange battery. A backing filter is required which prevents the disturbing voltage from reaching other equipment sharing the power supply.

Common mode disturbances is injected into the 230 V mains between phase(s), neutral and ground plane. If the unit has protective ground this is connected to the ground plane. If the unit is operated without protective ground (class II) the equipment floats with respect to the ground plane.

6. NOTATION

Forced by the limited space available the notation used in the tables page 3 to 7 appears in somewhat condensed form. The meaning of the various elements are explained below.

6.1. Frequency dependence

f1 – f2 – f3	or	f1 – f2 – f3	or	f1 – f2
a1 – a2 – a3		a1 – a2/a'2 – a3		a

means that points (f_i a_i) are connected by straight lines in a doubly logaritmic plot.

The dash ("/") states a discontinuity (step) from a_i to a'_i at frequency f_i.

Where only one value "a" is stated this applies to the whole frequency interval f_1 to f_2.

6.2. Multiple values

If multiple values are assigned to a single parameter these values are separated by ";". Such values are co-ordinate, connected values of two or more parameters are vertically aligned.

6.3. Duration and repetition

The application of a transient exposure may be given by repetition frequency and duration/recovery time or number of applications x duration (/recovery time).

7. REFERENCES

[1] IEC publ 721-3-0: Classification of groups of environmental parameters and their severities. Introduction.

[2] Nordic Telecommunication Coordinating Committee. Specification NT/ENV-SPEC-SE4/2 (draft).

[3] CCITT com V Rec. KY (draft).

[4] Danish Telecommunication Council, Circular No. 32: "Environmental conditions". Spec. EE 21.1 (Preliminary specification).
Proposal to Danish Standard, The Danish Electrotechnical Commission: "Emission of narrow band interference from electrical equipment in the frequency range 0.15-1000 MHz".

[5] Recommandation T/TR 02-02 concerning the Rack/Telecommunications centre power supply interface.

[6] Limits to the Radiated Susceptibility and emission are currently studied by CEPT SWG TR2/GEA: HP TR02/08. Neither limits nor test methods have been established at present.