



INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

V.26 *ter*

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

DATA COMMUNICATION OVER THE TELEPHONE NETWORK

**2400 BITS PER SECOND DUPLEX MODEM
USING THE ECHO CANCELLATION
TECHNIQUE STANDARDIZED FOR USE ON
THE GENERAL SWITCHED TELEPHONE
NETWORK AND ON POINT-TO-POINT 2-WIRE
LEASED TELEPHONE-TYPE CIRCUITS**

ITU-T Recommendation V.26 *ter*

(Extract from the *Blue Book*)

NOTES

- 1 ITU-T Recommendation V.26 *ter* was published in Fascicle VIII.1 of the *Blue Book*. This file is an extract from the *Blue Book*. While the presentation and layout of the text might be slightly different from the *Blue Book* version, the contents of the file are identical to the *Blue Book* version and copyright conditions remain unchanged (see below).
- 2 In this Recommendation, the expression “Administration” is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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Recommendation V.26 *ter*

2400 BITS PER SECOND DUPLEX MODEM USING THE ECHO CANCELLATION TECHNIQUE STANDARDIZED FOR USE ON THE GENERAL SWITCHED TELEPHONE NETWORK AND ON POINT-TO-POINT 2-WIRE LEASED TELEPHONE-TYPE CIRCUITS

(Malaga-Torremolinos, 1984; amended at Melbourne, 1988)

The CCITT,

considering

(a) that there is a demand for data transmission at 2400 bit/s in the duplex mode on the general switched telephone network (GSTN) and on point-to-point 2-wire leased telephone-type circuits;

(b) that there will be a demand to have compatibility with higher data signalling rate duplex modems in the fall-back mode;

(c) that in this case the echo cancellation technique (ECT) is foreseen,

unanimously declares

the view that the characteristics of the modems for this service shall provisionally be as follows:

1 Introduction

This modem is intended for use on connections on the GSTN and on point-to-point 2-wire leased telephone-type circuits (see Note 1). Its principal characteristics are as follows:

- a) duplex mode of operation on the GSTN and point-to-point leased circuits,
- b) half-duplex mode of operation (optional) on the GSTN and point-to-point leased circuits (Note 2),
- c) channel separation by echo cancellation,
- d) differential phase-shift modulation for each channel with synchronous line transmission at 1200 baud (nominal),
- e) inclusion of a scrambler,
- f) inclusion of a compromise or adaptive equalizer,
- g) inclusion of test facilities,
- h) operation with data terminal equipment (DTE) in the following modes:
 - 2400 bit/s synchronous,
 - 1200 bit/s synchronous (fall-back rate),
 - 2400 bit/s start stop (optional),
 - 1200 bit/s start stop (optional) (fall-back rate),
- i) inclusion of an operating sequence intended to allow interworking with 2-wire duplex 4800 bit/s modem (which modem is for further study).

Note 1 - In certain countries the use of such a modem over the GSTN may not be allowed.

Note 2 - When the optional half-duplex mode of operation is used, provisions in § 7 shall supersede provisions given elsewhere in this Recommendation.

2 Line signals

2.1 Carrier frequency

The carrier frequency shall be 1800 ± 1 Hz. No separate pilot tones are provided.

2.2 Data line signal level

The power levels used will conform to Recommendation V.2.

2.3 Equalizer

If a fixed compromise equalizer is used, it shall be incorporated in the receiver. The characteristics of this equalizer may be selected by Administrations.

The possibility of producing compromise equalizer characteristics for international connections is for further study.

If an adaptive equalizer is used, it shall be able to converge on data signals at 2400 bit/s without a training sequence.

2.4 Spectrum and group-delay characteristics

A 100% raised cosine amplitude spectrum shaping is equally divided between the receiver and transmitter. The energy density at 1200 Hz and 2400 Hz shall be attenuated $3.0 \text{ dB} \pm 2.0 \text{ dB}$ with respect to the maximum energy density between 1200 Hz and 2400 Hz.

The group-delay of the transmit filters shall be within ± 100 microseconds over the frequency range 1200-2400 Hz.

2.5 Modulation

2.5.1 Data signalling rates

The data signalling rate transmitted to line shall be 2400 bit/s or 1200 bit/s $\pm 0.01\%$ with a modulation rate of 1200 baud $\pm 0.01\%$.

2.5.2 Encoding of data bits

2.5.2.1 2400 bits per second

At 2400 bit/s the data stream is divided into groups of two bits (dibits). Each dibit is encoded as a phase change relative to the phase of the immediately preceding signal element (see Table 1/V.26 *ter*). At the receiver, the dibits are decoded and reassembled in the correct order. The left-hand digit of the dibit is the one occurring first in the data stream as it enters the modulator portion of the modem after the scrambler.

TABLE 1/V.26 *ter***Line encoding at 2400 bit/s**

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

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.

2.5.2.2 *1200 bits per second*

At 1200 bit/s each bit shall be encoded as a phase change relative to the phase of the preceding signal element (see Table 2/V.26 *ter*).

TABLE 2/V.26 *ter***Line encoding at 1200 bit/s**

Bit values	Phase change (see Note)
0	0°
1	180°

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.

2.6 *Received signal frequency tolerance*

The receiver shall be able to operate with frequency offsets in the signal received from the other modem of up to ± 7 Hz.

2.7 *Synchronizing signals*

Synchronizing signals are used in the operating sequence and in the half-duplex mode (see §§ 6.3 and 7). The synchronizing signals, for both data signalling rates, are divided into two segments as follows:

2.7.1 The composition of segment 1 is continuous 180° phase reversals for 32 symbol intervals.

2.7.2 Segment 2 is a pattern derived by scrambling binary ones with the scramblers defined in § 5. The length of the pattern is 64 bits (32 symbol intervals) for 2400 bit/s and 64 bit/s (64 symbol intervals) for 1200 bit/s. The patterns are defined in Table 3/V.26 *ter*. See also Appendix I.

TABLE 3/V.26 *ter*

Data signalling rate	Srambler (see § 5)	Segment 2 phase changes (in degrees)
2400 bit/s	GPC	0, 180, 180, 180, 180, 0, 0, 0, 0, 180, 180, 270, 90, 180, 0, 0, 90, 180, 0 . . .
2400 bit/s	GPA	0, 180, 180, 180, 180, 0, 0, 0, 0, 180, 180, 270, 90, 180, 0, 180, 180, 270, 0 . . .
1200 bit/s	GPC	0, 0, 180, 180, 180, 180, 180, 180, 180, 180, 0, 0, 0, 0, 0, 0, 0, 0, 180, 180, 180, 180, 180, 0, 0, 180, 180, 180, 0, 0, 0, 0, 0, 180, 180, 180 . . .
1200 bit/s	GPA	0, 0, 180, 180, 180, 180, 180, 180, 180, 180, 180, 0, 0, 0, 0, 0, 0, 0, 0, 180, 180, 180, 180, 180, 0, 0, 180, 180, 180, 0, 0, 180, 180, 180, 0, 0, 180, 180, 0, 180, 0 . . .

3 Interchange circuits

3.1 Essential and optional interchange circuits

These are listed in Table 4/V.26 *ter*.

TABLE 4/V.26 *ter*

Interchange circuit (see Note 1)		Notes
No.	Designation	
102	Signal ground or common return	
103	Transmitted data	
104	Received data	
105	Request to send	
106	Ready for sending	
107	Data se ready	
108/1 or	Connect data set to line	2
108/2	Data terminal ready	2
109	Data channel received line signal detector	
111	Data signalling rate selector (DTE source)	3
112	Data signalling rate selector (DCE source)	
113	Transmitter signal element timing (DTE source)	
114	Transmitter signal element timing (DCE source)	5
115	Receiver signal element timing (DCE source)	5
125	Calling indicator	6
140	Loopback/maintenance test	
141	Local loopback	
142	Test indicator	

Note 1 - All essential interchange circuits and any others which are provided shall comply with the functional and operational requirements of Recommendation V.24. All interchange circuits provided shall be properly terminated in the data terminal equipment and in the data circuit-terminating equipment in accordance with the appropriate Recommendation for electrical characteristics (see § 3.5).

Note 2 - This circuit shall be capable of operation as circuit 108/1 or circuit 108/2 depending on its use.

Note 3 - This circuit is optional.

Note 4 - When the modem is not operating in a synchronous mode at the interface, any signals on circuit 113 shall be disregarded. Many DTEs operating in an asynchronous mode do not have a generator connected to this circuit.

Note 5 - When the modem is not operating in a synchronous mode, this circuit shall be clamped to the OFF condition. Many DTEs operating in an asynchronous mode do not terminate this circuit.

Note 6 - This circuit is for use with the general switched telephone network only.

3.2 *Circuit 106 response times (see Table 5/V.26 ter)*

Circuit 106 response times are from the application of an ON or OFF condition on circuit 105. See also § 6.3 for conditions of circuit 106 during the operating sequence.

TABLE 5/V.26 ter

	Constant carrier
<i>Circuit 106</i>	
OFF to ON	≤ 2 ms
ON to OFF	≤ 2 ms

3.3 *Threshold and response times of circuit 109*

3.3.1 *Threshold*

The level of received line signal at the receive line terminals of the modem for all types of connections, i.e. the general switched telephone network or non-switched 2-wire leased telephone type circuits, is:

- greater than -43 dBm: circuit 109 ON
- less than -48 dBm: circuit 109 OFF

Where transmission conditions are known and allowed, it may be desirable at the time of modem installation to change these response levels of the received line signal detector to less sensitive values (e.g. -33 dBm and -38 dBm respectively).

In addition, for use over special quality leased circuits (see Recommendation M.1020) the response levels of the received line signal detector shall be:

- greater than -26 dBm: circuit 109 ON
- less than -31 dBm: circuit 109 OFF