INTERNATIONAL TELECOMMUNICATION UNION

ITU-T V.22 *bis*

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

DATA COMMUNICATION OVER THE TELEPHONE NETWORK

2400 BITS PER SECOND DUPLEX MODEM USING THE FREQUENCY DIVISION 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.22 *bis*

(Extract from the *Blue Book*)

NOTES

1 ITU-T Recommendation V.22 *bis* 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.

Recommendation V.22 *bis*

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

(Malaga-Torremolinos, 1984; and al Melbourne, 1988)

The CCITT,

considering

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

(b) that there is a demand to have the fall-back mode compatibility with modems in accordance with Recommendation V.22;

(c) that in this case the frequency division technique shall be used,

(unanimously) declares

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

1 Introduction

These modems are intended for use on connections on the GSTN and on point-to-point 2-wire leased telephone-type circuits (see Note). The principal characteristics of these modems are as follows:

a) duplex mode of operation on the GSTN and point-to-point leased circuits,

b) channel separation by frequency division,

c) quadrature amplitude modulation for each channel with synchronous line transmission at 600 baud (nominal),

d) inclusion of a scrambler,

e) inclusion of an adaptive equalizer and a compromise equalizer,

f) inclusion of test facilities,

g) data signalling rates of:

2400 bit/s synchronous,

2400 bit/s start-stop,

1200 bit/s synchronous,

1200 bit/s start-stop,

h) it is compatible with a V.22 modem operating in Modes i) or ii) at the 1200 bit/s signalling rate and includes automatic bit rate recognition.

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

2 Line signals

2.1 *Carrier and guard tone frequencies*

The carrier frequencies shall be 1200 ± 0.5 Hz for the low channel and 2400 ± 1 Hz for the high channel. A guard tone of 1800 ± 20 Hz, to be transmitted only when the modem is transmitting in the high channel, may be disabled as a national option. An alternative guard tone of 550 ± 20 Hz, to be transmitted only when the modem is transmitting in the high channel, may be incorporated as a national option.

2.2 *Data and guard tone line signal levels*

The 1800 Hz or 550 Hz guard tones shall be levels 6 ± 1 dB or 3 ± 1 dB, respectively, below the level of the data signal power in the high channel. Because of the 1800 Hz guard tone, the power level of data signals in the high channel will be approximately 1 dB lower than that of data signals in the low channel.

2.3 *Fixed compromise equalizer*

Fixed compromise equalization shall be incorporated in the modem transmitter.

2.4 *Spectrum and group delay characteristics*

The transmitted line signals, excluding the characteristics of the fixed compromise equalizer, shall have a frequency amplitude spectrum equivalent to the square root of a raised cosine shaping with 75% roll-off and within the limits shown in Figure 1/V.22 *bis.* Similarly, the group delay of the transmitter output shall be within the range of ± 150 microseconds over the frequency ranges 900-1500 Hz (low channel) and 2100-2700 Hz (high channel). These figures are provisional.

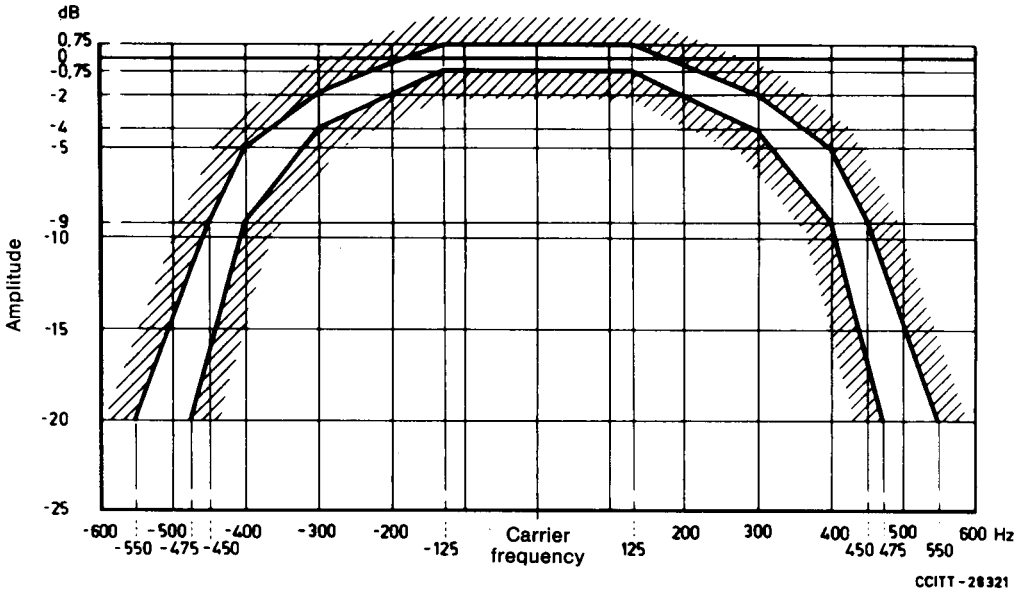


FIGURE 1/V.22 *bis*

Amplitude limits for transmitted line signal (unequalized)

2.5 *Modulation*

2.5.1 *Data signalling rates*

The data rate transmitted to line shall be 2400 bit/s or 1200 bit/s ± 0.01% with a modulation rate of 600 baud ± 0.01%.

2.5.2 *Encoding of data bits*

2.5.2.1 *2400 bits per second*

The data stream to be transmitted shall be divided into groups of 4 consecutive bits (quadbits). The first two bits of a quadbit shall be encoded as a phase quadrant change relative to the quadrant occupied by the preceding signal element. (See Figure 2/V.22 *bis* and Table 1/V.22 *bis.)*

The last two bits of each quadbit define one of 4 signalling elements associated with the new quadrant (see Figure 2/V.22 *bis).* The left hand bits in Table 1/V.22 *bis* and Figure 2/V.22 *bis* are the first of each pair in the data stream as it enters the modulator portion of the modem after the scrambler.

TABLE 1/V.22 *bis*

Line encoding

First two bits in quabit (2400 bit/s) or dibit values (1200 bit/s)	Phase quadrant change	
00	1→ 2 2→ 3 3→ 4 4→ 1	90°
01	1→ 1 2→ 2 3→ 3 4→ 4	0°
11	1→ 4 2→ 1 3→ 2 4→ 3	270°
10	1→ 3 2→ 4 3→ 1 4→ 2	180°

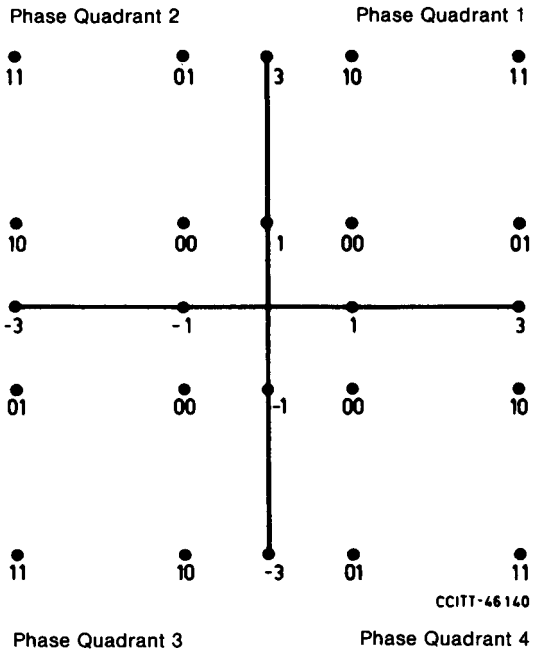


FIGURE 2/V.22 *bis*

Signal constellation

2.5.2.2 *1200 bits per second*

The data stream to be transmitted shall be divided into groups of 2 consecutive bits (dibits). The dibits shall be encoded as a phase quadrant change relative to the quadrant occupied by the preceding signal element (see Table 1/V.22 *bis).* The signalling elements corresponding to 01 in the signal constellation (Figure 2/V.22 *bis)* shall be transmitted irrespective of the quadrant concerned. This ensure compatibility with Recommendation V.22.

2.6 *Received signal frequency tolerance*

The receiver shall be able to operate with received frequency offsets of up to ± 7 Hz.

3 Interchange circuits

3.1 *Essential and optional interchange circuits*

These are listed in Table 2/V.22 *bis.*

3.2 *Circuits 106 and 109 response times*

After the handshaking sequences, circuit 106 will follow OFF to ON or ON to OFF transitions of circuit 105 within 3.5 ms. The OFF to ON transition of circuit 109 is part of the handshake sequence specified in § 6. Circuit 109 shall turn OFF 40 to 65 ms after the level of the received signal appearing at the line terminal of the modem falls below the relevant threshold defined in § 3.3. In the fall-back mode, the response time may be reduced to a value in the 10 to 24 ms range specified in Recommendation V.22. Following a dropout, after the initial handshake, circuit 109 shall turn ON 40 to 205 ms after the level of the received signal appearing at the line terminal of the modem exceeds the relevant threshold defined in § 3.3.

3.3 *Circuit 109 threshold*

High channel threshold:

- greater than -43 dBmcircuit 109 ON

- less than -48 dBmcircuit 109 OFF

Low channel threshold:

- greater than -43 dBmcircuit 109 ON

- less than -48 dBmcircuit 109 OFF

The condition of circuit 109 between the ON and OFF levels is not specified except that the signal detector shall exhibit a hysteresis action, such that the level at which the OFF to ON transition occurs shall be at least 2 dB greater than that for the ON to OFF transition.

Circuit 109 thresholds are specified at the input to the modem when receiving scrambled binary 1.

Administrations are permitted to change these thresholds where transmission conditions are known.

Circuit 109 shall not respond to the 1800 Hz or the 550 Hz guard tones, or the 2100 Hz (nominal) answer tone during the handshake sequence.

3.4 *Circuit 111 and data rate control*

Data rate selection may be by switch (or similar means) or by circuit 111 or a combination of both.

The ON condition on circuit 111, where provided, shall select 2400 bit/s operation and the OFF condition shall select 1200 bit/s operation.

TABLE 2/V.22 *bis*

Interchange circuit (Note 1)

Interchange circuit		Notes
No.	Description	
102	Signal ground or common return	
103	Transmitted data	
104	Received data	
105	Request to send	Note 2
106	Ready for sending	
107	Data set ready	
108/1	Connect data set to line	Note 3
108/2	Data terminal ready	Note 3
109	Data channel received line signal detector	
111	Data signalling rate selector (DTE source)	Note 4
112	Data signalling rate selector (DCE source)	
113	Transmitter signal element timing (DTE source)	Note 5
114	Transmitter signal element timing (DCE source)	Note 6
115	Receiver signal element timing (DCE source)	Note 6
125	Calling indicator	Note 7
140	Loopback/maintenance test	
141	Local loopback	
142	Test indicator	

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

Note 2 - Some automatic calling equipments are designed to emit a calling tone to line by turning ON circuit 105 to the calling modem. The general switched telephone network (GSTN) constant carrier handshake is such that no calling tone will be emitted by the V.22 *bis* modem when used with these equipments.

Note 3 - This circuit shall be capable of operation as circuit 108/1 or 108/2 depending on its use.

Note 4 - This circuit is optional.

Note 5 - When the modem is not operating in a synchronous mode at the interface, any signals on this circuit shall be disregarded. Many DTEs operating in an asynchronous mode do not have a generator connected to this circuit.

Note 6 - When the modem is not operating in a synchronous mode at the interface, this circuit shall be clamped to the OFF condition. Many DTEs operating in an asynchronous mode do not terminate this circuit.

Note 7 - This circuit is for use with the general switched telephone network only.

3.5 *Electrical characteristics of interchange circuits*

3.5.1 Use of electrical characteristics conforming to Recommendation V.28 is recommended together with the connector and pin assignment plan specified by ISO 2110.

Note - Manufacturers may wish to note that the long-term objective is to replace electrical characteristics specified in Recommendation V.28, and that Study Group XVII has agreed that the work shall proceed to develop a more efficient, all-balanced, interface for the V-Series application which minimizes the number of interchange circuits.

3.6 *Fault condition of interchange circuits*

See Recommendation V.28, § 7 for association of the receiver failure detection types.)

3.6.1 The DTE should interpret a fault condition on circuit 107 as an OFF condition using failure detection type 1.

3.6.2 The DCE should interpret a fault condition on circuits 105 and 108 as an OFF condition using failure detection type 1.

3.6.3 All other circuits not referred to above may use failure detection types 0 or 1.

4 Modes of operation

The modem can be configured for the following modes of operation:

Mode 1 2400 bit/s ± 0.01% synchronous

Mode 2 2400 bit/s start-stop 8, 9, 10 or 11 bits per character

Mode 3 1200 bit/s ± 0.01% synchronous

Mode 4 1200 bit/s start-stop 8, 9, 10 or 11 bits per character.

4.1 *Transmitter*

4.1.1 In the synchronous modes of operation, the modem shall accept synchronous data from the DTE on circuit 103 under control of circuit 113 or circuit 114. The data shall then be scrambled in accordance with § 5 and then passed to the modulator for encoding in accordance with § 2.5.

4.1.2 In the start-stop modes, the modem shall accept a data stream of start-stop characters from the DTE at a nominal rate of 2400 or 1200 bits per second. The start-stop data to be transmitted shall be converted in conformity with Recommendation V.14 to a synchronous data stream suitable for transmission in accordance with § 4.1.1

4.2 *Receiver*

Demodulated data shall be decoded in accordance with § 2.5.2, then descrambled in accordance with § 5.2 and then passed to the converter in conformity with Recommendation V.14 for regaining the data stream of start-stop characters.

The intracharacter signalling rate provided to the DTE over circuit 104 shall be in the ranges given in Table 3/V.22 *bis* when operating in the basic or in the extended signalling rate ranges, respectively.

TABLE 3/V.22 *bis*

Intracharacter signalling rate range

Data rate	Signalling rate range	
	Basic	Extended
2400 bit/s 1200 bit/s	2400 to 2424 bit/s 1200 to 1212 bit/s	2400 to 2455 bit/s 1200 to 1227 bit/s

5 Scrambler and descrambler

5.1 *Scrambler*

A self synchronizing scrambler having the generating polynomial $1 \oplus x^{-14} \oplus x^{-17}$ shall be included in the modem transmitter. The message data sequence applied to the scrambler shall be effectively divided by the generating polynomial. The coefficients of the quotients of this division, taken in descending order, form the data sequence which shall appear at the output of the scrambler. The scrambler output data sequence shall thus be:

$$D_s = D_i \oplus D_s \cdot x^{-14} \oplus D_s \cdot x^{-17}$$

where

D_S is the data sequence at the output of the scrambler

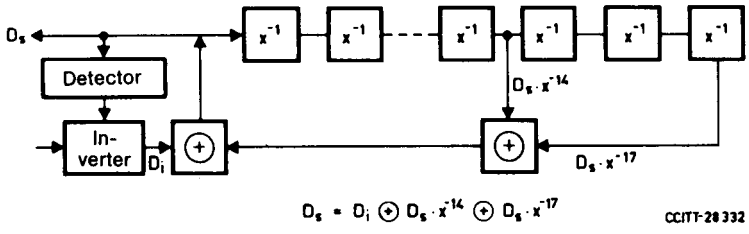
D_i is the data sequence applied to the scrambler

$\oplus$ denotes module 2 addition

. denotes binary multiplication.

Figure 3/V.22 *bis* shows a suitable implementation.

To prevent occasional inadvertent instigation of remote loop 2 caused by scrambler lockup, circuitry shall be included to detect a sequence of 64 consecutive ones at the scrambler output (D_S) and, if detected, invert the next input to the scrambler (D_i) and reset the counter of 64 consecutive ones. This circuitry shall operate whenever the scrambler is operational. No scrambler initialization is required during the handshake or retrain sequence.



Note – Marks (binary 1) and spaces (binary 0) at the V. 24 interface correspond to ones and zeros, respectively, in this logic diagram.

FIGURE 3/V.22 *bis*

Scrambler

5.2 *Descrambler*

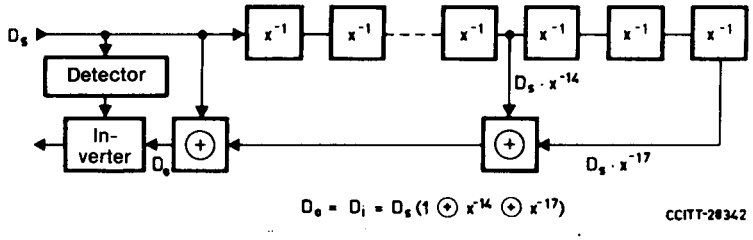
A self synchronizing descrambler having the polynomial $1 \oplus x^{-14} \oplus x^{-17}$ Shall be provided in the modem receiver. The message data sequence produced after demodulation shall be effectively multiplied by the generating polynomial $1 \oplus x^{-14} \oplus x^{-17}$ to form the descrambled message. The coefficients of the recovered message sequence taken in descending order form the output data sequence D_o which is given by

$$D_o = D_s (1 \oplus x^{-14} \oplus x^{-17})$$

where the notation is as defined in § 5.1.

Circuitry may be included to detect a sequence of 64 consecutive ones at the input to the descrambler (D_S) and, if detected, invert the next output from the descrambler (D_O) This detector shall operate whenever the descrambler is operational.

Figure 4/V.22 *bis* shows a suitable implementation.



Note – Marks (binary 1) and spaces (binary 0) at the V. 24 interface correspond to ones and zeros, respectively, in this logic diagram.

FIGURE 4/V.22 *bis*

Descrambler

6 Operating sequences

6.1 *Channel allocation and signalling rate selection*

6.1.1 *GSTN*

On the general switched telephone network, the modem at the calling data station shall transmit in the low channel and receive in the high channel (call mode). The modem at the answering data station shall receive in the low channel and transmit in the high channel (answer mode).

In some situations however, such as when calls are established on the GSTN by operators, bilateral agreement on channel allocations will be necessary.

Signalling rate selection at the call mode modem shall be either manual or by means of a logical condition applied on circuit 111 (if this circuit is provided). The handshake sequence, as defined in § 6.3.1, allows each modem to automatically condition itself to operate at the correct signalling rate.

6.1.2 *Point-to-point leased circuits*

Channel allocation and signalling rate selection on point-to-point leased circuits will, in general, be by bilateral agreement between users.

6.2 *V.25 automatic answering sequence*

The V.25 automatic answering sequence shall be transmitted from the answer mode modem on international GSTN connections. The transmission of the sequence may be omitted in national connections on point-to-point leased circuits or on the GSTN, where permitted by the Administrations.

6.3 *Handshake sequence*

6.3.1 *GSTN*

The means of achieving synchronism between the calling modem and the answering modem on international GSTN connections is shown in Figures 5/V.22 *bis*, 6/V.22 *bis* and 7/V.22 *bis.* Both calling and answering modems shall be manually conditioned to operate either in the synchronous modes (Modes 1 and 3), or in the start-stop modes (Modes 2 and 4). If both calling and answering modems are V.22 *bis* modems, the handshake will normally condition both modems to operate at 2400 bit/s. If however one or both of the modems has been set to operate at 1200 bit/s, either manually or via circuit 111, then the handshake will condition both modems to operate at 1200 bit/s. If either the calling or answering modem is a V.22 modem operating in V.22 Modes i) or ii) the handshake will condition both the V.22 *bis* and V.22 modem to operate at 1200 bit/s. The signalling rate is communicated to the DTE by a logical condition on circuit 112. The handshake sequence is independent of which modem, calling or answering, is connected to line first.

6.3.1.1 *Interworking at 2400 bit/s*

6.3.1.1.1 *Calling modem*

a) On connection to line the calling modem shall be conditioned to receive signals in the high channel at 1200 bit/s and transmit signals in the low channel at 1200 bit/s in accordance with § 2.5.2.2. It shall apply an ON condition to circuit 107 in accordance with Recommendation V.25. The modem shall initially remain silent.

b) After 155 ± 10 ms of unscrambled binary 1 has been detected, the modem shall remain silent for a further 456 ± 10 ms then transmit an unscrambled repetitive double dibit pattern of 00 and 11 at 1200 bit/s for 100 ± 3 ms. Following this signal the modem shall transmit scrambled binary 1 at 1200 bit/s.

c) If the modem detects scrambled binary 1 in the high channel at 1200 bit/s for 270 ± 40 ms, the handshake shall continue in accordance with §§ 6.3.1.2.1 c) and d). However, if unscrambled repetitive double dibit 00 and 11 at 1200 bit/s is detected in the high channel, then at the end of receipt of this signal the modem shall apply an ON condition to circuit 112.

d) 600 ± 10 ms after circuit 112 has been turned ON the modem shall begin transmitting scrambled binary 1 at 2400 bit/s, and 450 ± 10 ms after circuit 112 has been turned ON the receiver may begin making 16-way decisions.

e) Following transmission of scrambled binary 1 at 2400 bit/s for 200 ± 10 ms, circuit 106 shall be conditioned to respond to circuit 105 and the modem shall be ready to transmit data at 2400 bit/s.

f) When 32 consecutive bits of scrambled binary 1 at 2400 bit/s have been detected in the high channel the modem shall be ready to receive data at 2400 bit/s and shall apply an ON condition to circuit 109.

6.3.1.1.2 *Answering modem*

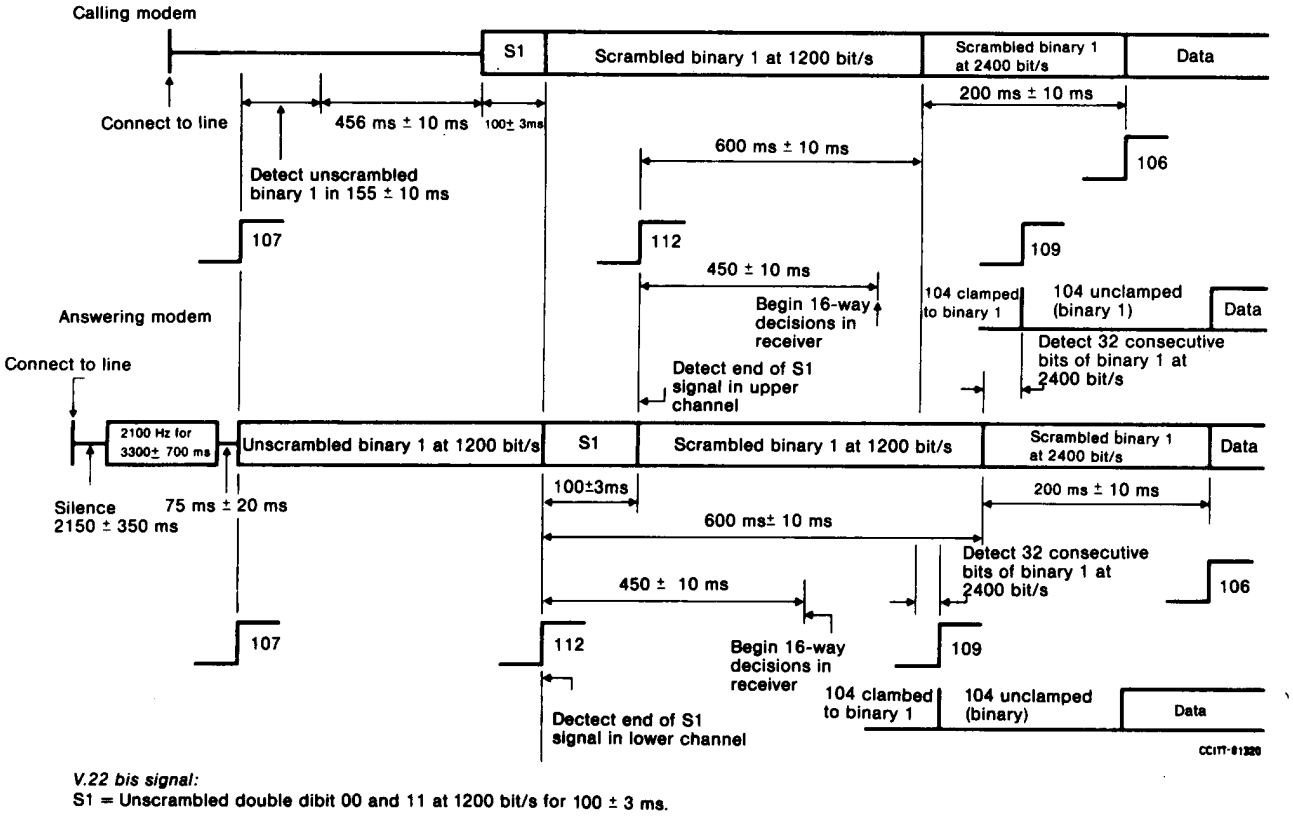
a) On connection to line the answering modem shall be conditioned to transmit signals in the high channel at 1200 bit/s in accordance with § 2.5.2.2 and receive signals in the low channel at 1200 bit/s. Following transmission of the answer sequence in accordance with Recommendation V.25, the modem shall apply an ON condition to circuit 107 and then transmit unscrambled binary 1 at 1200 bit/s.

b) If the modem detects scrambled binary 1 or 0 in the low channel at 1200 bit/s for 270 ± 40 ms, the handshake shall continue in accordance with §§ 6.3.1.2.2 b) and c). However, if unscrambled repetitive double dibit 00 and 11 at 1200 bit/s is detected in the low channel, at the end of receipt of this signal the modem shall apply an ON condition to circuit 112 and then transmit an unscrambled repetitive double dibit pattern of 00 and 11 at 1200 bit/s for 100 ± 3 ms. Following these signals the modem shall transmit scrambled binary 1 at 1200 bit/s.

c) 600 ± 10 ms after circuit 112 has been turned ON the modem shall begin transmitting scrambled binary 1 at 2400 bit/s, and 450 ± 10 ms after circuit 112 has been turned ON the receiver may begin making 16-way decisions.

d) Following transmission of scrambled binary 1 at 2400 bit/s for 200 ± 10 ms, circuit 106 shall be conditioned to respond to circuit 105 and the modem shall be ready to transmit data at 2400 bit/s.

e) When 32 consecutive bits of scrambled binary 1 at 2400 bit/s have been detected in the low channel the modem shall be ready to receive data at 2400 bit/s and shall apply an ON condition to circuit 109.



V.22 bis signal:
S1 = Unscrambled double dibit 00 and 11 at 1200 bit/s for 100 ± 3 ms.

FIGURE 5/V.22 *bis*

Handshake sequence at 2400 bit/s (with V.25 automatic answering)

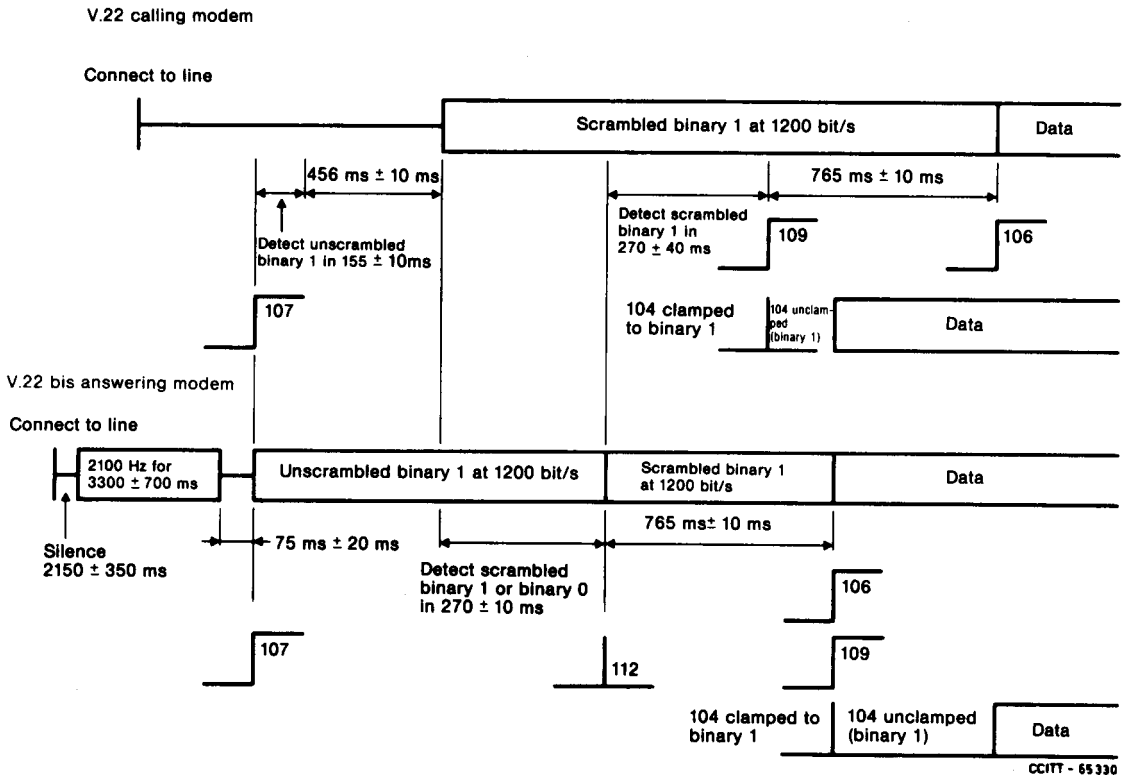


FIGURE 6/V.22 *bis*

Handshake sequence at 1200 bit/s with V.22 calling modem (with V.25 automatic answering)

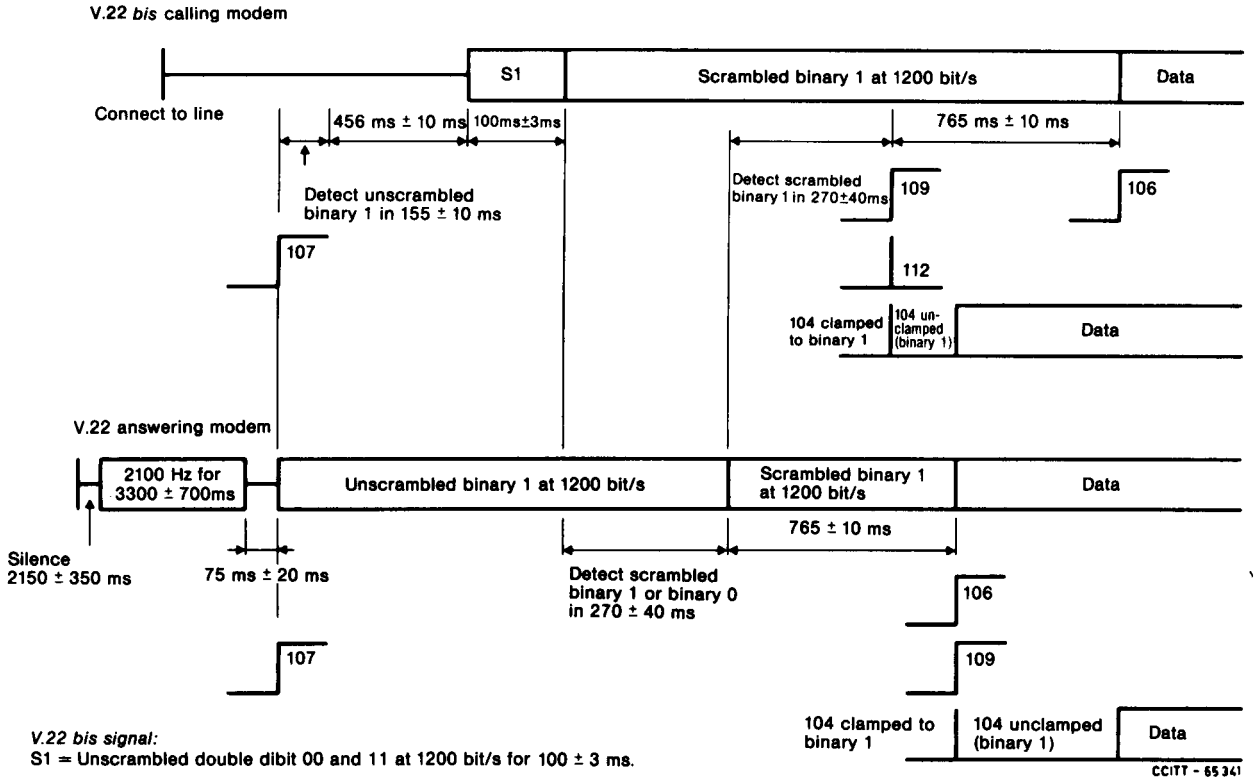


FIGURE 7/V.22 *bis*

Handshake sequence at 1200 bit/s with V.22 answering modem (with V.25 automatic answering)

6.3.1.2 *Interworking at 1200 bit/s*

The following handshake is identical to the Recommendation V.22 alternative A and B handshake.

6.3.1.2.1 *Calling modem*

a) On connection to line the calling modem shall be conditioned to receive signals in the high channel at 1200 bit/s and transmit signals in the low channel at 1200 bit/s in accordance with § 2.5.2.2. It shall apply an ON condition to circuit 107 in accordance with Recommendation V.25. The modem shall initially remain silent.

b) After 155 ± 10 ms of unscrambled binary 1 has been detected, the modem shall remain silent for a further 456 ± 10 ms then transmit scrambled binary 1 at 1200 bit/s (a preceding V.22 bis signal, as shown in Figure 7/V.22 *bis*, would not affect the operation of a V.22 answer modem).

c) On detection of scrambled binary 1 in the high channel at 1200 bit/s for 270 ± 40 ms the modem shall be ready to receive data at 1200 bit/s and shall apply an ON condition to circuit 109 and an OFF condition to circuit 112.

d) 765 ± 10 ms after circuit 109 has been turned ON, circuit 106 shall be conditioned to respond to circuit 105 and the modem shall be ready to transmit data at 1200 bit/s.

6.3.1.2.2 *Answering modem*

a) On connection to line the answering modem shall be conditioned to transmit signals in the high channel at 1200 bit/s in accordance with § 2.5.2.2 and receive signals in the low channel at 1200 bit/s.

   Following transmission of the answer sequence in accordance with V.25 the modem shall apply an ON condition to circuit 107 and then transmit unscrambled binary 1 at 1200 bit/s.

b) On detection of scrambled binary 1 or 0 in the low channel at 1200 bit/s for 270 ± 40 ms the modem shall apply an OFF condition to circuit 112 and shall then transmit scrambled binary 1 at 1200 bit/s.

c) After scrambled binary 1 has been transmitted at 1200 bit/s for 765 ± 10 ms the modem shall be ready to transmit and receive data at 1200 bit/s, shall condition circuit 106 to respond to circuit 105 and shall apply an ON condition to circuit 109.

Note - Manufacturers may wish to note that in certain countries, for national purposes, modems are in service which emit an answering tone of 2225 Hz instead of unscrambled binary 1.

6.3.2 *Point-to-point leased circuits*

6.3.2.1 *Interworking at 2400 bit/s*

Operation on leased circuits shall be continuous carrier in both directions. On initial power on and after line signal interruptions, operation shall be according to § 6.5.

6.4 *Retrain sequence (2400 bit/s operation)*

A retrain may be initiated during data transmission between two V.22 *bis* modems if either modem incorporates a means of detecting loss of equalization.

Transmission of a retrain sequence shall be initiated either by detection of loss of equalization or by detection of unscrambled repetitive double dibit 00 and 11 at 1200 bit/s from the distant modem.

The following sequence of events shall take place during the retrain:

a) Following detection of loss of equalization or the end of detection of unscrambled repetitive double dibit 00 and 11 at 1200 bit/s from the distant modem, the OFF condition shall be applied to circuit 106 and circuit 104 may be clamped to binary 1. The modem shall transmit an unscrambled repetitive double dibit pattern of 00 and 11 at 1200 bit/s for 100 ± 3 ms. Following this signal the modem shall transmit scrambled binary I at 1200 bit/s.

b) 600 ± 10 ms after the end of detection of unscrambled repetitive double dibit 00 and 11 at 1200 bit/s from the distant modem, the modem shall begin transmitting scrambled binary 1 at 2400 bit/s and 450 ± 10 ms after the end of this detection the receiver may begin making 16-way decisions.

c) Following transmission of scrambled binary 1 at 2400 bit/s for 200 ± 10 ms, circuit 106 shall be conditioned to respond to circuit 105 and the modem shall be ready to transmit data at 2400 bit/s.

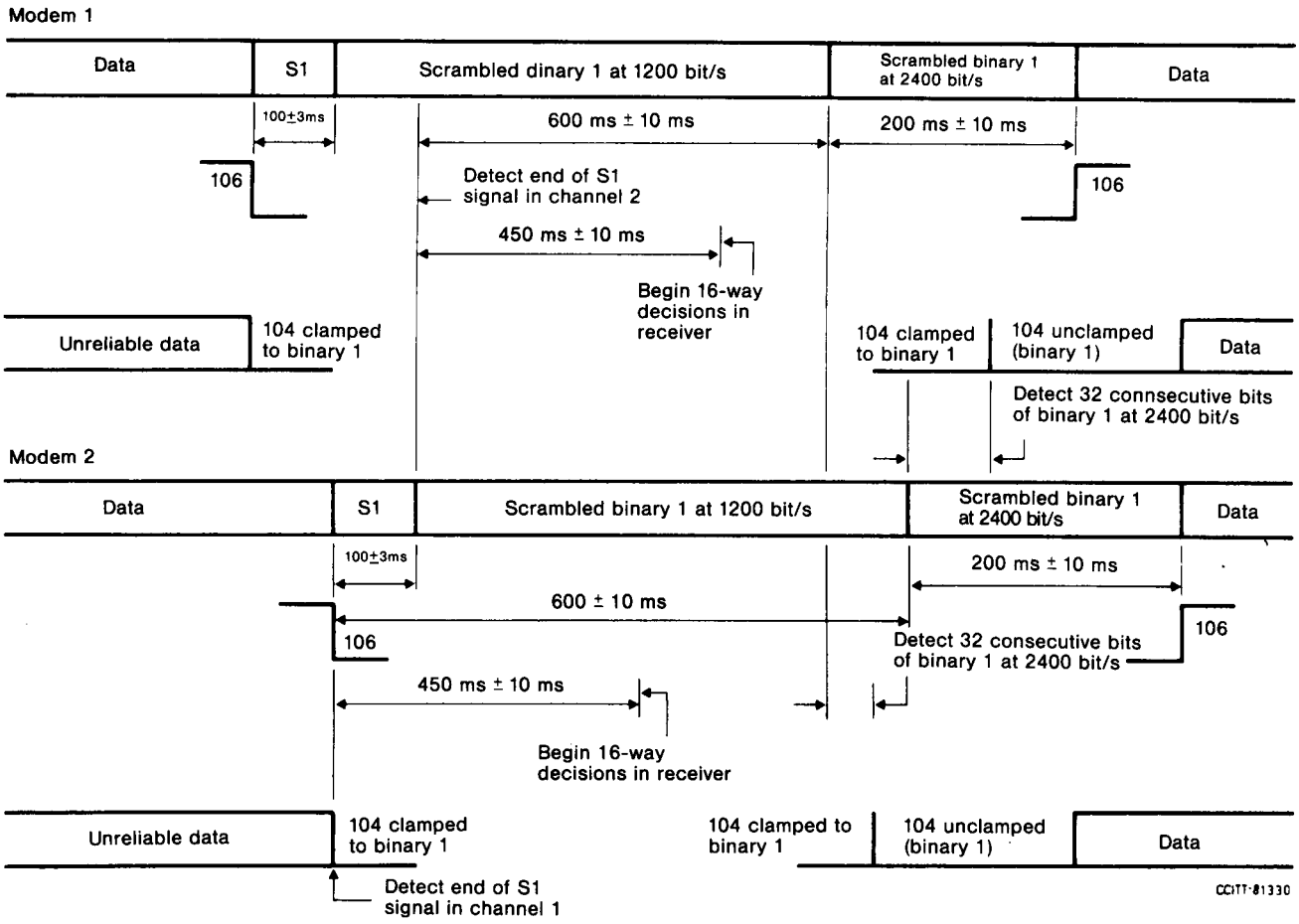
d) When 32 consecutive bits of scrambled binary 1 at 2400 bit/s have been detected from the remote modem, the modem shall be ready to receive data at 2400 bit/s and shall remove the clamp from circuit 104.

A retrain between two modems is shown in Figure 8/V.22 *bis.* Clocks presented on circuits 114 and 115 shall remain at 2400 bit/s during the entire retrain sequence.

If a modem has transmitted a retrain signal and has not received unscrambled repetitive double dibit 00 and 11 at 1200 bit/s immediately prior, or during, or within a time interval equal to the maximum expected two-way propagation delay, the modem shall return to the beginning of the retrain signal as defined above and repeat the procedure until unscrambled repetitive double dibit 00 and 11 is received from the remote modem. A time interval of 1.2 seconds is recommended for the maximum expected two-way propagation delay.

If the modem fails to synchronize on the received retrain sequence, the modem shall transmit another retrain signal.

During this retraining, circuits 109 and 107 shall remain ON.



V.22 bis signal:
S1 = Unscrambled double dibit 00 and 11 at 1200 bit/s for 100 ± 3 ms.

FIGURE 8/V.22 *bis*

A retrain at 2400 bit/s

6.5 *Operation after loss of line signal*

When the modem detects loss of received line signal (as specified in §§ 3.2 and 3.3) it shall turn OFF circuit 109 and shall clamp circuit 104 to binary 1. If received line signal is then detected (as specified in §§ 3.2 and 3.3) the modem shall turn ON circuit 109 but shall leave circuit 104 clamped to binary 1. If during the next 100 ms the modem detects a retrain sequence it shall proceed according to § 6.4 above. If the modem has not detected a retrain sequence by the end of the same 100 ms it shall remove the clamp from circuit 104. If at any time after turning ON circuit 109 following a drop out the modem detects loss of equalization, it shall proceed according to § 6.4 above.

6.6 *Optional rate signalling*

A modem may optionally instigate a rate change in response to a change in circuit 111 or manually, by a switch (or other means). The request may be made to change the operating rate from 1200 bit/s to 2400 bit/s or from 2400 bit/s to 1200 bit/s without disconnection from the GSTN (Note 1).

6.6.1 *Instigation of a rate change*

a) Upon initiation of a rate change, manually or by a change in the condition of circuit 111, the modem shall apply an OFF condition to circuit 106, clamp circuit 104 to binary ones and shall transmit unscrambled repetitive double dibit 00 and 11 at 1200 bit/s for 100 ± 3 ms. During this procedure, circuits 109 and 107 shall remain on.

b) Following this, the modem shall transmit scrambled R1 as defined in Table 3/V.22 *bis* at a rate of 1200 bit/s.

c) 450 ± 10 ms after detection of unscrambled repetitive double dibit 00 and 11 at 1200 bit/s from the distant modem, the receiver shall examine the descrambled repetitive dibits R2 from the distant modem to determine the operating rate for subsequent transmission as defined in Table 3/V.22 *bis; at* this time, the receiver may begin making decisions at the rate indicated by R2 which may differ from R1.

d) 600 ± 10 ms after detection of unscrambled repetitive double dibit 00 and 11 at 1200 bit/s from the distant modem, the transmission shall begin transmission of scrambled binary ones at a rate indicated by the dibit R2 from the distant modem. Following transmission of 200 ± 10 ms of scrambled binary ones, the modem shall condition circuit 106 to respond to circuit 105 and the modem shall be ready to transmit data.

e) When 32 consecutive bits of scrambled binary one at the rate indicated by dibit R2 from the distant modem have been detected, the modem shall set circuit 112 to indicate the operating rate and unclamp circuit 104.

f) If a modem has transmitted a rate change sequence and has not received unscrambled repetitive double dibit 00 and 11 at 1200 bit/s immediately prior, or during, or within a time interval equal to the maximum expected two-way propagation delay, the modem may return to the beginning of the rate change sequence as defined above and repeat the procedure until unscrambled repetitive double dibit 00 and 11 is received from the remote modem. A time interval of 1.2 seconds is recommended for the maximum expected two-way propagation delay.

6.6.2 *Response to a rate change*

a) When the modem detects unscrambled repetitive double dibit 00 and 11 at 1200 bit/s from the distant modem, the modem shall turn circuit 106 OFF and clamp circuit 104 to binary one. During this procedure, circuit 109 and 107 shall remain on.

b) When the end of unscrambled repetitive double dibit 00 and 11 at 1200 bit/s from the distant modem is detected, the modem shall condition its receiver for operation at 1200 bit/s and examine the descrambled repetitive dibit Rl (Note 2).

c) After having detected 32 consecutive rate dibits Rl, at 1200 bit/s, the modem shall transmit unscrambled repetitive double dibit 00 and 11 at 1200 bit/s for 100 ± 3 ms followed by transmission of scrambled repetitive dibit R2 defining the operating rate (Note 3).

d) 450 ± 10 ms after the detection of 32 consecutive rate dibits Rl at 1200 bit/s from the distant modem, the modem may condition its receiver to begin operation at the data rate indicated by R2.

e) 600 ± 10 ms after the detection of 32 consecutive rate dibits Rl at 1200 bit/s, the modem shall begin transmission of scrambled binary ones at the data rate indicated by R2. After 200 ± 10 ms of scrambled binary ones, the modem shall condition circuit 106 to respond to circuit 105 and the modem shall be ready to transmit data.

f) When 32 consecutive bits of scrambled binary one, at the rate indicated by the dibit R2 have been detected from the distant modem, the modem shall set circuit 112 to indicate the operating rate and unclamp circuit 104.

Note 1 - This mode of operation, where implemented, should be provided on both GSTN circuits and leased circuits.

Note 2 - In the event where the initiating modem is requesting a retrain, the responding modem may delay transmission of the S1 sequence (which should be transmitted immediately following the detection of the end of receipt of the S1 sequence per § 6.4) by more than 32 dibit duration after receipt of the end of the S1 sequence from the initiating modem.

Note 3 - It is the intent that for a rate change to occur, dibit R2 be set equal to dibit R1. Modems not supporting this option may return a dibit R2 that differs from Rl.

TABLE 4/V.22 *bis*

Operating rate	Dibit R1 and R2
2400 1200	11 01 or 10

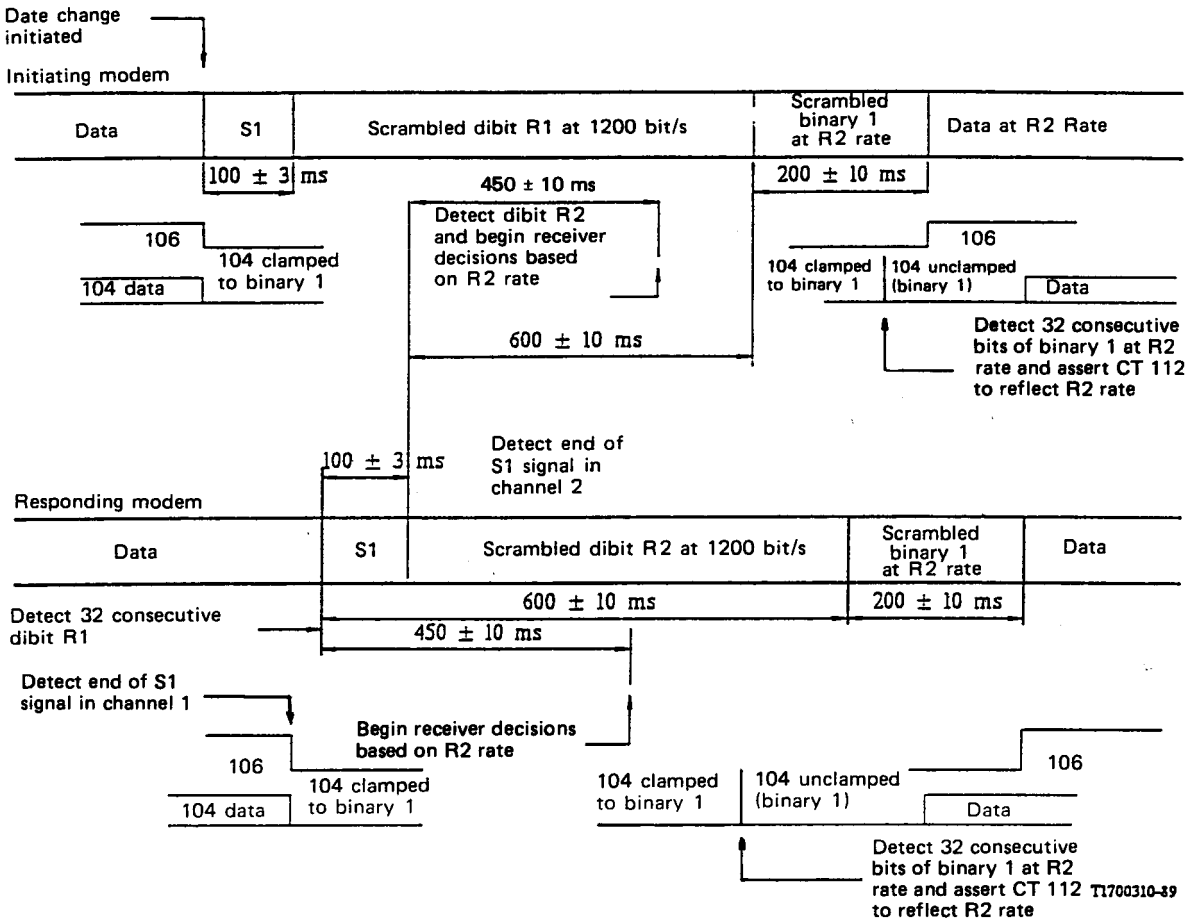


FIGURE 9/V.22 bis

Optional rate change sequence

7 Testing facilities

7.1 *Test loops*

Test loops 2 (local and remote) and 3 as defined in Recommendation V.54 shall be provided. Interface operation shall be as defined in Recommendation V.54. Instigation and termination sequences are not compatible with Recommendation V.54.

7.1.1 *Instigation of remote loop 2*

Signals controlling the application of remote loop 2 may only be transmitted after the synchronizing handshake has been completed.

As in Recommendation V.54, the modems are referred to as Modem A and Modem B.

When Modem A is instructed to instigate a remote loop 2, the modem shall transmit an initiation signal of unscrambled binary 1 at 2400 bit/s (or 1200 bit/s).

Modem B shall detect 154-231 ms of the initiation signal, and then transmit to Modem A scrambled alternating binary ones and zeros (reversals) at 2400 bit/s (or 1200 bit/s).

Modem A shall detect 231-308 ms of scrambled reversals, cease transmission of the initiation signal, and then transmit scrambled binary 1 at 2400 bit/s (or 1200 bit/s).

Modem B shall detect the loss of initiation signal and achieve loop 2 within Modem B.

Modem A, upon receiving 231-308 ms of scrambled binary 1 shall indicate to the DTE that it may begin sending test messages.

7.1.2 *Termination of remote loop 2*

When Modem A is instructed to terminate a remote loop 2 the line signal shall be suppressed for a period of 77 ± 10 ms, after which transmission shall be restored.

Modem B detects the loss of line signal in 40 to 65 ms and detects the re-appearance of the signal within 155 ± 50 ms, after which the modem B returns to normal operation.

7.2 *Self tests*

7.2.1 *Self test end-to-end*

Upon activation of the self test switch, an internally generated data pattern of alternative binary ones and zeros (reversals) at the selected bit rate shall be applied to the scrambler. An error detector, capable of identifying errors in a stream of reversals, shall be connected to the output of the descrambler. The presence of errors shall be indicated by a visual indicator. All generating interchange circuits except 114 (if used), 115, 125 and 142 shall be clamped to the binary 1 or OFF condition. If circuit 113 is used, the DCE shall disregard this interchange circuit and use its internal clock.

7.2.2 *Self test with loop 3*

Loop 3 shall be applied to the modem as defined in Recommendation V.54. The self-test switch shall be activated and DCE operation shall be as in § 7.2.1.

7.2.3 *Self test with remote loop 2*

The modem shall be conditioned to instigate a loop 2 at the remote modem as specified in § 7.1. The self-test switch shall be activated and DCE operation shall be as in § 7.2.1.

It shall be possible to perform the above tests (in §§ 7.2.1, 7.2.2 and 7.2.3) with or without the DTE connected to the modem. These tests employ an internally generated data pattern that is controlled by a switch on the DCE.

7.2.4 During any self-test mode, interchange circuits 103, 105 and 108 will be ignored. Note that self tests do not test asynchronous-to-synchronous converter circuits in either the transmitter or receiver.

Note - Inclusion of remote loop signalling according to Recommendation V.54 is for further study.