INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

V.36

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

DATA COMMUNICATION OVER THE TELEPHONE NETWORK

MODEMS FOR SYNCHRONOUS DATA TRANSMISSION USING 60-108 kHz GROUP BAND CIRCUITS

ITU-T Recommendation V.36

(Extract from the *Blue Book*)

NOTES

1   ITU-T Recommendation V.36 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.36

MODEMS FOR SYNCHRONOUS DATA TRANSMISSION USING
60-108 kHz GROUP BAND CIRCUITS

(Geneva, 1976; amended at Geneva, 1980,
Malaga-Torremolinos, 1984 and Melbourne, 1988)

On leased circuits, considering that there exist and will come into being other modems with features designed to meet the requirements of the Administrations and users, this Recommendation in no way restricts the use of any other modems.

The only group reference pilot frequency which can be used in conjunction with this modem is 104.08 kHz.

1   Scope

The family of modems covered by this Recommendation should be applicable to the following uses:

a)   transmission of data between customers on leased circuits;

b)   transmission of a multiplex aggregate bit stream for public data networks;

c)   extension of a PCM channel at 64 kbit/s over analogue facilities;

d)   transmission of a common channel signalling system for telephony and/or public data networks;

e)   extension of Single-Channel-Per-Carrier (SCPC) circuit from a satellite earth station;

f)   transmission of a multiplex aggregate bit stream for telegraph and data signals.

Principal recommended characteristics to be used for simultaneous both-way synchronous operation are the following:

2   Data signalling rates

2.1   *Application a)*

The recommended data signalling rate (equals the customer signalling rate) for international use is synchronous at 48 kbit/s. For certain national applications or with bilateral agreement between Administrations, the following data signalling rates are applicable: 56, 64 and 72 kbit/s.

2.2   *Applications b), c) and d)*

For these applications, the recommended data signalling rate is synchronous at 64 kbit/s.

For those synchronous networks requiring the end-to-end transmission of both the 8 kHz and 64 kHz timing together with the data at 64 kbit/s, a data signalling rate of 72 kbit/s on the line is suggested.

The corresponding data format should be obtained by inserting one extra bit E just before the first bit of each octet of the 64 kbit/s data stream. The bits E convey alignment and housekeeping information, according to the pattern shown in Figure 1/V.36.

.... 1 | octet | 0 | octet | H | octet | 1 | octet | 0 | octet | H | octet | ....

FIGURE 1/V.36

The use of the housekeeping bits H is determined with bilateral agreement between Administrations. When not used, these bits should be assigned the value 1. A framing strategy is not specified in this Recommendation.

When the transmission of the 8 kHz timing is not required, the data signalling rate on the line may be 64 kbit/s.

2.3   *Applicaticn e)*

The recommended data signalling rate (equals the customer signalling rate) for international use is synchronous at 48 kbit/s. For certain national applications or with bilateral agreement between Administrations the data signalling rate of 56 kbit/s is applicable.

2.4   *Application f)*

The recommended data signalling rate is synchronous at 64 kbit/s.

2.5   The permitted tolerance for all the data signalling rates mentioned above is $\pm\, 5 \times 10^{-5}$ bit/s.

Note - There are equipments in service which will only work successfully with a maximum tolerance of the data signalling rate of $\pm\, 1$ bit/s.

3   Scrambler/descrambler

In order to be bit sequence independent and to avoid high amplitude spectral components on the line, the data should be scrambled and descrambled by means of the logical arrangements described in Appendix I.

4   Baseband signal

The equivalent baseband signal shaping process is based upon the binary coded partial response pulse, often referred to as class IV, whose time and spectral function are defined by:

$$ g\,(t) \;=\; \frac{2}{\pi} \;\cdot\; \frac{\sin\dfrac{\pi}{T}\,t}{\left(\dfrac{t}{T}\right)^{2} - 1} $$

and

$$ G\,(f) \;=\; \begin{cases} 2\,T\,j\,\sin 2\,\pi\,Tf\,, & |f| \leqslant \dfrac{1}{2\,T} \\[2ex] 0 & ,\; |f| > \dfrac{1}{2\,T} \end{cases} $$

respectively, where $1/T$ denotes the data signalling rate.

This shaping process should be effected in such a way that the decoding can be achieved by full wave rectification of the demodulated line signal.

The reference to equivalent baseband signals recognizes that the modem implementation may be such that the binary signal at the input and output of the modem is converted to and from the line signal without appearing as an actual baseband signal.

5   Line signal in 60-108 kHz band (at the line output of the modem)

5.1   In the 60-108 kHz band the line signal should correspond to a single sideband signal with its carrier frequency at 100 kHz $\pm$ 2 Hz.

5.2   The relationship between the binary signals at the real or hypothetical output of the scrambler and the transmitted line signal states shall be in accordance with the amplitude modulation case of Recommendation V.1, i.e., tone ON for binary 1 and tone OFF for binary 0.

In a practical case this means that the voltage or no voltage conditions which will result from the full wave rectification of the demodulated line signal will correspond with the binary 1 and binary 0 signals respectively at the output of the scrambler.

5.3   The amplitude of the theoretical line signal spectrum, corresponding to binary symbol 1 appearing at the output of the scrambler, is to be sinusoidal, with zeros and maxima at the frequencies listed below:

Data signalling rate (kbit/s)	Zeros at (kHz)	Maxima at (kHz)
64	68 and 100	84
48	76 and 100	88
56	72 and 100	86
72	64 and 100	82

5.4   In the 60-108 kHz band, amplitude distortion of the real spectrum relative to the theoretical spectrum as defined under § 5.3 above is not to exceed ± 1 dB; the group delay distortion is not to exceed 8 microseconds. These two requirements are to be met for each frequency band centred on one of the maxima mentioned in § 5.3 and whose width is equal to 80% of the frequency band used.

5.5   The nominal level of the line data signal should be -6 dBm0. The actual level should be within ± 1 dB of the nominal level.

5.6   A pilot carrier at the same frequency as the modulated carrier at the transmitter and with a level of -9 ± 0.5 dB relative to the actual level mentioned under § 5.5 above, should be added to the line signal. The relative phase between the modulated carrier and the pilot carrier at the transmitter should be time invariant.

6   Group reference pilot

6.1   Provision should be made for facilitating the injection of a group reference pilot of 104.08 kHz from a source external to the modem.

6.2   The protection of the group reference pilot should conform to Recommendation H.52 [1].

7   Voice channel

7.1   The service speech channel is an integral part of the applications a) and e) of this system and is used on an optional basis. The channel corresponds to channel 1 of a 12-channel SSB-AM system in the 104-108 kHz band (virtual carrier at 108 kHz). It can transmit continuous voice at a mean level of maximum -15 dBm0 or pulsed signalling tones according to the individual specifications.

To avoid overloading of the system by peak signals a limiter shall be used with cut-off levels above +3 dBm0.

To avoid stability problems the channel shall be connected to 4-wire equipment only.

For operator-to-operator signalling Recommendation Q.1 [2] shall be followed, but instead of 500/20 Hz a non-interrupted tone of 2280 Hz at a level of -10 dBm0 shall be used.

For other signalling purposes [application e)] the R1 or R2 inband signalling, described in Recommendations Q.322 [3], Q.323 [4] and Q.454 [5], Q.455 [6] respectively, is preferred.

The transmit filter shall be such that any frequency applied to the transmit input terminals at a level of -15 dBm0 will not cause a level exceeding:

a)   -73 dBm0p in the adjacent group,

b)   -61 dBm0 in the vicinity ($\pm$ 25 Hz) of the pilot 104.08 kHz,

c)   -55 dBm0 in the data band between 64 and 101 kHz,

d)   the values specified in Recommendation Q.414 [7] to protect the nearest low level signalling path.

The voice band is sufficiently protected if the same filter is used in the receive direction of the channel. The attenuation/frequency characteristic, measured between the voice-frequency input and the group band output or the group band input and the voice-frequency output, with respect to the value at 800 Hz is limited by:

-1 dB over the 300-3400 Hz band,

+2 dB between 540 and 2280 Hz.

7.2   The voice channel is inapplicable to applications b), c), d) and f). It is used on an optional basis for applications a) and e).

Note - When the modem is installed at the repeater station, the voice channel should be extended to the renter's premises.

8   Adjacent channel interference

In the bands 36-60 kHz and 108-132 kHz, the adjacent channel interference should conform to Recommendation H.52 [1].

9   Line characteristics

The modem is intended to operate satisfactorily over group links according to reference [8] at data signalling rates of 48 up to 64 kbit/s.

For group links, comprising more than three group sections, or where a data signalling rate of 72 kbit/s is required, the characteristics given in reference [8] are not adequate.

Furthermore, compliance of a group link with reference [8] does not necessarily guarantee proper operation of the modem, nor does noncompliance imply improper operation.

In Annex A a method is presented to calculate the suitability of a group link for data transmission using a modem according to this Recommendation.

When an automatic adaptive equalizer is included in the modem, proper operation over a circuit of similar construction as the hypothetical reference circuit as specified in reference [9] will be possible at data signalling rates up to 64 kbits.

Note 1 - Reference [9] specifies a maximum number of 8 through-group filters, but this figure is subject to further study and possible amendment.

Note 2 - The modem may allow operation at 72 kbit/s over a circuit having a maximum of 5 through group filters. This value is left for further study.

10   Interface

10.1   *Interface for applications a), e) and f) indicated in § 1*

10.1.1   *List of interchange circuits* (See Table 1/V.36)

TABLE 1/V.36

Interchange circuit (see Note 1)		Remark
102	Signal ground or common return	See Note 2
102 a	DTE common return	See Note 3
102 b	DCE common return	See Note 3
103	Transmitted data	
104	Received data	
105	Request to send	
106	Ready for sending	
107	Data set ready	
109	Data channel received line signal detector	
113	Trasmitter signal element timing (DTE source)	
114	Trasmitter signal element timing (DCE source)	
115	Receiver signal element timing (DCE source)	
140	Loopback/Maintenance test	See Note 2
141	Local loopback	See Note 2
142	Test indicator	See Note 2

Note 1 - When the modem is installed at the repeater station, this interface should appear at the customer's premises without restrictions regarding the data signalling rate and the provision of the voice channel. The method to achieve this is subject to national regulations.

Note 2 - Equipment may be in service that does not implement these circuits.

Note 3 - Interchange circuits 102a and 102b are required where the electrical characteristics defined in Recommendation V.10 are used.

10.1.2   *Electrical characteristics*

Use of electrical characteristics conforming to Recommendation V.10 and/or V.11 is recommended together with the use of the connector and pin assignment plan specified by ISO 4902.

i)   Concerning circuits 103, 104, 113, 114 and 115, both the generators and the receivers shall be in accordance with Recommendation V.11.

ii)   In the case of circuits 105, 106, 107 and 109, generators shall comply with Recommendation V.10 or alternatively Recommendation V.11. The receivers shall comply with Recommendation V.10, category 1 or V.11 without termination.

iii)   In the case of all other circuits, Recommendation V.10 applies with receivers configured as specified by Recommendation V.10 for category 2.

Note - For an interim period the connector and contact-assignment plan specified in ISO 2593 and commonly referred to as the "V.35 interface" may optionally be used. In this case electrical characteristics may be either V.11 for circuits 103, 104, 113, 114 and 115 together with V.10 (receivers configured as specified in category 2) for all other circuits, or V.35 Appendix II together with V.28 respectively.

10.2   *Interface for applications b), c) and d) indicated in § 1*

For applications b), c) and d) the interface may comply with the functional requirements given in reference

[10] for the 64 kbit/s interface. In these cases, the electrical characteristics may comply with reference [11].

If an end-to-end transmission of the 8 kHz timing signal is not used, an 8 kHz timing signal across the interface will not be supplied nor utilized by the modem.

Alternatively the interface according to § 10.1 may be used for these applications.

11 Threshold and response time of circuit 109

11.1 *Threshold*

For a data line signal level greater than -13 dBm0, circuit 109 is ON. For data line signal level less than -18 dBm0, circuit 109 is OFF.

Note - The corresponding levels for the pilot carrier are -22 dBm0 and -27 dBm0 respectively.

The condition of circuit 109 for levels between the above 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 is at least 2 dB greater than that for the ON to OFF transition. To measure the thresholds of the detector, a modulated data signal with its pilot carrier at the level specified in § 5.6 should be used.

11.2 *Response time*

From OFF to ON: 15 ms to 150 ms,

From ON to OFF: 5 ms to 15 ms.

The response times of circuit 109 are the time intervals between the appearance or disappearance of the line signal at the reception input terminal of the modem and the occurrence of the corresponding ON or OFF condition on circuit 109.

The line signal level should be within the range from 3 dB above the actual threshold of the line signal detector at reception and the maximum permissible level of the signal at reception.

12 Error performance

12.1 For a hypothetical reference circuit, 2500 km in length, with characteristics in accordance with Recommendation H.14 [8], and with not more than two through-group connection equipments, the performance objective in terms of error rate should be not worse than 1 error per 10^7 bits transmitted. This is based on an assumed Gaussian noise power of 4 pW per km/per 4 kHz band psophometrically weighted (this figure corresponds to 4 pW0p/km).

13 Additional information for the designer

13.1 *Input level variation*

The step-change in the input level is, under normal conditions, smaller than ± 0.1 dB. The gradual input level change is smaller than ± 6 dB and includes the tolerance of the transmitter output level.

13.2 *Interference from adjacent group bands*

A sinusoidal signal of +10 dBm0 in the frequency bands of 36-60 kHz and 108-132 kHz can appear together with the data line signal at the input of the receiver.

ANNEX A

(to Recommendation V.36)

Line characteristics

For proper operation of the modem, the line characteristic of a group link shall comply with:

$$\varepsilon = \sqrt{\frac{c^2}{a^2 + b^2} - \frac{1}{2}} < 0.08$$

where

$$a = \frac{2}{T} \int_{f_i - \frac{1}{2T}}^{f_i} |G(f)|^2 \cdot |H(f)| \cos[\theta(f) + 2\pi f \bar{\tau}] \, df,$$

$$b = \frac{2}{T} \int_{f_i - \frac{1}{2T}}^{f_i} |G(f)|^2 \cdot |H(f)| \sin[\theta(f) + 2\pi f \bar{\tau}] \, df,$$

$$c^2 = \frac{2}{T} \int_{f_i - \frac{1}{2T}}^{f_i} |G(f)|^2 \cdot |H(f)|^2 \, df,$$

$|H(f)|$ is the attenuation characteristic of the link,

$\theta(f)$ is the phase characteristic of the link,

$G(f)$ is the spectral function of the transmitted line signal $= 2jT \sin\{2\pi (f_i - f)T\}$,

$\bar{\tau}$ represents a constant time delay which should be chosen in such a way as to minimize ε, and

f_i is 100 kHz.

APPENDIX I

(to Recommendation V.36)

Scrambling process

I.1   *Definitions*

I.1.1   **applied data bit**

The data bit which has been applied to the scrambler but has not affected the transmission at the time of consideration.

I.1.2   **next transmitted bit**

The bit which will be transmitted as a result of scrambling the applied data bit.

I.1.3   **earlier transmitted bits**

Those bits which have been transmitted earlier than the next transmitted bit. They are numbered sequentially

in reverse time order, i.e. the first earlier transmitted bit is that immediately preceding the next transmitted bit.

I.1.4   **adverse state**

The presence of any one of certain repetitive patterns in the earlier transmitted bits.

I.2   *Scrambling process*

The binary value of the next transmitted bit shall be such as to produce odd parity when considered together with the twentieth and third earlier transmitted bits and the applied data bit unless an adverse state is apparent, in which case the binary value of the next transmitted bit shall be such as to produce even instead of odd parity.

An adverse state shall be apparent only if the binary values of the pth and $(p+8)^{th}$ earlier transmitted bits have not differed from one another when p represents all the integers from 1 to q inclusive. The value of q shall be such that, for $p = (q+1)$, the pth and $(p+8)^{th}$ earlier transmitted bits had opposite binary values and $q = (31 + 32\ r)$, r being 0 or any positive integer.

At the time of commencement, i.e. when no earlier bits have been transmitted, an arbitrary 20-bit pattern may be assumed to represent the earlier transmitted bits. At this time also it may be assumed that the pth and $(p+8)^{th}$ earlier transmitted bits have had the same binary value when p represents all the integers up to any arbitrary value. Similar assumptions may be made for the descrambling process at commencement.

Note 1 - From this it can be seen that received data cannot necessarily be descrambled correctly until at least 20 bits have been correctly received and any pair of these bits, separated from each other by seven other bits, have differed in binary value from one another.

Note 2 - It is not possible to devise a satisfactory test pattern to check the operation of the Adverse State Detector (ASD) because of the large number of possible states in which the 20 state shift register can be at the commencement of testing. For those modems in which it is possible to bypass the scrambler and the descrambler and to strap the scrambler to function as a descrambler, the following method may be used. A 1 : 1 test pattern is transmitted with the ASD of the scrambler bypassed. If the ASD of the descrambler is functioning correctly the descrambled test pattern will contain a single element error every 32 bits, i.e. 90 000 errors per minute for a modem operating at 48 kbit/s indicates that the descrambler is functioning correctly. The operation of the ASD of the scrambler may be checked in a similar manner with the scrambler strapped as a descrambler and the descrambler bypassed.

I.3   Figure I-1/V.36 is given as an indication only, since with another technique this logical arrangement might take another form.
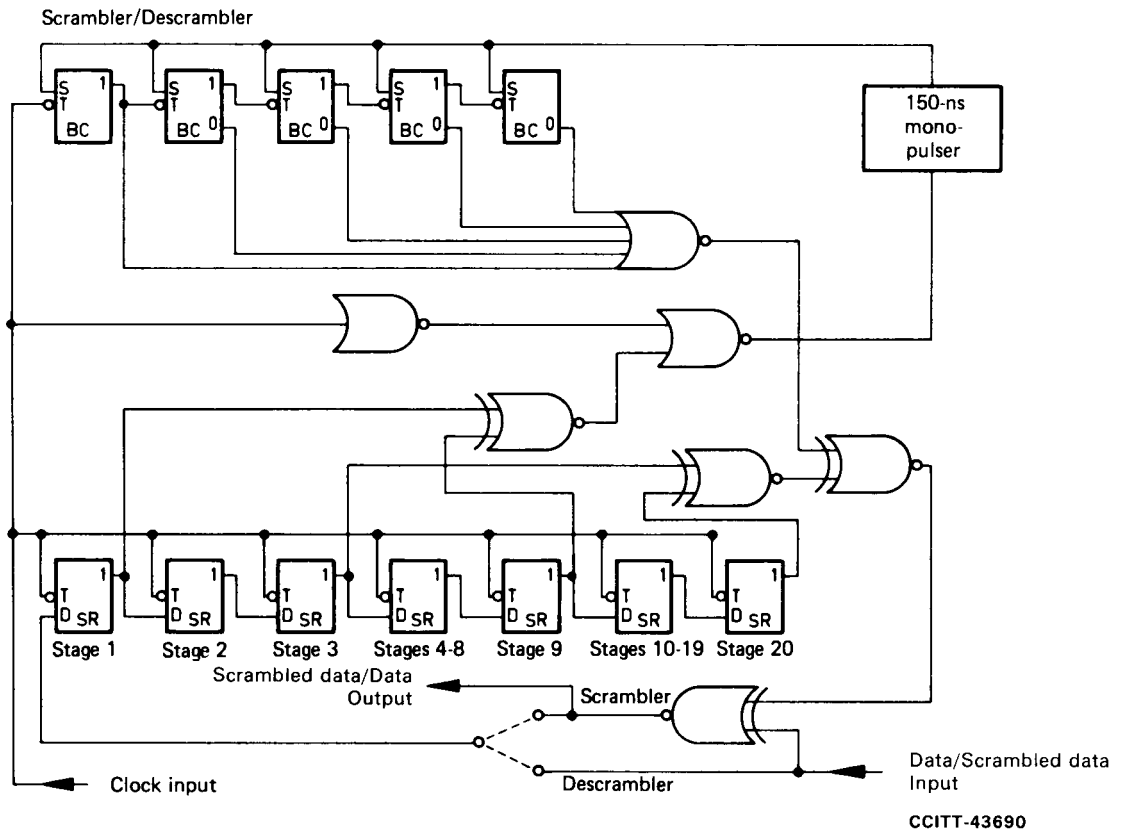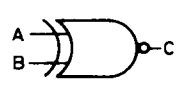
Symbol truth tables

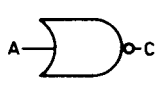| A	B	C
0	0	1
0	1	0
1	1	0
1	0	0

Or / Or-Not
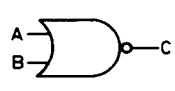
A	B	C
0	0	1
0	1	0
1	1	1
1	0	0

Exclusive or-not

A	C
1	0
0	1

Inverter
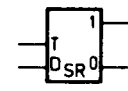
T	D	1 output	0 output
1	Q	–	–
0	–	Q	$\bar{Q}$

Q is either 0 or 1

Shift register
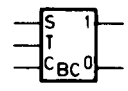
T	1 output	0 output
1	Q	$\bar{Q}$
0	$\bar{Q}$	Q

S	1 output	0 output
0	Q	$\bar{Q}$
1	1	0

(Reset)

Binary counter

Note − Negative-going transitions of clocks (i.e. 1 to 0 transitions) coincide with data transitions. This is self-synchronizing.

FIGURE I-1/V.36

An example of scrambler and descrambler circuitry

References

[1]   CCITT Recommendation *Transmission of wide-spectrum signals (data, facsimile, etc.) on wideband group links*, Vol. III, Rec. H.52.

[2]   CCITT Recommendation *Signal receivers for manual working,* Vol. VI, Rec. Q.1.

[3]   CCITT Recommendation *Multifrequency signal sender,* Vol. VI, Rec. Q.322.

[4]   CCITT Recommendation *Multifrequency signal receiving equipment,* Vol. VI, Rec. Q.323.

[5]   CCITT Recommendation *The sending part of the multifrequency signalling equipment,* Vol. VI, Rec. Q.454.

[6]   CCITT Recommendation *The receiving part of the multifrequency signalling equipment,* Vol. VI, Rec. Q.455.

[7]   CCITT Recommendation *Signal sender,* Vol. VI, Rec. Q.414.

[8]   CCITT Recommendation *Characteristics of group links for the transmission of wide-spectrum signals,* Vol. III, Rec. H.14, § 2.

[9]   *Ibid.,* § 3.

[10]   CCITT Recommendation *Physical/electrical characteristics of hierarchical digital interfaces*, Vol. III, Rec. G.703, § 1.

[11]   *Ibid.,* § 1.2.