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OF ITU

V.32

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DATA COMMUNICATION OVER THE TELEPHONE NETWORK

**A FAMILY OF 2-WIRE, DUPLEX MODEMS
OPERATING AT DATA SIGNALLING RATES
OF UP TO 9600 bit/s FOR USE ON
THE GENERAL SWITCHED TELEPHONE
NETWORK AND ON LEASED
TELEPHONE-TYPE CIRCUITS**

ITU-T Recommendation V.32

(Previously "CCITT Recommendation")

FOREWORD

The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of the International Telecommunication Union. The ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Conference (WTSC), which meets every four years, established the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

ITU-T Recommendation V.32 was revised by the ITU-T Study Group XVII (1988-1993) and was approved by the WTSC (Helsinki, March 1-12, 1993).

NOTES

1 As a consequence of a reform process within the International Telecommunication Union (ITU), the CCITT ceased to exist as of 28 February 1993. In its place, the ITU Telecommunication Standardization Sector (ITU-T) was created as of 1 March 1993. Similarly, in this reform process, the CCIR and the IFRB have been replaced by the Radiocommunication Sector.

In order not to delay publication of this Recommendation, no change has been made in the text to references containing the acronyms "CCITT, CCIR or IFRB" or their associated entities such as Plenary Assembly, Secretariat, etc. Future editions of this Recommendation will contain the proper terminology related to the new ITU structure.

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.32

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DATA SIGNALLING RATES OF UP TO 9600 bit/s FOR USE
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AND ON LEASED TELEPHONE-TYPE CIRCUITS**

*(Malaga-Torremolinos, 1984, amended Melbourne, 1988
and Helsinki, 1993)*

1 Introduction

This family of modems is intended for use on connections on general switched telephone networks (GSTNs) (see Note 1) and on point-to-point leased telephone-type circuits. The principal characteristics of the modems are as follows:

- a) Duplex mode of operation on GSTN and 2-wire point-to-point leased circuits (see Note 2).
- b) Channel separation by echo cancellation techniques.
- c) Quadrature amplitude modulation for each channel with synchronous line transmission at 2400 bauds.
- d) Any combination of the following data signalling rates may be implemented in the modems:
 - 9600 bit/s synchronous (optional),
 - 4800 bit/s synchronous (mandatory),
 - 2400 bit/s synchronous (for further study).
- e) At 9600 bit/s, two alternative modulation schemes, one using 16 carrier states and one using trellis coding with 32 carrier states, are provided for in this Recommendation. However, modems providing the 9600 bit/s data signalling rate shall be capable of interworking using the 16-state alternative.
- f) Exchange of rate sequences during start-up to establish the data rate, coding and any other special facilities.
- g) Optional provision of an asynchronous mode of operation in accordance with Recommendations V.14 or V.42.

NOTES

1 On international GSTN connections that utilize circuits that are in accord with Recommendation G.235 (16-channel terminal equipments), it may be necessary to employ a greater degree of equalization within the modem than would be required for use on most national GSTN connections.

2 The transmit and receive rates in each modem shall be the same. The possibility of asymmetric working remains for further study.

2 Line signals**2.1 Carrier frequency**

The carrier frequency is to be 1800 ± 1 Hz. No separate pilot tones are to be provided. The receiver must be able to operate with received frequency offsets of up to ± 7 Hz.

2.2 Transmitted spectrum

The transmitted power level must conform to Recommendation V.2. With continuous binary ones applied to the input of the scrambler, the transmitted energy density at 600 Hz and 3000 Hz should be attenuated 4.5 ± 2.5 dB with respect to the maximum energy density between 600 Hz and 3000 Hz.

2.3 Modulation rate

The modulation rate shall be 2400 bauds $\pm 0.01\%$.

2.4 Coding

2.4.1 Signal element coding for 9600 bit/s

Two alternatives are defined.

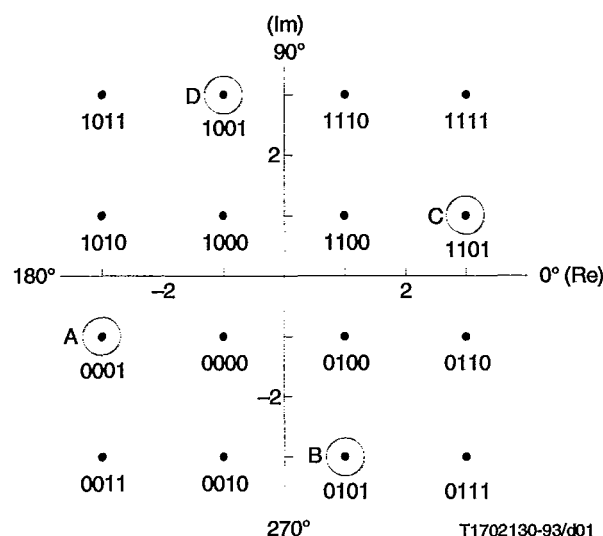
2.4.1.1 Nonredundant coding

The scrambled data stream to be transmitted is divided into groups of 4 consecutive data bits. The first two bits in time $Q1_n$ and $Q2_n$ in each group, where the subscript n designates the sequence number of the group, are differentially encoded into $Y1_n$ and $Y2_n$ according to Table 1. Bits $Y1_n$, $Y2_n$, $Q3_n$ and $Q4_n$ are then mapped into the coordinates of the signal state to be transmitted according to the signal space diagram shown in Figure 1 and as listed in Table 3.

TABLE 1/V.32

Differential quadrant coding for 4800 bit/s and for nonredundant coding at 9600 bit/s

Inputs		Previous outputs		Phase quadrant change	Outputs		Signal state for 4800 bit/s
$Q1_n$	$Q2_n$	$Y1_{n-1}$	$Y2_{n-1}$		$Y1_n$	$Y2_n$	
0	0	0	0	+ 90°	0	1	B
0	0	0	1		1	1	C
0	0	1	0		0	0	A
0	0	1	1		1	0	D
0	1	0	0	0°	0	0	A
0	1	0	1		0	1	B
0	1	1	0		1	0	D
0	1	1	1		1	1	C
1	0	0	0	+180°	1	1	C
1	0	0	1		1	0	D
1	0	1	0		0	1	B
1	0	1	1		0	0	A
1	1	0	0	+270°	1	0	D
1	1	0	1		0	0	A
1	1	1	0		1	1	C
1	1	1	1		0	1	B



NOTE – The binary numbers denote $Y1_n$ $Y2_n$ $Q3_n$ $Q4_n$

FIGURE 1/V.32

16-point signal structure with nonredundant coding for 9600 bit/s
and subset A B C and D of states used at 4800 bit/s and for training

2.4.1.2 Trellis coding

The scrambled data stream to be transmitted is divided into groups of 4 consecutive data bits. As shown in Figure 2, the first two bits in time $Q1_n$ and $Q2_n$ in each group, where the subscript n designates the sequence number of the group, are first differentially encoded into $Y1_n$ and $Y2_n$ according to Table 2. The two differentially encoded bits $Y1_n$ and $Y2_n$ are used as input to a systematic convolutional encoder which generates a redundant bit $Y0_n$. This redundant bit and the 4 information-carrying bits $Y1_n$, $Y2_n$, $Q3_n$ and $Q4_n$ are then mapped into the coordinates of the signal element to be transmitted according to the signal space diagram shown in Figure 3 and as listed in Table 3.

2.4.2 Signal element coding for 4800 bit/s

The scrambled data stream to be transmitted is divided into groups of 2 consecutive data bits. These bits, denoted $Q1_n$ and $Q2_n$, where $Q1_n$ is the first in time, and the subscript n designates the sequence number of the group, are differentially encoded into $Y1_n$ and $Y2_n$ according to Table 1. Figure 1 shows the subset A, B, C and D of signal states used for 4800 bit/s transmission.

2.4.3 Signal element coding for 2400 bit/s

For further study.

3 Interchange circuits

3.1 List of interchange circuits

These are listed in Table 4.

3.2 Transmit data

The modems shall accept synchronous data from the DTE on circuit 103 under control of circuit 113 or 114.

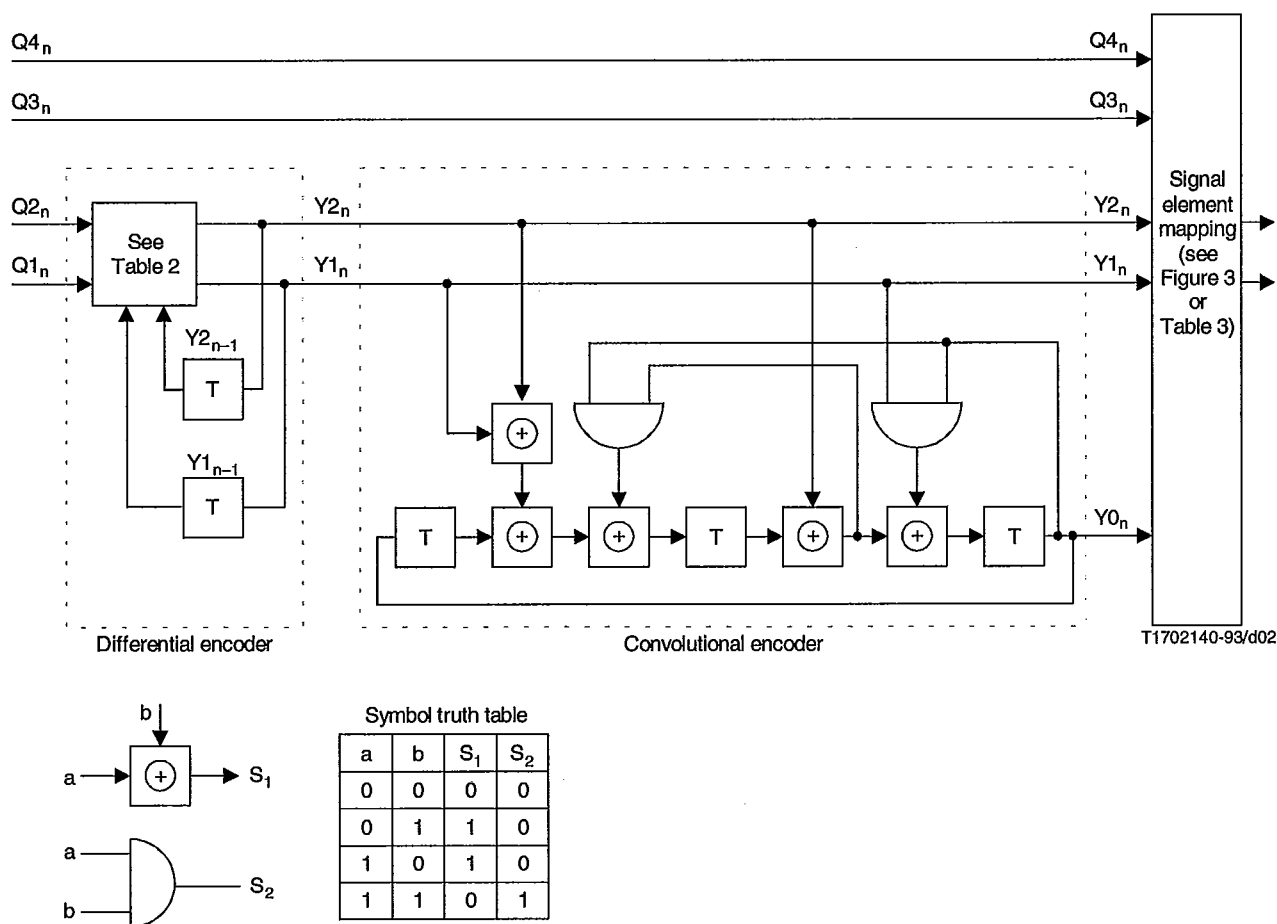


FIGURE 2/V.32
Trellis coding at 9600 bit/s

3.3 Receive data

The modems shall pass synchronous data to the DTE on circuit 104 under the control of circuit 115.

3.4 Timing arrangements

Clocks shall be included in the modems to provide the DTE with transmitter signal element timing on circuit 114 and receiver signal element timing on circuit 115. The transmitter timing may originate in the DTE and be transferred to the modem via circuit 113. In some applications it may be necessary to slave the transmitter timing to the receiver timing inside the modem.

3.5 Data rate control

Data rate selection may be by switch (or similar means) or alternatively by circuit 111. In cases where three different data signalling rates are implemented in a modem, a manual selector may be provided which determines the two data signalling rates selected by circuit 111.

The ON condition of circuit 111 selects the higher data signalling rate and the OFF condition of circuit 111 selects the lower data signalling rate.

TABLE 2/V.32

Differential encoding for use with trellis coded alternative at 9600 bit/s

Inputs		Previous outputs		Outputs	
$Q1_n$	$Q2_n$	$Y1_{n-1}$	$Y2_{n-1}$	$Y1_n$	$Y2_n$
0	0	0	0	0	0
0	0	0	1	0	1
0	0	1	0	1	0
0	0	1	1	1	1
0	1	0	0	0	1
0	1	0	1	0	0
0	1	1	0	1	1
0	1	1	1	1	0
1	0	0	0	1	0
1	0	0	1	1	1
1	0	1	0	0	1
1	0	1	1	0	0
1	1	0	0	1	1
1	1	0	1	1	0
1	1	1	0	0	0
1	1	1	1	0	1

3.6 Circuit 106

After the start-up and retrain sequences, circuit 106 must follow the state of circuit 105 within 2 ms.

3.7 Circuit 109

OFF to ON and ON to OFF transitions of circuit 109 should occur solely in accordance with the operating sequences defined in 5. Thresholds and response times are inapplicable because a line signal detector cannot be expected to distinguish wanted received signals from unwanted talker echoes.

3.8 Electrical characteristics of interchange circuits

3.8.1 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.