



INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

V.16

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

**DATA COMMUNICATION OVER THE TELEPHONE
NETWORK**

**MEDICAL ANALOGUE DATA TRANSMISSION
MODEMS**

ITU-T Recommendation V.16

(Extract from the *Blue Book*)

NOTES

1 ITU-T Recommendation V.16 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.16

MEDICAL ANALOGUE DATA TRANSMISSION MODEMS

(Geneva, 1976)

The CCITT,

considering that

(a) computer-aided automatic ECG (electro-cardiogram) interpretation is being made available by special diagnostic centres to general practitioners and hospitals at remote places and suitable transmission equipment is necessary for this reason;

(b) such a service can be implemented to advantage in a special data collection system using simple remote stations and a high-quality central unit;

(c) for such applications particularly suitable and compatible transmission facilities are necessary which must not interfere with other telephone services;

(d) analogue as well as digitalized transmission of the analogue data (e.g. ECG records) are in principle possible;

(e) in most cases, however, on-line transmission with analogue transmission methods can be implemented more easily and economically;

(f) in practice, analogue transmission generally promises a sufficient degree of quality;

(g) in cases of emergency and monitoring of implanted pacemakers, very simple, acoustically coupled equipment may be of great assistance to the persons concerned;

unanimously declares the following view

1 Analogue transmission of medical analogue data, e.g. ECGs, should be permitted in the public telephone network. Reliable, sufficiently interference-free transmission cannot be taken for granted on every connection or route. Therefore, it is necessary to test the connections under consideration before such a service is definitely introduced.

2 This service requires two basically different transmission devices (modems):

- 1) transmission equipment for simultaneous transmission of three ECG signals on a telephone channel from a remote station to the central station, preferably for direct galvanic coupling to the telephone channel;
- 2) transmission equipment, preferably for emergency use and for monitoring of implanted pacemakers, to simultaneously transmit only one ECG signal from a remote station to a central station with acoustic or galvanic coupling to a telephone channel.

The ECG station usually consists of an ECG recorder, including separating amplifier, data input/output device and the modem specified in this Recommendation (see Figure 1/V.16).

The central station usually comprises the central modem specified herein and the interpretation system for ECGs (e.g. a computer programmed for ECG interpretation).

This Recommendation covers the modems, the desired transmission characteristics of the ECG transmission channel as well as the necessary interchange circuits and the method of transmitting the digital data associated with the ECG (e.g. patients' identification codes, control signals in both transmission directions and the interpretation record).

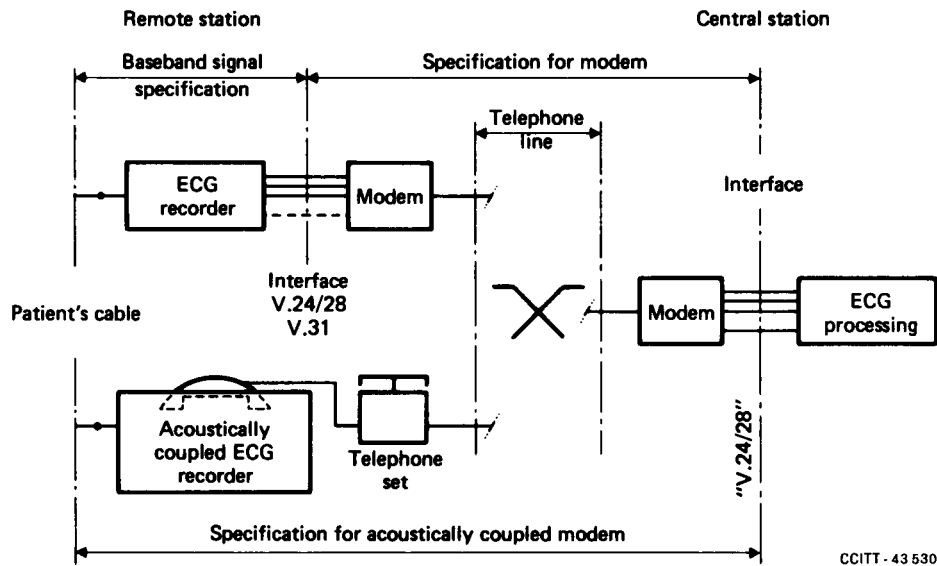


FIGURE 1/V.16
Example of analogue transmission of medical analogue data

3 Modems for simultaneous analogue transmission of three ECG records

3.1 Basic characteristics of the analogue channels

The equipment specified below is mainly intended for operation with direct galvanic coupling to telephone lines.

3.1.1 Baseband signal

Baseband signal requirements at the modem input:

- number of simultaneously transmitted ECG records 3
- frequency response of the separating amplifier flat
- signal-to-noise ratio with 10 Hz square wave signals ± 1 V ≥ 50 dB (unweighted)
- full scale limit (see Note 1) ± 2.5 V
- linearity deviation of an ECG channel related to full scale and the optimum straight line 1%
- permissible group delay distortion of the input signal at the modulator input (including channel filter in the baseband) from 3 to 60 Hz $\Delta\tau \leq 2$ ms (outside this range, see Figure 2/V.16)

- spectrum: if a.c. coupling is applied, a time constant of $\tau = 3.2$ s, corresponding to a lower cut-off frequency of 0.5 Hz, should be used.
- baseband pre-emphasis (see Note 2) (between separating amplifier and modem) rise of 6 dB/octave;
cut-off frequency: 15 Hz

Note 1 - Existing instruments (ECG recorders, etc.) are designed for ± 2.5 V full scale. If, however, the International Electrotechnical Commission specifies ± 1 V or ± 1.25 V as the full scale limit, this value should be adopted. The slope of the modulator characteristic (see § 3.1.2 below) must then be adjusted accordingly.

Note 2 - This value will require further study if, at a later date, amplitude companders are used to improve the signal-to-noise ratio.

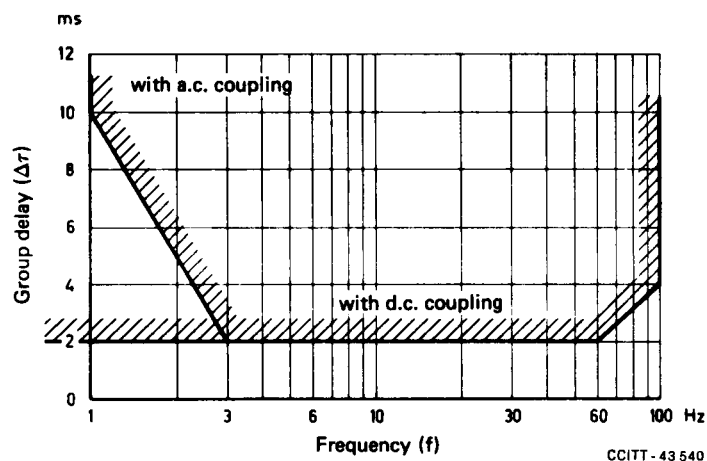


FIGURE 2/V.16
Permissible group-delay distortion in the baseband

3.1.2 Requirements for the transmission equipment (modems)

The modem should be capable of transmitting baseband signals with a bandwidth of up to approximately 100 Hz. The transmission equipment (modems) should not deteriorate the performance of the baseband signal as specified under § 3.1.1 above by more than 10%. The exact value of the admissible deterioration needs further study.

Since the centre channel of the transmission equipment will in future be used for digital transmission of ECG-associated digital data and other biological data, it must be capable of transmitting d.c. components. The same should apply to the other channels.

- *line signals* for transmitting the ECG: signals as specified under § 3.1.1 above
- modulation method: frequency modulation
- subcarrier frequencies f_n and associated maximum transmission levels p_n :

$f_1 = 950 \text{ Hz} \pm 6 \text{ Hz}$	$p_1 = 7 \text{ dB}$ lower than the resulting
$f_2 = 1400 \text{ Hz} \pm 15 \text{ Hz}$ (see Note 1)	$p_2 = 5 \text{ dB}$ level p_0 as specified in
$f_3 = 2100 \text{ Hz} \pm 15 \text{ Hz}$	$p_3 = 3 \text{ dB}$ Recommendation V.2
- resulting maximum level: p_0 as specified in Recommendation V.2
- simultaneous transmission of all three subcarriers is mandatory, if subcarriers f_1 and/or f_3 are used.
- maximum frequency deviation per channel in the case of linear operation: $\Delta f = \pm 100 \text{ Hz}$

- slope of the modulator characteristic (subcarrier deviation sensitivity): 40 Hz/V (see Note 2)
- a positive signal should cause a rise in the subcarrier frequency
- FM channel bandwidth (3 dB points): ≤ 350 Hz
- resulting level accepted by receiver (upper threshold-level): - 6 dBm to -43 dBm
- lower threshold level: -46 dBm

Note 1 - This frequency selection makes allowance for the following boundary conditions:

- a) best possible decoupling between the three ECG channels. Nonlinear distortion may cause a small degree of cross-talk;
- b) CCITT standardized subcarrier frequencies (2100 Hz and 1400 Hz) should be used as far as possible;
- c) no interference to existing CCITT signalling systems by simulation of switching signals.

Some of the existing ECG transmission systems use subcarrier frequencies $f_1 = 1075$ Hz, $f_2 = 1935$ Hz, $f_3 = 2365$ Hz. Due to the relatively slow modulation by ECGs, the modulated subcarrier frequencies f_2 and f_3 may simulate signals of CCITT Signalling Systems No. 2 and No. 4. This would cause interference to the ordinary telephone service. Where this kind of interference is not to be expected, use of the subcarrier frequencies concerned should be allowed over a transition period covering two CCITT study periods. Thereafter, the aforementioned frequencies (950 Hz, 1400 Hz and 2100 Hz) only should be used in the interest of mutual compatibility of the ECG transmission systems from different suppliers.

Note 2 - This value should be changed to 100 Hz/V, or 80 Hz/V if the full-scale voltage of ± 1 V or ± 1.25 V (see § 3.1.1 above) is applied.

3.2 *Forward digital data transmission from the remote station to the central station*

The analogue centre channel with a subcarrier frequency $f_2 = 1400$ Hz should be used for transmission of ECG-associated digital data. Channel characteristics are:

- centre frequency: $f_2 = 1400$ Hz (see Note)
- symbol 1, (mark): $f_z = f_2 - 80$ Hz
- symbol 0, (space): $f_a = f_2 + 80$ Hz
- coding: International Alphabet No. 5 as indicated in Recommendations V.3 and V.4, with start/stop transmission
- nominal modulation rate: 100 bauds
- power level: $p_2 \leq -11$ dBm

Note - In addition to the aforementioned signalling system, the following systems for forward digital data transmission are also in use:

- a) tri-level code, derived from frequencies $f_{1,2,3}$ and $f_{1,2,3} \pm$ approximately 100 Hz;
- b) serial code with $f_1 = 1075$ Hz ± 40 Hz and frequency shift keying (FSK);
- c) signalling with push-button telephone frequencies as specified in Recommendation Q.23 [1].

These variants should be allowed to remain in use for a transition period of two study periods. Afterwards, only the above recommended version should be used in order to obtain mutual technical compatibility of the instruments. This should also apply to future developments.

3.3 *Digital transmission in the backward direction from the central station to the remote station*

In order to send back interpretation results, control signals, etc., a digital backward channel with the following parameters should be provided:

- modulation by frequency shift keying with the following frequencies:

symbol 1 (mark):	$f_z = 390$ Hz (see Note)
symbol 0 (space):	$f_a = 570$ Hz

- nominal modulation rate: 200 bauds
- coding: International Alphabet No. 5 as indicated in Recommendations V.3 and V.4, with start/stop transmission
- transmission level: as specified in Recommendation V.2
- idle condition: symbol 1 (mark), 390 Hz
- level accepted by receiver: - 6 dBm to -40 dBm
- lower threshold level: -46 dBm.

Note - $f_z = 390$ Hz is in accordance with Recommendation V.23. For single tone signalling, $f = 389$ Hz (EIA standard for tone signalling) should be allowed for a transition period of two study periods. Afterwards, the above CCITT standard should be applied.

3.4 *Calibration signal*

At the beginning of the ECG recording a standardized calibration signal can be transmitted from the ECG recorder. by transmitting the combination ENQ (0/5) of International Alphabet No. 5 to the remote station (ECG recorder) the central station should call up and repeat this calibration signal whenever desired.

3.5 *Quality control*

In order to monitor the transmission quality and eliminate those parts of the transmitted ECG which contain interference pulses, suitable monitoring measures should be provided in the central modem. If a part of the transmitted ECG is disturbed, the central unit should send the signal DEL to the remote station.

A 40-dB signal-to-noise ratio in the baseband ECG channel is provisionally recommended as threshold level. The exact value needs further study.

3.6 *Interchange circuits*

The following interchange circuits should be optional. If interchange circuits are required, the following circuits should be provided:

3.6.1 *Interchange circuits between recording system and remote station modem*

If interchange circuits are necessary between the recorder and the modem, their functions should be in accordance with Recommendation V.24, and their electrical values in accordance with Recommendation V.28 or V.31, except circuits carrying analogue signals.

3.6.2 *Interchange circuits between the central modem and the interpretation system*

If these interchange circuits are necessary, they should also be in accordance with Recommendations V.24 and V.28.

The choice of the required interchange circuits needs further study.

3.7 *Procedures*

The required procedures also need further study with respect to mutual compatibility, echo suppressor disabling, answering tones, etc.

Note - A frequency scheme of subcarrier frequencies and associated digital channels is given in Figure 3/V.16.

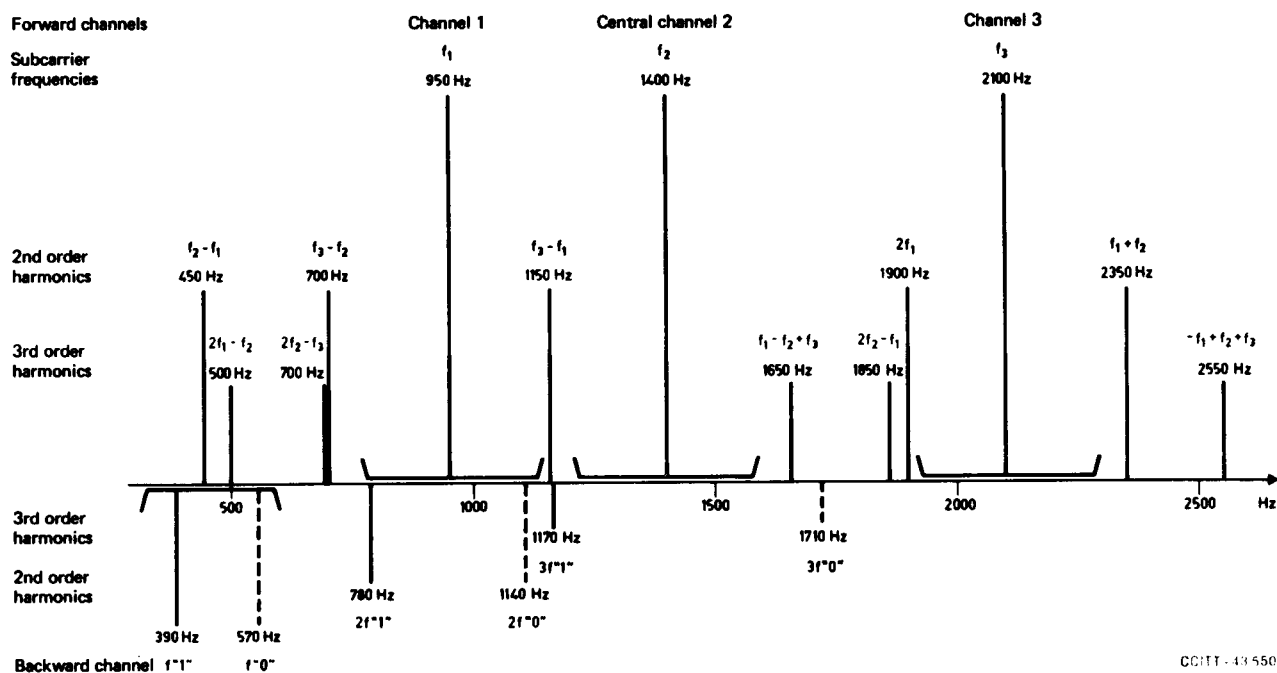
4 Modem for simultaneous analogue transmission of one ECG record

4.1 *General*

This specification enables single channel equipment for direct galvanic coupling or acoustic coupling to be designed which is compatible with the centre channel of the three-channel transmission equipment described in § 3 above.

4.2 Baseband signal when transmitting from the remote station to the central unit as specified in § 3.1.1 above but with the following amendments to be made to the parameters of the line signals:

- frequency: $f_2 = 1400$ Hz;
- power level: $p_2 \leq -6$ dBm.



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FIGURE 3/V.16

Frequency scheme of subcarrier frequencies and associated digital channels

In the case of acoustic coupling the above power level should not be exceeded at the output of the telephone set. The full scale limit may be extended to ± 5 mV. Linear operation is required up to ± 2.5 mV in this case. The slope of the modulator characteristic should be 40 Hz/mV for linear operation. These parameters are related to the patient's cable.

4.3 Digital transmission in the forward direction

Due to the limited number of possible applications, the use of the digital forward transmission channel should be optional. If provided, it should be in accordance with the digital transmission method described under § 3.2 above.

4.4 Digital transmission in the backward direction

The use of the digital backward channel should be optional. If provided, it should be in accordance with § 3.3 above. If no digital backward channel is provided, the answering tone (389 Hz) should be sent.

4.5 Single channel central modem

If required, a single channel central modem for direct galvanic coupling to the telephone line can also be designed with the parameters of the centre channel. The maximum deviation may be extended to 200 Hz. Here, all means for transmission of ECG-associated digital data are optional. If provided, they should be in accordance with the digital transmission method described under §§ 3.2 and 3.3 above.

Reference

- [1] CCITT Recommendation *Technical features of push-button telephone sets*, Vol. VI, Rec. Q.23.