

**Recommendation T/CS 46-03 (Innsbruck 1981, revised at Nice 1985)**

**SIGNALLING SYSTEM FOR PUSH-BUTTON TELEPHONES COMBINING  
BASIC MULTIFREQUENCY SIGNALLING WITH DIRECT CURRENT SIGNALLING**

Recommendation proposed by Working Group T/WG 11 "Switching and Signalling" (CS)

*Revised text of the Recommendation adopted by the "Telecommunications" Commission:*

"The European Conference of Postal and Telecommunications Administrations,

*considering*

- that access to the services of the telephone network will be provided by telephone sets equipped with 12 or 16 push-buttons as recommended in CCITT Recommendation Q.11 [1] for multifrequency signalling;
- that the use of these telephone sets and their signalling technique for a simple type of end-to-end data transmission in the international as well as in national networks requires standardisation of the technique to be used;
- that the existing CCITT Recommendations on the subject do not yet assure the required standardisation;
- that the Administrations are in favour of harmonising telecommunications equipment and systems which could lead to a reduction in development and manufacturing cost for those industries that provide equipment for several countries,

*recommends*

to the members, the application of the signalling system for push-button telephones (including those of private automatic branch exchanges), conforming with the specifications set out below, when a method combining basic multifrequency signalling with direct current signalling is used."

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1. **PRINCIPLES AND CODING**

1.1. **General**

This section deals with the general characteristics of the combined multifrequency and direct current signalling system.

The signalling frequencies used are in accordance with CCITT Recommendation Q.23 [2], the line current during signal transmission being reduced from that under normal conversational conditions (accompanying direct current signal).

1.2. **Signal frequencies and codes**

1.2.1. *Signal frequencies*

The signal frequencies shall be selected from two separate groups within the speech band (300-3,400 Hz), a low group and a high group, each group providing four signalling frequencies. These frequencies shall be:

— low group frequencies: 697, 770, 852 and 941 Hz;

— high group frequencies: 1,209, 1,336, 1,477 and 1,633 Hz.

1.2.2. *Signal format*

Each signal shall consist of two and only two of the signalling frequencies, one frequency from each of the low and high groups, accompanied by a decrease in line current. Both frequencies and the decreased line current shall be applied simultaneously to the line.

1.2.3. *Signal code*

The sixteen discrete signals shall be allocated as shown in Table 1 (T/CS 46-03) below.

		High group frequencies			
Hz		1209	1336	1477	1633
Low group frequencies	697	1	2	3	A
	770	4	5	6	B
	852	7	8	9	C
	941	*	0	□	D

Table 1 (T/CS 46-03).

Table 1 (T/CS 46-03) gives the full allocation of signal codes.

The system may be utilized with only 10 discrete signals, in which case the signals designated \*, #, A, B, C and D will not be used; or with 12 discrete signals, in which case the signals A, B, C and D will not be used.

*Note:* The presentation in Table 1 (T/CS 46-03) corresponds to the actual lay-out of the push-buttons on the terminal equipment. The arrangements and designations of buttons are further specified in Recommendation T/CS 34-01 [3].

## 2. PUSH-BUTTON SENDER

### 2.1. Area of application and general

- 2.1.1. This Section deals with the multifrequency sender to be used in push-button telephones with accompanying direct current signal.
- 2.1.2. The sender has basically been specified for signalling to the exchange. However, regard has also been taken of the possible use of push-button telephones for end-to-end data transmission when manual operation applies.
- 2.1.3. The requirements stated in this Section apply to an unregulated generator, i.e. a generator in which the output levels are not controlled by the line current.

### 2.2. Operational conditions

The sender is expected to operate under varying environmental conditions.

- (a) A general purpose sender should operate in temperature controlled locations and partly temperature controlled locations, i.e. in normal living and working areas as well as entrances, staircases of buildings, factories and industrial plants, etc. The relevant climate conditions are described in Recommendation T/TR 02-06 [4]. The sender must meet the requirements within these conditions.
- (b) A wide temperature range sender should operate in open air as well as sites with heat trap, i.e. telephone booths and similar installations. The relevant climatic conditions are described in Recommendation T/TR 02-06 [4], Figure 3. The wide temperature range sender must meet the requirements within these conditions.

### 2.3. Output requirements

#### 2.3.1. Frequency tolerance

The output frequencies shall be maintained within  $\pm 1.5\%$  of their nominal values. This tolerance shall also include the effect of different line impedances offered to the sender.

#### 2.3.2. Sending level

The sending levels with a load resistance of 600 ohms shall be for:

option 1

- the high frequency group:  $-9 \text{ dBm} \pm 2 \text{ dB}$ ,
- the low frequency group:  $-11 \text{ dBm} \pm 2 \text{ dB}$ ;

option 2

- the high frequency group:  $-6 \text{ dBm} \pm 2 \text{ dB}$ ,
- the low frequency group:  $-8 \text{ dBm} \pm 2 \text{ dB}$ ;

with a restriction that the level of the higher frequency component of the compound signal shall be  $2 \pm 1 \text{ dB}$  above the level of the lower frequency component.

#### 2.3.3. Unwanted frequency components

##### 2.3.3.1. When a signal is output:

- (a) the total power level of all unwanted frequency components shall be at least 20 dB below the level of the low group frequency component of the signal;
- (b) the level of any individual unwanted frequency component shall not exceed the following limits:
  - in the frequency band 300-4,300 Hz: 33 dBm;
  - in the frequency band 4,300-28,000 Hz:  $-37 \text{ dBm}$  at 4,300 Hz, then falling at 12 dB/octave until 28 kHz;
  - in the frequency band 28-70 kHz:  $-70 \text{ dBm}$ ;
  - in the frequency band 70-200 kHz:  $-80 \text{ dBm}$ ;
  - in the frequency band above 200 kHz:  $-70 \text{ dBm}$ .

##### 2.3.3.2. When no signal is output, the level of any single frequency emitted from the sender to line shall not exceed $-80 \text{ dBm}$ .

#### 2.3.4. Risetime

The level of each of the two frequency components of the multifrequency signal shall be within 1 dB of the final value after 7 ms from the time that the line current starts to decrease.

The direct current of the line shall decrease to the upper limit of the signalling condition in not more than 8 ms from the time that the current starts to decrease.

### 2.3.5. *Signal timing*

When a button is depressed, the signal is output to line. It continues until the button is released.

If the signal output is automatically timed, the duration of the signal shall be  $70 \pm 5$  ms excluding risetime. In this case, the interdigital pause shall have a minimum value of 65 ms.

#### *Note 1. Frequency tolerance*

The tolerance specified in CCITT Recommendation Q.23 [2] is 1.8%. However, it was considered that 1.5% could be achieved in practice without any difficulty for the operating conditions specified in Section 2.2.

#### *Note 2. Sending level*

The lower sending levels are based on the application of CCITT Recommendation Q.15 [5] to the use of push-button telephones for end-to-end data transmission. Assumptions were made for average power losses and activity factors.

The pre-emphasis of 2 dB is a compromise between different national requirements. A tolerance of 1 dB was specified because it can be assumed that the drift in the power levels of the two single frequency components will be correlated.

#### *Note 3. Unwanted frequency components*

In § 2.3.4.1. the requirement (a) is related to the performance of the multifrequency signalling system itself. The requirement (b) is to avoid interference to this and other inband signalling systems and other channels in multiplex systems.

#### *Note 4. Risetime*

While a button is moving from the undepressed to the depressed position, the direct current and alternating current characteristics of the telephone set are changed, which will cause transients. The transients and the characteristics of the two-frequency signal limit the accuracy by which the risetime can be measured. Further, the time at which the button is operated may be difficult to identify. A firmer requirement than 7 ms can therefore hardly be verified in practice.

The amplitude of the transients depends upon the characteristics of the sender, the local line and the exchange feeding bridge. Although a limitation of the transients is necessary, it has not yet been possible to specify maximum values.

Two factors must be taken into account when specifying the amplitude and duration of transients:

- (a) for signalling to the exchange the influence of transients on the receiver performance must be limited;
- (b) for the purpose of data transmission, Administrations must ensure that in practice (e.g.: when the telephone, sender, local line and feeding bridge are associated) the amplitude and duration of transients at the output of the exchange feeding bridge does not significantly increase the level of the mean power transmitted to the national network.

#### *Note 5. Signal timing*

Provision is made here for the timing of signals from the sender to be achieved in either of two ways. Either the signal duration is controlled solely by the length of time the keypad button is depressed, or the sender itself may exert control on the signal duration in the manner specified.

## 2.4. **Electrical characteristics**

### 2.4.1. *Impedance*

The return loss of the sender against a pure resistance of 600 ohms shall be at least 14 dB in the frequency band 300-3,400 Hz.

### 2.4.2. *Speech suppression*

When a button is depressed the sending efficiency of the telephone set (from microphone to line) shall be decreased by at least 60 dB.

### 2.4.3. *Impedance unbalance to earth*

The impedance unbalance to earth measured in accordance with the principle of measurement in CCITT Recommendation Q.45 [6] shall be not worse than or equal to:

- in the frequency band 40- 300 Hz: 40 dB;
- in the frequency band 300- 600 Hz: 50 dB;
- in the frequency band 600-3,400 Hz: 55 dB.

During the measurement the telephone set shall be placed on a metallic surface which is connected to earth potential.

### 2.4.4. *Direct current condition*

The sender shall be powered by the line current feed. The sender shall function correctly with either normal or reversed current feed.

### 2.4.5. *Overvoltage protection*

The sender shall be adequately protected, in accordance with national requirements, against overvoltage, e.g. lightning, with buttons either operated or non-operated.

### 2.4.6. *Dial tone*

The sender shall operate correctly in the presence of dial tone.

#### *Note 1. Impedance*

The return loss is specified against a pure resistance of 600 ohms as this is in accordance with international practice and maintains a constant reference impedance throughout the specification. However, it is recognised that higher impedances are more appropriate for a number of national networks.

*Note 2. Direct current conditions*

The current feeding systems used by Administrations can differ significantly to the extent that it is not possible to specify requirements other than those stated in § 2.4.4. However, in order to facilitate the efforts of achieving a common design of senders to meet the requirements of different direct current feeding systems to be used with push-button telephones, the following information is provided (see U/I diagram, Figure 1 (T/CS 46-03)).

- i) Areas C in Figure 1 (T/CS 46-03) represent conditions which will not occur during normal operation. Their boundaries are the following straight lines:  
segment a :  $U = 106 - 1.4 I$   
segment b :  $U = 53 - 0.3 I$   
and  
segment c :  $U = 31 - 2.2 I$   
segment d :  $U = 42 - 3.4 I$   
(U: Volt; I: mA)
- ii) Area A in Figure 1 (T/CS 46-03) represents conditions which may occur in speech state. Its boundary (with the forbidden BB area) is represented by the following straight lines:  
segment e :  $I = 25$   
segment f :  $U = 1.975 + 0.271 I$   
segment g :  $U = 8.54 - 0.158 I$   
(U: Volt; I: mA)
- iii) Area B in Figure 1 (T/CS 46-03) represents conditions which may occur in signalling state. Its boundaries (with the forbidden BB area) are the following straight lines:  
segment i :  $U = 5.17 I$   
segment j :  $U = 18 I - 60$   
segment k :  $U = 6.5$   
and  
segment l :  $I = 9$   
segment m :  $U = 4 I$   
(U: Volt; I: mA)
- iv) For a sender during signalling state in areas C of Figure 1 (T/CS 46-03) there are no requirements.
- v) During speech state the U/I curve should not enter areas BA and BB.

*Note 3. Overvoltage protection*

The overvoltage protection provided should also take care of the effects of the ringing voltage which might occur with buttons either undepressed or depressed.

*Note 4. Control tone*

If a control tone is required by Administrations when a button is depressed, then it is necessary to specify a requirement for the sender such that the tone at the telephone receiver is at an acceptable level, e.g. about 65 to 85 dB relative to 20  $\mu$ Pa measured by a CCITT recommended artificial ear.

### 3. THE EXCHANGE RECEIVER

#### 3.1. Area of application

This Section deals with the receiver or receiver function for use in local exchanges and in private automatic branch exchanges.

The receiver shall respond to signals received over a line from a distant sender conforming to Section 2. The receiver shall be equipped to recognise the sixteen signals designated 1 to 0, ★, #, A, B, C and D. The system may be utilised with only ten discrete signals, in which case the signals designated ★, #, A, B, C and D will not be used; or with twelve discrete signals, in which case the signals A, B, C and D will not be used.

*Note 1:* The principles uses of the receiver are expected to be:

- (a) in a local exchange, connecting with an ordinary subscriber;
- (b) in a local exchange, connecting with a private automatic branch exchange, and,
- (c) in a private automatic branch exchange, connecting with an extension.

*Note 2:* Should the need arise to recognize all 16 signals, it should be possible to adapt the receiver equipment without excessive cost.

#### 3.2. Operating conditions

The requirements specified shall be met when the receiver is installed in a local exchange or a private automatic branch exchange and is thus subject to the environments therein. The relevant climatic conditions are described in Recommendation T/TR 02-03 [7], and the receiver must be designed to operate properly within these conditions.

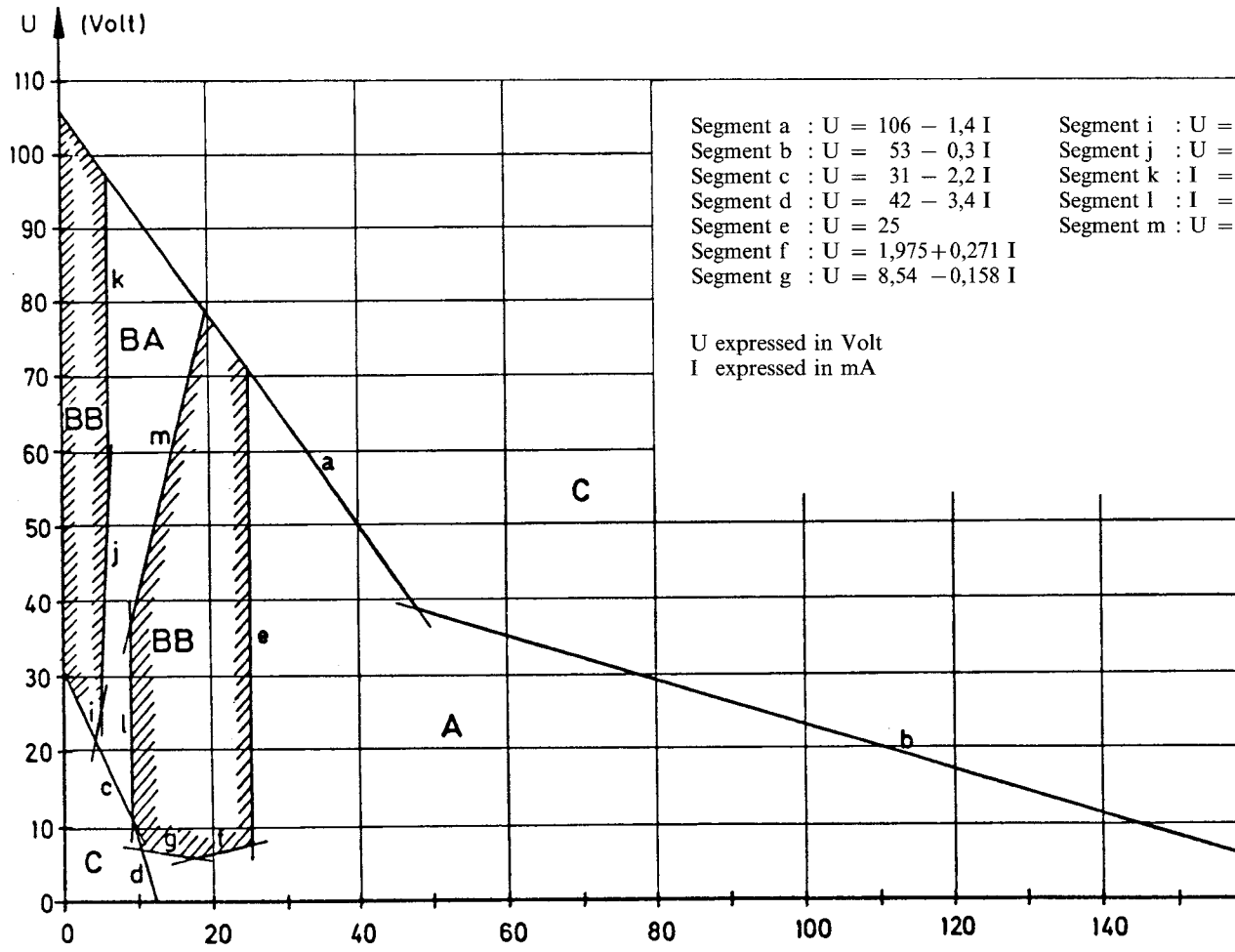


Figure 1 (T/CS 46-03).

### 3.3. Operate and non-operate requirements

#### 3.3.1. Signal condition

The *signal condition* (SC) is defined as the state of the line at the input of the receiver when the electrical signals on it correspond to a genuine signal (as specified in Section 1.2.) accompanied by an acceptable amount of other unwanted frequencies. The exact definition of the components concerned is given in paragraph 3.3.3.

#### 3.3.2. Character recognition condition

The *character recognition condition* (CRC) is defined as the functional state which the receiver is in, when the signal condition and time requirements (as specified in paragraph 3.3.4.) are satisfied. This functional state causes the correct one of the 16 (or 12 or 10 depending on the system utilisation) possible signal codes (as specified in Section 1.2.) to be output. When required by the exchange the receiver will also output information on the beginning and end of the character recognition condition.

#### 3.3.3. Signal condition requirements

The following applies provided that a receiver has been associated to the line by an accompanying direct current signal generated as described in paragraphs 2.3.4. and 2.4., Note 2, iii) (direct current conditions).

##### 3.3.3.1. The signal condition as defined in paragraph 3.3.1. and in accordance with the system utilisation as described in paragraph 3.3.2., exists if, on the line at the functional input of the receiver:

- (a) two of the signalling frequencies are present, one of each of the low and high frequency groups as specified in Section 2.1.2., *and*
- (b) each of these signalling frequencies is within  $\pm (1.5\% + 2 \text{ Hz})$  of the nominal value, *and*
- (c) the level of each of these two signalling frequencies is within the range A to A + 25 dBm (where A will be specified by each individual Administration in the range -22 to -30 dBm), *and*
- (d) the difference in level of these two signalling frequencies is less than 6 dB, *and*
- (e) these two frequencies are accompanied by other frequencies not exceeding:
  - i) in the range 15-480 Hz, an individual level of A + 48 dBm at 15 Hz until 33 Hz then falling at 20 dB per octave until 300 Hz. From 300-480 Hz a level of A - 16 dBm. Also when dial tone protection is present in the receiver a total level of A + 22 dBm in the range 100-480 Hz shall additionally apply to cover interference from this source;
  - ii) in the range 480-3,400 Hz, a total level of 20 dB below the level of the *low* group signalling frequency, or A - 16 dBm, whichever is the higher;
  - iii) in the range over 3,400 Hz, an individual level of A - 9 dBm at 3,400 Hz rising at 6 dB per octave to a level of +10 dBm.

##### 3.3.3.2. The signal condition as defined in paragraph 3.3.1. does not exist if, on the line at the functional input of the receiver:

- (a) the level of that signalling frequency in the low signalling frequency group (as defined in Section 1.2.) which has the highest level of the four signalling frequencies of the group is less than A - 9 dBm, or
- (b) the level of that signalling frequency in the high signalling frequency group (as defined in Section 1.2.) which has the highest level of the four signalling frequencies of the group is less than A - 9 dBm.

The non-existence of the signal condition and the simultaneous existence of the accompanying direct current signal must be considered as a failure of the system. The simultaneous non-existence of the signal condition and of the accompanying direct current signal represents the pause condition.

#### 3.3.4. Character recognition requirements

##### 3.3.4.1. The character recognition condition as defined in paragraph 3.3.2. shall exist if:

- (a) the corresponding signal condition is preceded by the continuous non-existence of a signal condition for more than 30 ms, or (optionally) by a different character recognition condition, and
- (b) the signal condition then exists continuously for more than 30 ms. However, when this signal condition exists for less than 10 ms, this character recognition condition shall not exist.



3.3.4.2. Once the character recognition condition exists, it shall be unaffected by an interval of less than 10 ms. Between two signal conditions corresponding to the same signal code (as specified in Section 1.2.) the interval consists either:

- (a) of any break in the signal condition, or
- (b) of a signal condition corresponding to a different signal code (as defined in Section 1.2.).

*Note 1. Signal condition*

This paragraph and the following one define the philosophy used in this specification; that is, to specify all the requirements in terms of the input and the functional output of the receiver only, with the objective to minimise the restrictions imposed on the variety of possible design implementations.

*Note 2. Character recognition condition*

In the cases where the system is implemented using only 10 or 12 possible signal codes, pairs of signalling frequencies corresponding to unused signal codes either:

- (a) are deemed to be unwanted frequencies and thus are treated in the manner specified in paragraphs 3.3.1. and 3.3.3., or
- (b) cause the recognition condition to exist (dependent, of course, on the requirements of paragraph 3.3.4.), but cause no signal code to be output.

The structure of the receiver will determine which of the above two options is used.

*Note 3. Signal condition requirements*

As an aid to the understanding of this paragraph, Table 2 (T/CS 46-03) is given.

Signal condition	Frequency deviation	Signal level x	Signal level difference y	Unwanted frequencies z
Does exist	$\leq \pm (1.5\% + 2 \text{ Hz})$	$A \leq x \leq A + 25 \text{ dBm}$	$y < 6 \text{ dB}$	$z \leq U^* \text{ dBm}$
May exist	$> \pm (1.5\% + 2 \text{ Hz})$	$A - 9 \leq x < A \text{ dBm}$ or $x > A + 25 \text{ dBm}$	$y \geq 6 \text{ dB}$	$z > U^* \text{ dBm}$
Does not exist		$x < \infty - 9 \delta > \mu$		

U\*: Paragraph 3.3.3.1., Point (e), i) to iii) inclusive.

Table 2 (T/CS 46-03).

It is realised that certain electrical signals may exist on the line at the input of the receiver which do not fulfil either the requirements of the *does* row or those of the *does not* row.

- i) The frequency deviation requirement of paragraph 3.3.3.1. (b) is specified in two parts, a percentage part and a frequency part. This method is chosen because it is recognized that deviation from nominal value is due to two causes. Firstly, deviation is caused by frequency tolerances within the push-button sender and for this, the percentage part is specified; secondly, deviation is also caused by frequency shifts due to any frequency division multiplex carrier systems which may be encountered in the signalling path and for this, the frequency part is specified.
- ii) In part (c) of paragraph 3.3.3.1., a dynamic range of 25 dB is specified to take into account tolerances in the send levels of the push-button sender and also variations in attenuation found in the local lines of the various Administrations. The parameter A is specified to take into account the possible variations in the attenuation of the exchange between the subscriber's line exchange termination and the receiver.
- iii) It is pointed out that, in paragraph 3.3.3.1. (e), iii) additional protection may be required by some Administrations to cover interference from specified sources, e.g. meter pulses.

*Note 4. Character recognition condition requirements*

As an aid to the understanding of this paragraph, Table 3 (T/CS 26-1) is given.

Character recognition	When $\overline{\text{CRC}}^*$ and then	Character recognition	When CRC and then
Shall	$\text{SC} > 30 \text{ ms}$	Shall	$\overline{\text{SC}} > 30 \text{ ms}$
May	$10 \leq \text{SC} \leq 30 \text{ ms}$	May	$10 \leq \overline{\text{SC}} \leq 30 \text{ ms}$
Shall not exist	$\text{SC} < 10 \text{ ms}$	Shall not cease	$\overline{\text{SC}} < 10 \text{ ms}$

\* or optionally a different character recognition condition.

Table 3 (T/CS 46-03).

- Legend:*
- $\text{SC}$  = The continuous existence of signal condition.
  - $\overline{\text{SC}}$  = The continuous non-existence of signal condition.
  - $\text{CRC}$  = The existence of character recognition condition.
  - $\overline{\text{CRC}}$  = The non-existence of character recognition condition.

- i) Depending on the design of the telephone containing the multifrequency sender, the signal condition may be preceded by a transient due to the change in the direct current resistance of the telephone instrument.
- ii) It is pointed out that the maximum permitted delay time of the sender accompanying direct line current as specified in § 2.3.5. is 8 ms. This will have an effect on the time for which a push-button will have to be depressed in order to achieve character recognition.

3.4. **Speech immunity**

No specification is required.

Speech immunity is achieved by presence of the accompanying direct current signal.

3.5. **Electrical characteristics**

3.5.1. *Impedance*

The impedance measured at the receiver input shall be at least 10 kohms over the frequency range 300-3,400 Hz.

For the case when the subscriber's line is terminated with the input of the receiver and for testing purposes, a nominal impedance of 600 ohms shall be connected across the receiver.

3.5.2. *Unbalance to earth*

The impedance unbalance to earth presented by the receiver and a parallel resistor equal in value to the nominal impedance of the exchange termination is measured in accordance with the principles of measurement in CCITT Recommendation Q.45 [6]. When the receiver is connected directly across the line, it shall be not worse than or equal to 46 dB over the frequency range 15-40 Hz and 60 dB over the range 30-3,400 Hz.

3.5.3. *Protection against common mode noise*

The correct operation of the receiver must not be adversely affected when the subscriber's line is subjected to common mode noise with a total e.m.f. of less than or equal to 60 volts (r.m.s.) in the range 15-60 Hz.

3.5.4. *Power feed*

All voltages used to power the receiver circuits must be derived from the exchange battery.

*Note:* The battery voltages used by Administrations in their local exchanges to derive the power for the receiver differ significantly to the extent that it is not possible to specify requirements other than those stated.

However, in order to aid the achievement of a common design of receiver to meet the requirements of different battery voltages to be used with the exchange receiver, it is pointed out that minimum and maximum values of battery voltages are in all cases within the range from 31 to 66 volts.

**References**

- [1] CCITT Recommendation Q.11. *Numbering and dialling procedures for international service.*
- [2] CCITT Recommendation Q.23. *Technical features, of push-button telephone sets.*
- [3] Recommendation T/CS 34-01. *Arrangements of push-buttons and the symbols for their designation.*
- [4] Recommendation T/TR 02-06. *Environmental Conditions for Telecommunication Equipment, Conditions for Telecommunication Equipment at Weather-Protected Locations (excluding Telecommunication Centres with Temperature and Humidity Controls) and in the Open Air.*
- [5] CCITT Recommendation Q.15. *Nominal mean power during the busy hour.*
- [6] CCITT Recommendation Q.45. *Transmission characteristics of an international exchange.*
- [7] Recommendation T/TR 02-03. *Environmental conditions for the equipment to be installed in telecommunication centres.*