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**Public Switched Telephone Network (PSTN);
Multifrequency signalling system to be used
for push-button telephones**

[CEPT Recommendation T/CS 46-02 E (1985)]

ETSI

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Foreword

This ETSI Technical Report (ETR) has been produced by the Signalling Protocols and Switching (SPS) Technical Committee of the European Telecommunications Standards Institute (ETSI).

ETRs are informative documents resulting from ETSI studies which are not appropriate for European Telecommunication Standard (ETS) or Interim European Telecommunication Standard (I-ETS) status. An ETR may be used to publish material which is either of an informative nature, relating to the use or the application of ETSS or I-ETSS, or which is immature and not yet suitable for formal adoption as an ETS or an I-ETS.

This work was initiated by the restructuring of CEPT (Conférence Européenne des administrations des Postes et des Télécommunications) and the creation of ETSI. As reported to the 16th Technical Assembly of ETSI, CEPT has proposed to transfer some Recommendations to ETSI which pertain to standardization.

Technical Committee SPS decided to convert these Recommendations into ETRs without any modification. The reader should note that undated references may no longer be relevant.

Endorsement notice

The text of CEPT Recommendation T/CS 46-02 E (1985) was approved by ETSI as an ETR without any modification.

NOTE: Due to the unavailability of the endorsed CEPT Recommendation, it is reproduced on the following pages of this ETR.

Recommendation T/CS 46-02 (Innsbruck 1981, revised at Nice 1985)

MULTIFREQUENCY SIGNALLING SYSTEM TO BE USED FOR PUSH-BUTTON TELEPHONES

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

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

the use by the member Administrations of the multifrequency signalling system for push-button telephones (including those of private automatic branch exchanges), conforming with the specifications set out hereafter."

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BASIC MULTIFREQUENCY PUSH-BUTTON (MFPB) SIGNALLING SYSTEM

1. SIGNALLING SYSTEM PRINCIPLES AND CODING

1.1. General

This section deals with the general characteristics of the signalling system and conforms to CCITT Recommendation Q.23 [2].

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. Both frequencies shall be applied simultaneously in parallel across the line.

1.2.3. Signal code

The 16 discrete signals shall be allocated as shown in Table 1 (T/CS 46-02) 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 46-02).

Table 1 (T/CS 46-02) 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 46-02) 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

This Section deals with the multifrequency sender which is used in push-button telephones.

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.

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, Figure 3 [4]. The wide temperature range sender must meet the requirements within these conditions.

2.3. Signal 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 dBm at 4,300 Hz, then falling at 12 dB/octave until 28 kHz;
 - in the frequency band 28-70 kHz: -70 dBm ;
 - in the frequency band 70-200 kHz: -80 dBm ;
 - in the frequency band above 200 kHz: -70 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 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 within 7 ms from the time that any button is operated.

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 $70 \pm 5 \text{ ms}$ 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 § 2.3.3.1. 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.

The specification in § 2.3.3.2. assures that none of the frequencies is audible during the conversation condition.

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 with 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 could 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 (i.e.: 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 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 realisation of a common design of sender to meet the requirements of different direct current feeding systems to be used with push-button telephones, the following information is provided.

- i) Minimum and maximum conditions of the feeding systems in different countries are given in Table 2 (T/CS 46-02) below. The column *minimum current* relates to the current needed to hold the connection.
- ii) The minimum and maximum conditions for each system can be represented by straight lines in a U/I diagram, Figure 1 (T/CS 46-02):
 maximum condition $U = U_{\max} - I \cdot R_{\min}$
 minimum condition $U = U_{\min} - I \cdot R_{\max}$

| Country | Battery voltage (V) | | Total resistance of feeding bridge and line | | Minimum current (mA) |
|----------------|---------------------|------|---|---------------------|----------------------|
| | min. | max. | min. | max. | |
| Belgium | 44 | 52 | 400 | 1,600 | 20 |
| Denmark | 44 | 56 | 450 | 2,480 | 15.3 |
| Finland 1 | 44 | 53 | 700 | 2,500 | 15 |
| Finland 2 | 56 | 66 | 900 | 2,700 | 18 |
| France 1 | 45 | 53 | 300 | 1,820 | 12 |
| France 2 | 90 | 106 | 1,400 | 2,800 | 12 |
| FR Germany | 57 | 64 | 1,260 | 3,240 ¹⁾ | 17 |
| Italy | 44 | 52 | 720 | 3,010 | 12 ²⁾ |
| Netherlands | 42 | 56 | 640 | 2,140 | 16 |
| Norway | 44 | 52 | 500 | 2,000 | 17 |
| Spain 1 | 44 | 52 | 300 | 2,340 | 10 |
| Spain 2 | 44 | 56 | 500 | 1,856 | 15 |
| Sweden 1 | 31 | 45 | 1,000 | 2,200 | 11 |
| Sweden 2 | 42 | 56 | 1,600 | 3,400 | 9.5 |
| Switzerland 1 | 44 | 54 | 700 | 1,700 | 21 |
| Switzerland 2 | 56 | 66 | 1,000 | 2,000 | 22.5 |
| United Kingdom | 45 | 52 | 360 | 1,450 | 25 |

Table 2 (T/CS 46-02).

¹⁾ This includes the resistance of the telephone.

²⁾ This value also ensures the proper functioning of the meter at the subscriber's premises.

The area between these lines represents all possible feeding conditions for the sender. The part of this area with currents smaller than the minimum current should not be entered by the U/I curve of the sender. For the systems in Table 2 (T/CS 46-02), the lowest points of this forbidden area have been calculated, and are shown in Table 3 (T/CS 46-02).

- iii) A curve through the lowest points as shown in Figure 1 (T/CS 46-02) represents the lower boundary of the forbidden area B, for a sender which is suitable for all systems in Table 2 (T/CS 46-02). The other boundaries for area B are a vertical line starting in the point with the highest minimum current (25 mA) and lines representing the extremes in minimum feeding conditions (S_1 and S_2).
- iv) For the systems mentioned in Table 2 (T/CS 46-02); the upper limits are determined by the extremes in maximum feeding conditions.
- v) Area C represents conditions which will not occur during normal operation.
- vi) For a sender suitable for all systems in Table 2 (T/CS 46-02), the meaning of the areas is as follows.
 — For all conditions represented by the part of the U/I curve in area A, all requirements should be fulfilled.

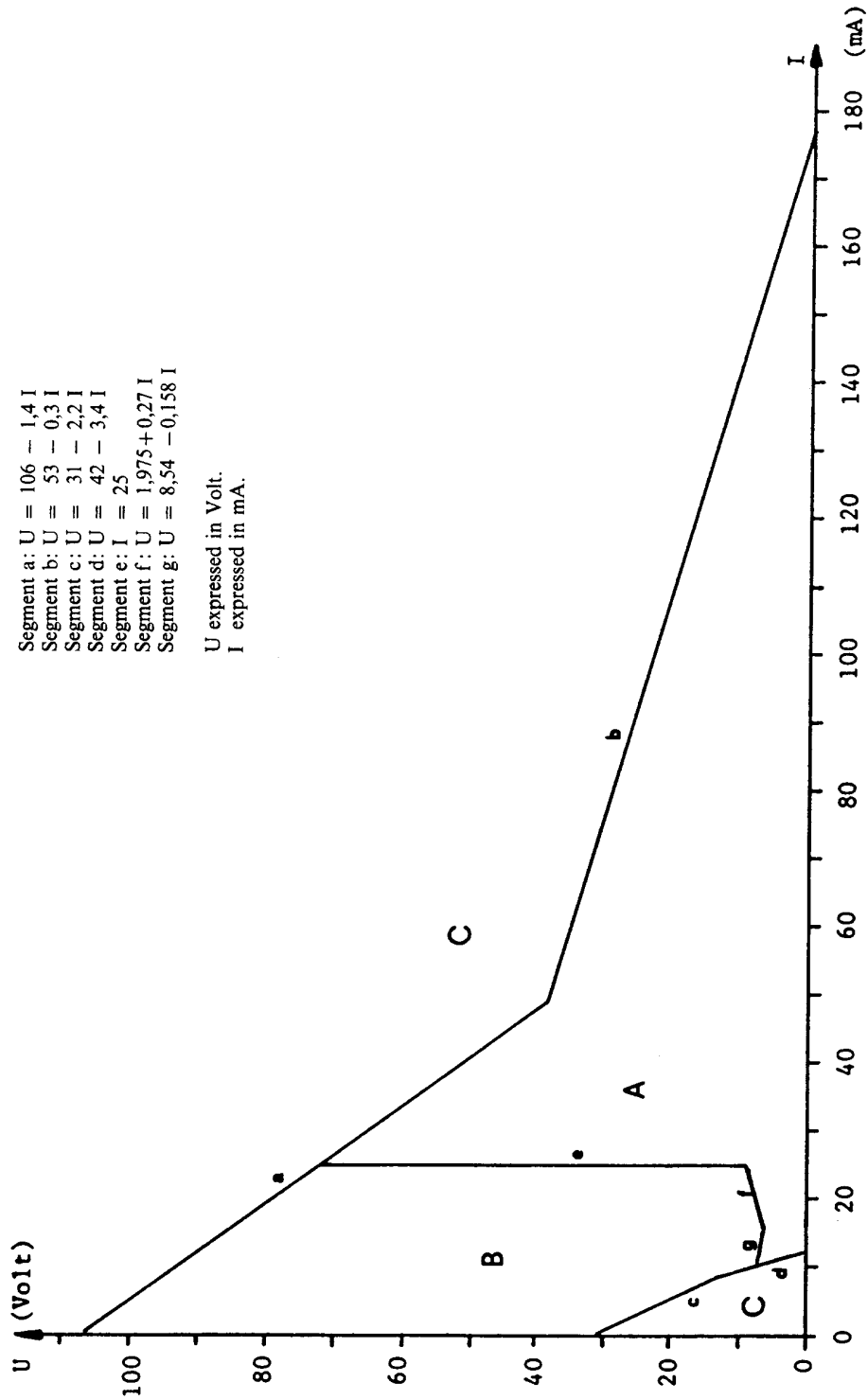


Figure 1 (T/CS 46-02).

| Country | Current (mA) | Voltage (volts) |
|----------------|--------------|-----------------|
| Belgium | 20 | 12 |
| Denmark | 15.3 | 6.12 |
| Finland 1 | 15 | 6.5 |
| Finland 2 | 18 | 7.4 |
| France 1 | 12 | 23 |
| France 2 | 12 | 56 |
| FR Germany | 17 | 9.2 |
| Italy | 12 | 7.88 |
| Netherlands | 16 | 7.76 |
| Norway | 17 | 10.0 |
| Spain 1 | 10 | 10.6 |
| Spain 2 | 15 | 16.16 |
| Sweden 1 | 11 | 6.8 |
| Sweden 2 | 9.5 | 9.7 |
| Switzerland 1 | 21 | 8.3 |
| Switzerland 2 | 22.5 | 11 |
| United Kingdom | 25 | 8.76 |

Table 3 (T/CS 46-02).

- The U/I curve should not enter area B.
- In area C there are no requirements.

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 µPa measured by a CCITT recommended artificial ear.

3. THE RECEIVER FOR ANALOGUE EXCHANGES

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 principal uses of the receiver are expected to be:

- (a) in a local exchange, for connection to ordinary subscriber lines;
- (b) in a local exchange, for connection to private automatic branch exchanges, and
- (c) in a private automatic branch exchange, for connection to extensions.

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.

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*

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 1.3.3.2. 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 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 $A + 25 \text{ dBm}$ (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 $15\text{--}480 \text{ Hz}$, an individual level of $A + 48 \text{ dBm}$ at 15 Hz until 33 Hz then falling at 20 dB per octave until 300 Hz . From $300\text{--}480 \text{ Hz}$ a level of $A - 16 \text{ dBm}$. Also when dial tone protection is present in the receiver a total level of $A + 22 \text{ dBm}$ in the range $100\text{--}480 \text{ Hz}$ shall additionally apply to cover interference from this source;
 - ii) in the range $480\text{--}3,400 \text{ Hz}$, a total level of 20 dB below the level of the *low* group signalling frequency, or $A - 16 \text{ dBm}$, whichever is the higher;
 - iii) in the range over $3,400 \text{ Hz}$, an individual level of $A - 9 \text{ dBm}$ at $3,400 \text{ Hz}$ rising at 6 dB per octave to a level of $+10 \text{ dBm}$.

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 $A - 9 \text{ dBm}$, 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 $A - 9 \text{ dBm}$.

This non-existence of the signal condition is also known as 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 40 ms , or (optionally) by a different character recognition condition, *and*
- (b) the signal condition then exists continuously for more than 40 ms . However, when this signal condition exists for less than 20 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 20 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 4 (T/CS 46-02) 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 | | $x < A - 9 \text{ dBm}$ | | |

Table 4 (T/CS 46-02).

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

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. In these circumstances, the requirements for the existence or non-existence of signal condition are not specified directly, but indirectly through the speech immunity requirements of Section 3.4.

- 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:
 - deviation is caused by frequency tolerances within the push-button sender and for this, the percentage part is specified;
 - 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.
- 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.
- 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 5 (T/CS 26-1) is given.

| Character recognition | When $\overline{\text{CRC}}$ * and then | Character recognition | When CRC and then |
|-----------------------|---|-----------------------|---|
| Shall exist | $\text{SC} > 40 \text{ ms}$ | Shall cease | $\overline{\text{SC}} > 40 \text{ ms}$ |
| May exist | $20 \leq \text{SC} \leq 40 \text{ ms}$ | May cease | $20 < \overline{\text{SC}} < 40 \text{ ms}$ |
| Shall not exist | $\text{SC} < 20 \text{ ms}$ | Shall not cease | $\overline{\text{SC}} < 20 \text{ ms}$ |

* or optionally a different character recognition condition.

Table 5 (T/CS 46-02).

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

- 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.
- It is pointed out that the maximum permitted risetime of the sender as specified in paragraph 2.3.4. is 7 ms and 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 performance (Test conditions)

3.4.1. The receiver should not perform more than 46 false operations per 100 speech hours at a long term (mean) level of speech while active at A + 15 dBm.

3.4.2. A speech hour is defined as a total duration of one hour when speech (in both directions) may be present, that is when the circuit is seized and the call established (conversation condition).

Note 1: The figure of 46 false operations specified was based upon an overall performance requirement of one false operation per 10,000 digits dialled, and the following assumed performance of the average subscriber:

Pre-dialling pause: 2.5 s
 Inter-digital pause: 0.5 s
 Number of digits dialled per call: 7

Note 2: In addition to the simulation of signals by speech entering via the microphone, misoperation may also be caused by disturbances blocking valid signals and/or splitting them into double digits. The design of a receiver with a very high rejection efficiency against signal imitation might lead to an intolerable increase in the number of blockings. The general design aim should be to limit both types of misoperation (imitation and blocking) to a total level not exceeding one per 10,000 digits dialled.

Note 3: The duration of 100 hours has been given as the recommended test duration to ensure accuracy and reliability of results. It may be possible to reduce this figure with some test methods.

- 3.4.3. For test of the speech immunity performance or for comparison between different receivers the test tape specified in Annex 1 can be used.

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 40-3,400 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, the information given in Table 6 (T/CS 46-02) is provided.

| Country | Battery voltages | |
|----------------|------------------|------|
| | min. | max. |
| Belgium | 44 | 52 |
| Denmark | 44 | 56 |
| Finland 1 | 44 | 53 |
| Finland 2 | 56 | 66 |
| France | 45 | 53 |
| FR Germany | 57 | 64 |
| Italy 1 | 41 | 52 |
| Italy 2 | 52 | 66 |
| Netherlands | 42 | 56 |
| Norway | 44 | 52 |
| Spain 1 | 44 | 52 |
| Spain 2 | 44 | 56 |
| Sweden 1 | 31 | 45 |
| Sweden 2 | 42 | 56 |
| Switzerland 1 | 42 | 54 |
| Switzerland 2 | 54 | 66 |
| United Kingdom | 45 | 52 |

Table 6 (T/CS 46-02).

4. THE RECEIVER FOR DIGITAL EXCHANGES

4.1. Area of application

- 4.1.1. This Section deals with the receiver or receiver function for use in digital local exchanges and in digital private automatic branch exchanges.
- 4.1.2. The receiver shall respond to signals received over an analogue line from a distant sender conforming to Section 2.

- 4.1.3. 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 principal uses of the receiver are expected to be:

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

4.2. Operation conditions

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

4.3. Operate and non-operate requirements

4.3.1. 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 input of the receiver is assessed at the MDF (Main distribution frame). The exact definition of the components concerned is given in paragraph 4.3.3.

4.3.2. 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 4.3.4.) 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.

4.3.3. Signal condition requirements

- 4.3.3.1. The signal condition as defined in paragraph 4.3.1. and in accordance with the system utilisation as described in paragraph 4.3.2. exists if, on the line at the MDF:

- (a) two of the signalling frequencies are present, one of each of the low and high frequency groups as specified in Section 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 -4 dBm0 to B (where B will be specified by each individual Administration in the range -22 to -29 dBm0), and
- (d) the difference in level of these two signalling frequencies is less than 6 dB,
- (e) these 2 frequencies are accompanied by other frequencies not exceeding:
 - i) in the range 15-300 Hz an individual level of 0 dBm0 at 15 Hz until 50 Hz then falling at 12 dB per octave until 300 Hz (-31 dBm0). The total amount of all signal frequency components should not exceed 0 dBm0;
the exchanges shall ensure character recognition condition in the presence of dial tone in addition to the disturbances specified in this paragraph in any loop condition; specification of parameters of the dial tone is the subject of another recommendation;
 - ii) in range 300-3,400 Hz a total level of 20 dB below the level of the low group signalling frequencies or $(B - 16) \text{ dBm0}$ whichever is the higher;
 - iii) the range over 3,400 Hz is for further study.

- 4.3.3.2. The signal condition as defined in paragraph 4.3.1. does not exist if, on the line at the MDF:

- (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 $(B - 9) \text{ dBm0}$, 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 $(B - 9) \text{ dBm0}$.

This non-existence of the signal condition is also known as the pause condition.

4.3.4. *Character recognition requirements*

4.3.4.1. The character recognition condition as defined in paragraph 4.3.2. shall exist if:

- (a) the corresponding signal condition is preceded by the continuous non-existence of a signal condition for more than 40 ms, or (optionally) by a different character recognition condition, and
- (b) the signal condition then exists continuously for more than 40 ms. However, when this signal condition exists for less than 20 ms, this character recognition condition shall not exist.

4.3.4.2. Once the character recognition condition exists, it shall be unaffected by an interval of less than 20 ms between two signal conditions corresponding to the same signal code (as specified in Section 1.2.) where 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: Notes 1, 2, 3, 4 in paragraph 3.3.4.2. apply also to this paragraph.

4.4. **Speech immunity performance (test conditions)**

4.4.1. The receiver should not perform more than 46 false operations per 100 speech hours at a long term (mean) level of speech while active at (B + 15) dBm0.

4.4.2. A speech hour is defined as a total duration of one hour when speech (in both directions) may be present, that is when the circuit is seized and the call established (conversation condition).

Note 1: Notes 1, 2 and 3 in paragraph 3.4.2. apply also to this paragraph.

4.4.3. *Standardized common test tape*

For test of the speech immunity performance or for comparison between different receivers the test tape specified in Annex 1 can be used.

References

- [1] CCITT Recommendation Q.11. *Arrangement of figures, letters and symbols on rotary dials and pushbutton telephone sets.*
- [2] CCITT Recommendation Q.23. *Technical features of push-button telephone sets.*
- [3] CCITT Recommendation T/CS 34-01. *Arrangement of push-buttons and the symbols for their designation.*
- [4] CCITT 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 analogue exchange.*
- [7] CCITT Recommendation T/TR 02-03. *Environmental conditions for the equipment to be installed in telecommunication centres.*

Annex 1

Standardized common test tape

- (a) The speech immunity performance of the exchange receiver is tested by means of a standardized common test tape.
- (b) The common standardized test tape is the collection of "bursts" which simulate characters on a reference unprotected exchange receiver when a speech source is applied at the MDF.
The duration of the bursts can be fixed in $X = 200$ ms, the duration of the pauses can be fixed in $Y = 200$ ms.
- (c) The reference unprotected exchange receiver is defined in Figure 2 (T/CS 46-02) and in the notes to Figure 2.
- (d) The speech source is equally subdivided in five languages e.g. French, English, German, Spanish and Italian, and equal length of female and male voices.
The used parameters, concerning the speech source are those specified in paragraphs 3.4.1. and 3.4.2., Recommendation 46-02.
- (e) It is appropriate on the experience available to realise a test tape of about 20 minutes. This corresponds to a speech source without rest of about 10 hours.
It means that 2 hours of speech duration for each of the five used languages are required.
- (f) In order to realize the standardized common test tape the following instructions are provided.
The speech sources (different languages) are applied to the reference unprotected exchange receiver and to a computer, where these are sampled in a A/D converter (12 bit minimum) and continuously stored in a cyclic memory buffer, see Figure 3 (T/CS 46-02).
Each time the receiver recognizes a false digit a signal is sent to the computer and the content of the memory buffer is transferred to a magnetic tape, which becomes the master (reproducible) tape.
The length X ms (e.g. 200 ms) of the transferred burst is software controlled. It is assumed $X = X_1 + X_2$ where
 X_1 = Time preceding the false character recognition (e.g. 110 ms).
 X_2 = Time following the false character recognition (e.g. 90 ms).
About the level the digital samples are such, that the clipping point of the A/D converter is equal to the peak value of a sinusoid at 3.14 dBm. The analog Tape is obtained by reading all the digital bursts in sequence and converting them again in the analog form by means of a D/A converter followed by a PCM receiver filter.
A sinusoid wave at 1kHz with a level of 0 dBm must be digitally generated by the computer at the beginning of the tape so that it can be used to regulate the level of reproduced signals.
Particular attention has to be devoted in order to guarantee the best performance when the tape in analog form is used to test the receiver. An Hi-Fi tape recorder is suggested both to record the tape and to play it back.

Notes to Figure 2 (T/CS 46-02)

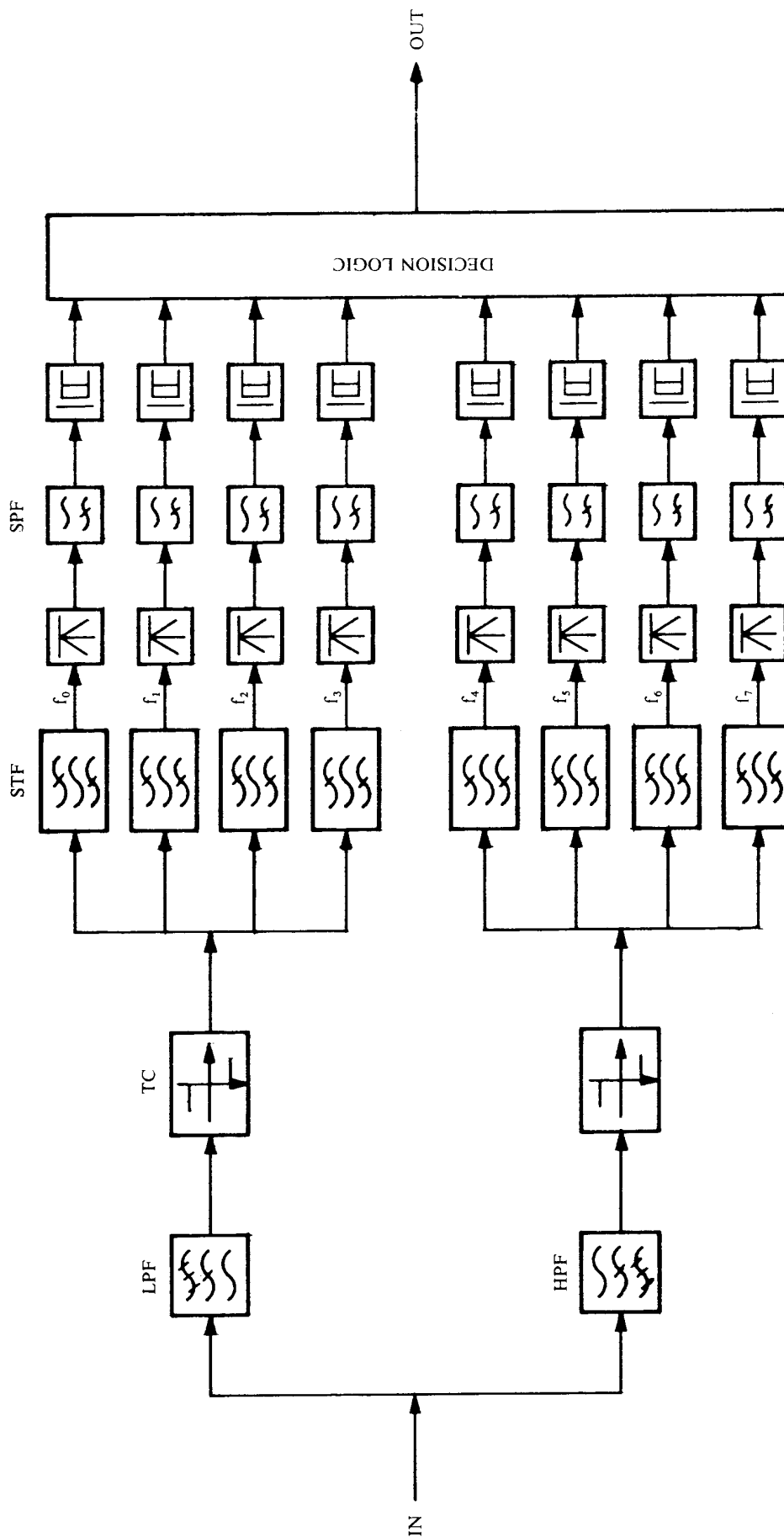
The scheme of the reference unprotected exchange receiver is given in Figure 2 (T/CS 46-02).

The characteristics of the components are:

- low-pass filter $F \leq 960$ Hz;
- high-pass filter $F \geq 1,190$ Hz;
- two threshold comparator;
- eight channel filters two pole filters, band pass 1.5 dB + nom. 1.5% 2 Hz;
- eight rectifiers;
- eight single pole (RC) filters, time constant $C = 4 \div 5$ ms.

The thresholds and decision logic are regulated in order not to recognize character signals with a level below -30 dBm and to recognize valid character signals with a level in the range of $+4$ dBm to $+30$ dBm.

No other protections are to be provided in the receiver.



LPF = Low pass filter.
HPF = High filter.
TC = Threshold comparator.
STF = Single tone filter.
R = Rectifiers.
SPF = Single pole filter.

Figure 2 (T/CS 46-02). Reference unprotected exchange receiver (Block diagram).

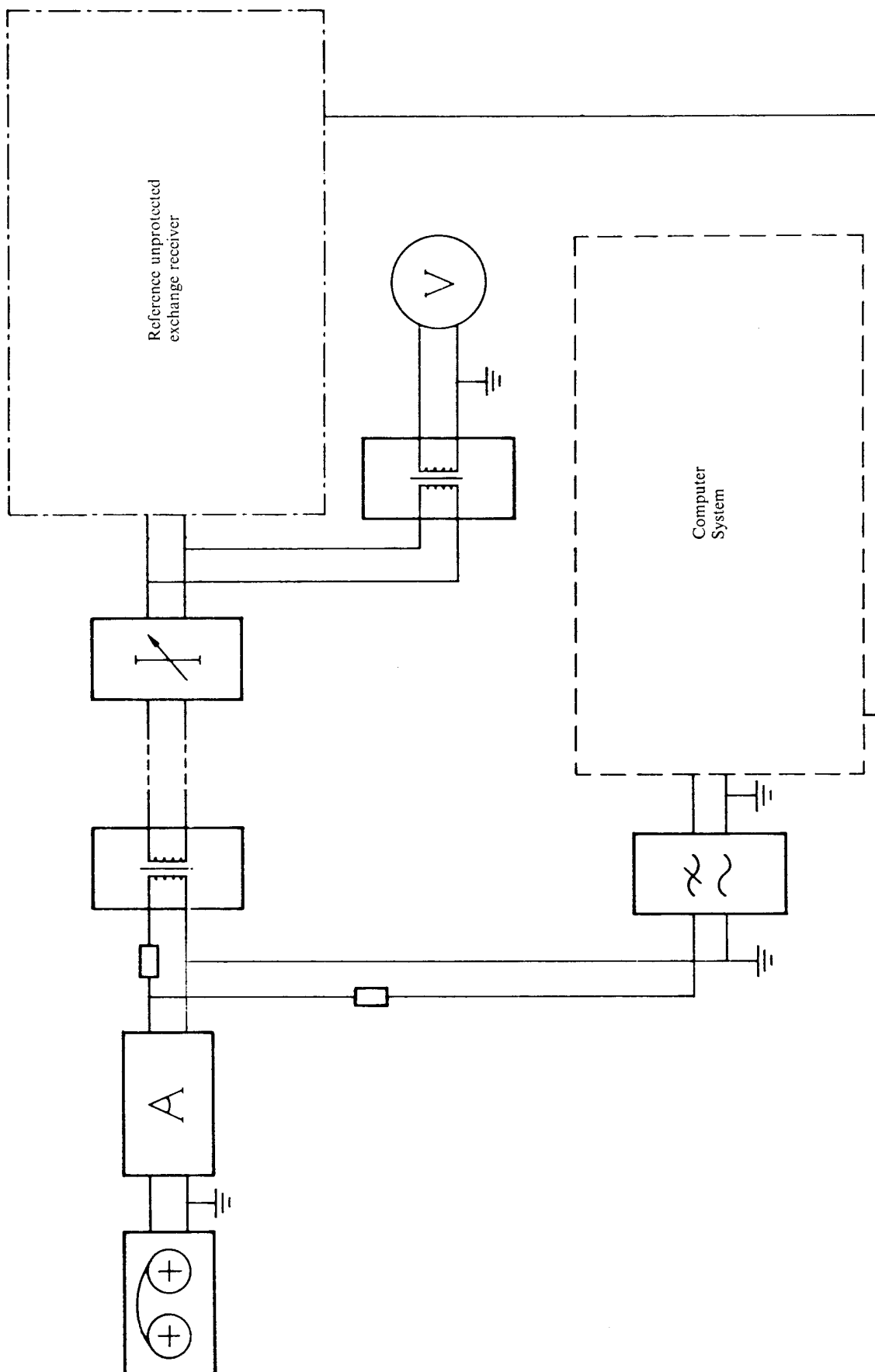


Figure 3 (T/CS 46-02). Standardized common test tape: recording set up.

History

| Document history | |
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