Recommendation T/CS 49-01 (Ostend 1979, revised in Vienna 1982 and Montpellier 1984)

SYSTEM L1 LINE SIGNALLING OVER INTERNATIONAL INTER-PRIVATE AUTOMATIC BRANCH EXCHANGE LINES

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

Text of the Recommendation revised adopted by Commission "Telecommunications":

"The European Conference of Postal and Telecommunications Administrations,

considering

— that there is an increasing need for the interconnection of private automatic branch exchanges located in different countries by means of international leased lines;

— that these international connections between private automatic branch exchanges should permit a fully automatic service between extensions connected to the private automatic branch exchanges concerned and authorised for international traffic;

— that CCITT Recommendations Q.1 [1] and Q.2 [2], since they are not directly applicable to international leased circuits, cannot cover the automatic service either;

— that a proliferation of private systems designed by suppliers tends to make operation and maintenance more difficult,

recommends

that the members, when introducing international interconnections over links between analogue transmission interfaces of private automatic branch exchanges, use the System L1 line signalling, which comprises the signals, equipment functions and procedures specified in the following. The requirements refer to the interfaces between the link and the outgoing or incoming private automatic branch exchange. The private automatic branch exchanges at both ends are regarded as functional units and no specifications are included on the ways and means for the provision of the functions concerned."

1. PRINCIPLES AND FIELDS OF APPLICATION

1.1. The line signalling system is to provide automatic and semi-automatic working between private automatic branch exchanges (PABXs) in different countries, via terrestrial circuits. The use of the system over satellite circuits and over composed terrestrial satellite circuits is possible, provided that echo-suppressors or echo-cancellers needed are installed on the customer side between the hybrid and the 2,280 Hz sending and receiving equipment.

1.2. The signalling system is a *single voice frequency (1 vf) tone-on-idle line signalling system* using a signalling frequency of 2,280 Hz.

The use of voice frequency signals renders the system suitable for all voice transmission media, except those using speech interpolation.

1.3. The system is intended for use on both-way inter-PABX circuits.

1.4. Either decadic pulsing or multifrequency interregister signalling may be used with the system (see *Explanatory notes on Group 49 Recommendations* preceding this Recommendation). The provision of particular line signals will depend upon the requirements of the associated interregister signalling system.

1.5. The system operates on a four-wire basis, forward and backward signals being segregated by utilising the four-wire circuit as two separate signalling paths. The send pair to which signals are applied is the receive pair at the distant end. Figure 1 (T/CS 49-01) shows a termination at one end.

1.6. In addition to the application or removal of signalling frequency (tone-on and tone-off) in continuous form, the transmission of pulses of signalling frequency is applied.

1.7. When in the idle condition, the signalling frequency applied to the line is reduced in power level to conform to the transmission loading requirements of CCITT Recommendation Q.15 [3].

1.8. The line signalling operates on a link-by-link basis and may be used to establish a multi-link tandem connection using one or more private automatic exchange(s) as a transit switch. Im accordance with CCITT Recommendation Q.25 [4], the signals are contaned within the appropriate link and are not allowed to spill over into subsequent or preceding links.

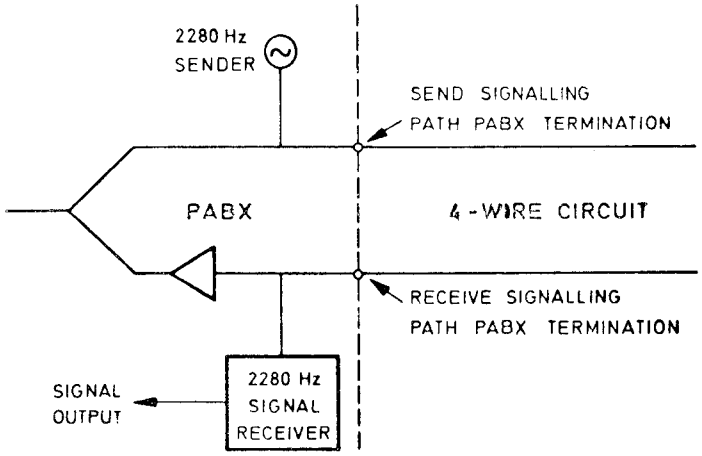

Figure 1 (T/CS 49-01). Four-wire private automatic branch exchange termination.

1.9. The maximum number of tandem connections over which a call may be set-up is determined by the type of interconnecting circuits and is subject to mutual agreement by the parties concerned. However, all circuits used in a tandem connection should be to the standard of CCITT Recommendations G.171 [5] and M.1010 to M.1060 [6].

1.10. Forward signals may be passed while speech or audible indications (tones or recorded announcements) are being received in the backward direction. A through speech path shall be provided in the backward direction of transmission during call set-up.

2. SYSTEM L1 LINE SIGNALS

The names and meanings of the signals specified for System L1 line signalling are in accordance with Recommendation T/CS 41-01 [7]. The following signals may be provided:
— Seizing signal.
— Seizing-acknowledgment/Proceed-to-send signal (see Section 5.2.).
— Clear-forward signal.
— Clear-back signal.
— Cleared signal.
— Answer signal.
— Forward-service-request-recall signal.
— Forward-link-recall signal.
— Backward-service-request-recall signal.
— Backward-link-recall signal.
— Intrusion signal.
— End-of-intrusion signal.
All signals above, except the proceed-to-send signal, are supervisory signals.

3. LINE SENDING AND DETECTING REQUIREMENTS

3.1. General

With the tone-on-idle signalling method, a signalling tone is sent continuously over the transmission channels in both directions when the circuit is idle. The presence of the tone indicates to both ends that the circuit is available and free to accept calls. This idle *line signal condition* represents the idle state of the circuit.
The tone is removed in the forward direction at the moment of seizure and in the backward direction when the first backward signal needs to be transferred. Restoring tone in the forward direction creates a total of four line signal conditions. The transition from one line signal condition to another one corresponds to the transfer of a line signal, according to the specifications referred to in Section 2. above.
The use of these transitions only, however, does not provide for a sufficient number of signals. Therefore, as a call proceeds, each signal condition on the line may be repeated, and also single and double tone-on pulses may be used. Distinction between different signals having the same characteristics shall be made by the position of the signal in the sequence of the signalling procedure.

3.2. Line signal conditions and signalling codes

The line signal conditions and the signalling codes shall be as shown in Table 1 (T/CS 49-01). Signal sending and detection requirements are given in Sections 3.3. and 3.4.
All signals sent shall give a true indication of the state the call-handling procedure has reached in the PABX concerned.

The provision and use of particular line signals, some of which are optional, will depend upon the requirements of the associated type of inter-register signalling (see Recommendations on System L1 call control signalling procedures).

3.3. **Sending of signals**

Tone-on and *tone-off conditions* referred to in Sections 3.1.-3.3. shall conform to the line signalling transmission requirements set out in Section 4.

Signals are sent by applying either a tone-on or a tone-off condition to the send signalling path in a continuous or pulsed form as defined below.

3.3.1. *Continuous tone-on condition*

A continuous tone-on condition shall be the application of the signalling frequency to the send signalling path for a period exceeding 300 ms.

3.3.2. *Continuous tone-off condition*

A continuous tone-off condition shall exist when any signalling frequency is absent from the send signalling path for a period exceeding 80 ms.

3.3.3. *Single tone-on pulse signal*

A single tone-on pulse signal shall be the application of a tone-on condition to the send signalling path for a period of 45 to 135 ms. This signal shall not be sent within 250 ms of a previous tone-on condition in the same direction.

3.3.4. *Double tone-on pulse signal*

A double tone-on pulse signal shall be the application of two pulses of tone-on condition to the send signalling path, each persisting for a period of 45-135 ms, separated by a tone-off condition for a period of 30-70 ms. This signal shall not be sent within 250 ms of a previous tone-on condition in the same direction.

Signal	Outgoing PABX	Incoming PABX
Idle (pro memoriam)	Continuous tone-on	Continuous tone-on
Seizing	Continuous tone-off	—
Seizing-acknowledgement or proceed-to-send	—	Continuous tone-off
Answer	—	Single tone-on pulse
Clear-forward	Continuous tone-on	—
Clear-back	—	Continuous tone-on
Cleared signal	—	Continuous tone-on
Forward-service-request-recall	Single tone-on pulse	—
Backward-service-request-recall	—	Single tone-on pulse
Intrusion	Single tone-on pulse	—
End-of-intrusion	Single tone-on pulse	—
Forward-link-recall	Double tone-on pulse	—
Backward-link-recall	—	Double tone-on pulse

Legend: — indicates that the signal is intended to be received by the PABX referred to at the top of the column.

Table 1 (T/CS 49-01). Line signal conditions and signalling codes.

3.4. **Detection of signals**

Electrical conditions conforming to the line signal transmission requirements specified in Section 4.2. applied to the PABX termination, shall be regarded as a potential signal.

Signals are received in a continuous or pulsed form, as weither a tone-on or a tone-off line signal condition on the receive signalling path.

To discriminate between signals having similar characteristics and between signals and spurious electrical conditions, it is necessary to state the minimum persistence time for a potential signal.

A potential signal is not recognised until the electrical condition proper to the signal (i.e. tone-on or tone-off) has persisted for a stated period. Until that period expires, only an electrical condition exists.

Paragraphs 3.4.1.-3.4.4. detail the minimum persistence of a defined electrical condition before it may be recognised as a signal, i.e. an electrical condition persisting for less than the stated period shall not be recognised as a signal. The period after which a potential signal must be recognised as a signal is a function of the PABX logic and is not given in these specifications. However, recognition should occur as soon as possible following expiration of the stated persistence check period, and the splitting and spill-over requirements (see Section 4.) must be met.

3.4.1. *Continuous tone-on condition*

A tone-on condition applied to the receive signalling path PABX termination may be recognised as a continuous tone-on condition for signalling when it has persisted for 150 ms.

3.4.2. *Continuous tone-off condition*

A tone-off condition applied to the receive signalling path PABX termination may be recognised as a continuous tone-off condition for signalling when it has persisted for 40 ms.

3.4.3. *Single tone-on pulse signal*

A tone-on condition applied to the receive signalling path PABX termination and persisting for a period of 35-150 ms, followed by a tone-off condition of longer than 200 ms, may be recognised as a single tone-on signal. A tone-on condition persisting for less than 25 ms followed by a tone-off condition for less than 80 ms, shall not be recognised as a single tone-on pulse signal.

3.4.4. *Double tone-on pulse signal*

Two pulses of tone-on condition applied to the receive signalling path PABX termination, each persisting for a period of 35-150 ms, separated by a tone-off condition for a period of 20-80 ms and followed by tone-off condition for longer than 200 ms, may be recognised as a double tone-on pulse signal.

Two tone-on pulses persisting for less than 25 ms, or separated by a tone-off condition for more than 200 ms, or followed by tone-off condition for less than 80 ms, shall not be recognised as a double tone-on pulse signal.

4. LINE SIGNALLING TRANSMISSION REQUIREMENTS

4.1. Signal sender

Signals are sent by the application of a tone-on condition or a tone-off condition or a combination of both to the transmit signalling path.

4.1.1. *Tone-on condition*

Tone-on condition shall be a signalling tone conforming to the following parameters and shall attain a stable state within 5 ms of application.

4.1.1.1. Signal tone frequency

The signalling tone shall be at a frequency of 2,280 ± 5 Hz.

4.1.1.2. Signal tone power

The tone-on condition shall have two power levels: a high level and a low level.

A high level tone shall be sent for the duration of the signal or for a minimum of 300 ms (whichever is shorter) and for a maximum of 550 ms after which it must be reduced to low level.

(a) A high level tone-on condition shall be a signalling tone transmitted at a level of −10 dBm0 ± 1 dB.

(b) A low level tone-on condition shall be a signalling tone transmitted at a level of −20 dBm0 ± 1 dB.

4.1.1.3. Long-term mean power during signalling

(a) In the frequency band 300-3,400 Hz, the long-term mean power applied to the transmit path, excluding the signalling tones, shall be at least 35 dB below the signalling tone power.

(b) At frequencies in the range 3.4 to 50 kHz, the short-term mean power level of any spectral component shall not lie above the line shown on Figure 2 (T/CS 49-01).

Note: Short-term here refers to a period not greater than 1 ms.

(c) In any 3 kHz band contained above 3.4 kHz, the long-term mean power shall not exceed the level which would be permitted in accordance with (b) above for a spectral component at the mid-frequency of that band.

Note: The requirements for the long-term mean power exclude any near end noise prior to splitting, according to CCITT Recommendation Q.25 [4], see §4.1.3., but include noise attributable to the action of splitting.

4.1.2. *Tone-off condition*

A tone-off condition requires the absence of signal tone and shall conform to the following:

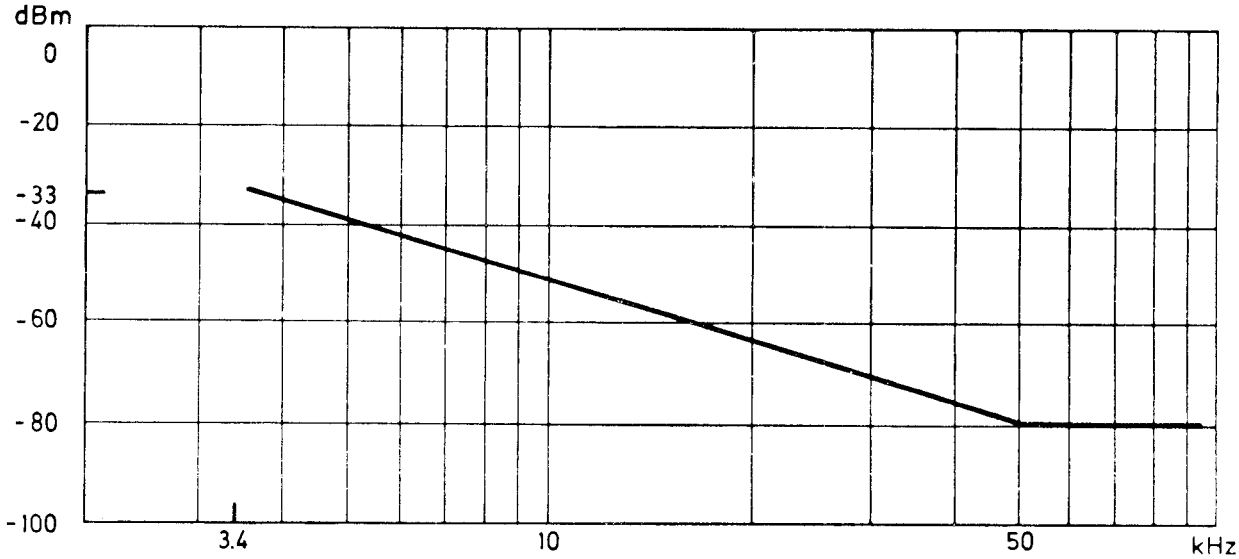

Figure 2 (T/CS 49-01).

— the stable state shall be attained within 5 ms of the commencement of the tone-off condition, and
— the total power of any signalling tone that may be present in the tone-off condition (i.e. the signal frequency leak), shall not exceed −70 dBm0.

4.1.3. *Sending-end splitting arrangements*

When a signal is to be sent on the line, the transmission path shall be split in accordance with CCITT Recommendation Q.25 [4], from any source of near end speech or noise. Transmission path splitting shall occur within a period from 20 ms before to 15 ms after application of a tone-on condition.

The transmission path restoration requirements may differ depending upon whether or not a speech path is provided while the tone-on signal condition exists on the line.

4.1.3.1. No speech path provided during sending tone-on

The transmission path remains split until a tone-off signal condition is to be established, in which case the transmission path shall be restored within a period of 75-160 ms after establishment of the tone-off condition.

4.1.3.2. Speech path provision during the tone-on signal condition on the line

(a) The transmission path splitting shall be maintained for a period of at least 350 ms following the application of a tone-on condition, after which it may be restored, unless a tone-on condition is being detected on the receive signalling path.

(b) If a tone-on condition is detected on the receive signalling path during a tone-on condition existing in the sending direction, the transmission path shall be split within 250 ms.

(c) When a tone-off condition is to be established, transmission path splitting shall occur within a period from 20 ms before to 15 ms after the start of the tone-off condition and shall remain split for 75-160 ms.

4.1.4. *Signal direction*

When a tone-on condition is established in the forward direction, any period of signalling tone attributable to that, that is applied to the preceding link, shall not exceed 15 ms.

When a tone-on condition is established in the backward direction, any period of signalling tone attributable to that, that is applied to the succeeding link, shall not exceed 15 ms.

4.2. **Signal receiver**

All electrical conditions applied to the receive signalling path shall be recognised as either tone-on or tone-off conditions.

4.2.1. *Signal conditions*

4.2.1.1. Tone-on condition

A frequency within the range 2,280 ± 15 Hz at an absolute level N, within the range $(-30 + n \leq N \leq -4 + n)$ dBm, shall be recognised as a tone-on condition; where n is the relative power level at the receive signalling path PABX termination (see CCITT Recommendation G.171 [5]).

4.2.1.2. Tone-off condition

Any frequency or combination of frequencies having a total absolute power level of less than $(-40 + n)$ dBm shall be recognised as a tone-off condition; where n is the relative power level at the receive signalling path PABX termination as in paragraph 4.2.1.1.

4.2.2. *Interference and simulation*

The conditions defined in § 4.2.1. shall be recognised as potential signals subject to the following requirements.

4.2.2.1. Signal recognition interference

(a) The recognition of tone-on and tone-off conditions shall not be affected by the presence of noise at a maximum level of −35 dBm0 and having uniform spectral energy over the range of 300 Hz to 10 kHz.

(b) The recognition of tone-on and tone-off conditions in the backward direction shall not be affected by speech or signalling frequency transmitted simultaneously in the forward direction.

(c) The recognition of tone-on and tone-off conditions in the forward direction shall not be affected by speech or other electrical signals such as supervisory audible indications and signalling frequency transmitted simultaneously in the backward direction.

4.2.2.2. Signal simulation

(a) False signal (simulation) rates shall not exceed one false recognition of a clear-forward or clear-back signal in 1,500 hours of normal speech and one false recognition of any other forward or backward signal of Table 1 (T/CS 49-01) in 70 hours of normal speech.

(b) Speech or other electrical signals such as supervisory audible indications, at power levels up to +10 dBm0, shall not cause any false recognition of a tone-off condition.

(c) A frequency outside the range 2,280 ± 75 Hz shall not cause any false recognition of a tone-on condition.

(d) A frequency within the range 2,280 ± 75 Hz shall not cause any false recognition of a tone-on condition, if the total power in the range 2,280 ± 75 Hz does not exceed the total power in any accompanying frequencies by more than is shown in Table 2 (T/CS 49-01).

Accompanying frequency (Hz)	500	750	1,000	1,250	1,500	1,750	2,000	3,000
Total power level by which 2,280 ± 75 Hz exceeds accompanying frequencies (dB)	7	10	12	12	12	12	7	9

Table 2 (T/CS 49-01).

4.2.3. *Receiving-end splitting arrangements and spill-over*

CCITT Recommendation Q.25 [4] applies. On receipt of a tone-on condition, any through-transmission to a subsequent inter-PABX circuit shall be attenuated by at least 35 dB within 20 ms.

Through-transmission shall be restored within 300 ms of the cessation of the tone-on condition.

Through-transmission shall not be restored during the tone-off periods of double tone-on pulse signals.

4.2.4. *Through-transmission interference*

The following requirements shall apply subsequent to the recognition of tone-off condition.

4.2.4.1. Speech immunity

Through-transmission attenuation (see § 4.2.3.) shall not occur for more than one 20 ms period in two continuous speech hours and one 50 ms period in ten continuous speech hours.

A continuous speech hour is one hour of speech and does not include those quiescent periods that occur in normal conversation.

A method of testing speech immunity has been given in Recommendation T/CS 46-02, Annex 1 [11].

4.2.4.2. Data immunity

Through-transmission attenuation (see § 4.2.3.) shall not occur if the total power in the range 2,280 ± 75 Hz does not exceed the total power in the accompanying frequencies by more than the amount shown in Table 2 (T/CS 49-01).

5. GENERAL LINE SIGNAL TRANSFER PROCEDURES

5.1. Seizure

The seizing signal is sent by the outgoing PABX upon selection of the inter-PABX circuit for an outgoing call. On recognition of the seizing signal, the incoming PABX bars access for outgoing calls to the circuit and prepares to receive address information. The incoming PABX takes a finite time to bar outgoing access. An outgoing call, originated at the incoming PABX during this unguarded period, would cause a tone-off condition to be established which then would be recognised by the outgoing PABX as either a seizing-acknowledgement or a proceed-to-send signal (dual-seizure situations).

5.2. Seizing-acknowledgement or proceed-to-send

Depending upon the capabilities of the incoming PABX, recognition of the seizing signal will initiate either a *seizing-acknowledgement* or a *proceed-to-send* procedure.

5.2.1. *Seizing-acknowledgement*

In this case, when the incoming PABX recognises the seizing signal, it returns a *seizing-acknowledgement signal.* The sending of this signal does not imply that the incoming PABX is ready to receive address information, and provision must be made to prevent premature sending by the outgoing PABX, e.g. by agreeing to use dialling tone or a pre-sending pause.

5.2.2. *Proceed-to-send*

In this case, when the incoming PABX recognises the seizing signal, it maintains the tone-on line signal condition until it is ready to receive address information, it then applies a *proceed-to-send signal* which is an interregister signal (see Recommendations T/CS 49-02 [8], 49-04 [9] and 49-07 [10]).

5.2.3. *Discrimination between seizing-acknowledgement and proceed-to-send signal*

As the seizing-acknowledgement and proceed-to-send signals are electrically identical, the meaning of the signal and the procedures must be mutually agreed upon by the parties involved, taking into account dual-seizure situations.

5.3. Clear-forward

A clear-forward signal is sent by the outgoing PABX to release the connection and the incoming PABX. Both PABXs bar access to the inter-PABX circuit until the clear-forward and the cleared of clear-back signal have been exchanged. If the incoming PABX sends the interregister clear-request signal the clear-forward signal is returned as an acknowledgement, see Recommendation T/CS 42-02 [8].

5.4. Clear-back

A clear-back signal is sent by the incoming PABX upon change of the called party extension line to an on-hook state, provided no clear-forward signal has yet been recognised. Upon recognition of the clear-back signal, the outgoing PABX sends a clear-forward signal. Both PABXs bar access to the inter-PABX circuit until the two signals have been exchanged.

5.5. Cleared signal

A cleared signal is applied by the incoming PABX upon recognition of a clear-forward signal if the call has not been answered. Both PABXs bar access to the inter-PABX circuit until the two signals, clear-forward and cleared, have been exchanged. The cleared signal is also applied by the incoming PABX if the called party extension line is still in the off-hook state at the moment the clear-forward signal is recognised.

5.6. Optional signals and procedures

Provision of the following optional signals and procedures depends on network requirements and is subject to mutual agreement by the parties involved.

5.6.1. *Answer*

Where the facility is provided and when the called party answers, the incoming PABX sends an answer signal on the signalling path.

Some PABXs do not use the answer signal, others require it for correct operation.

Where the answer signal is required by the outgoing PABX but the incoming PABX is unable to provide it, the signal must be artificially generated at the outgoing PABX. However, the signal may be generated at the incoming PABX by agreement between the parties involved.

A genuine answer signal will be necessary where calls are established end-to-end using multifrequency interregister signalling (see Recommendations T/CS 49-04 and T/CS 49-07 [9]).

5.6.2. *Recall signalling*

Service-request-recall and link-request-recall signals are used, subsequent to call set-up or the establishment of speech conditions, when a PABX requires another PABX to prepare to receive further address signals or information. The signals are used for forward and backward signalling and depend upon the requirements of the associated type of interregister signalling (see Recommendations on System L1 call control signalling [8, 9, 10]).

REFERENCES

[1] CCITT Recommendation Q.1. *Signal receivers for manual working.*

[2] CCITT Recommendation Q.2. *Signal receivers for automatic and semi-automatic working, used for manual working.*

[3] CCITT Recommendation Q.15. *Nominal mean power during the busy hour.*

[4] CCITT Recommendation Q.25. *Splitting arrangements and signal recognition times in "in-band" signalling systems.*

[5] CCITT Recommendation G.171. *Transmission characteristics of leased circuits forming part of a private telephone network.*

[6] CCITT Recommendations M.1010 to M.1060. *International leased circuits.*

[7] Recommendation T/CS 41-01. *Signal and signalling message names and meanings.*

[8] Recommendation T/CS 49-02. *System L1 decadic pulsing interregister signalling.*

[9] Recommendation T/CS 49-04. *System L1 multifrequency push-button interregister signalling.*

[10] Recommendation T/CS 49-07. *System L1 multifrequency code interregister signalling.*

[11] Recommendation T/CS 46-02. *Multifrequency signalling system to be used for push-button telephones.*