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THE INTERNATIONAL TELEGRAPH AND TELEPHONE CONSULTATIVE COMMITTEE

CCITT

SIXTH PLENARY ASSEMBLY

GENEVA, 27 SEPTEMBER - 8 OCTOBER 1976

ORANGE BOOK

VOLUME VI.3

SPECIFICATIONS OF SIGNALLING SYSTEMS R1 AND R2

Published by the
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ISBN 92-61-00411-3

CONTENTS OF THE CCITT BOOK
APPLICABLE AFTER THE SIXTH PLENARY ASSEMBLY (1976)

ORANGE BOOK

- Volume I** — Minutes and reports of the VIth Plenary Assembly of the CCITT.
— Resolutions and Opinions issued by the CCITT.
— General table of Study Groups and Working Parties for the period 1977-1980.
— Summary table of abridged titles of Questions under study in the period 1977-1980.
— Recommendations (Series A) on the organization of the work of the CCITT.
— Recommendations (Series B) relating to means of expression.
— Recommendations (Series C) relating to general telecommunication statistics.
- Volume II.1** — General tariff principles — Lease of circuits for private service: Series D Recommendations and Questions (Study Group III).
- Volume II.2** — Telephone operation, quality of service and tariffs: Series E Recommendations and Questions (Study Group II).
- Volume II.3** — Telegraph operations and tariffs: Series F Recommendations and Questions (Study Group I).
- Volume III** — Line transmission: Series G, H and J Recommendations and Questions (Study Groups XV, XVI, XVIII, CMBD).
- Volume IV.1** — Line maintenance and measurement: Series M and N Recommendations and Questions (Study Group IV).
- Volume IV.2** — Specifications of measuring equipment: Series O Recommendations and Questions (Study Group IV).
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- Volume VI.1** — General Recommendations relating to telephone switching and signalling: Series Q Recommendations and Questions (Study Group XI).
- Volume VI.2** — Signalling System No. 6: Recommendations.
- Volume VI.3** — Signalling Systems R1 and R2: Recommendations.
- Volume VI.4** — Programming languages for stored-programme control exchanges: Series Z Recommendations.
- Volume VII** — Telegraph technique: Series R, S, T and U Recommendations and Questions (Study Groups VIII, IX, X, XIV).
- Volume VIII.1** — Data transmission over the telephone network: Series V Recommendations and Questions (Study Group XVII).
- Volume VIII.2** — Public data networks: Series X Recommendations and Questions (Study Group VII).
- Volume IX** — Protection: Series K and L Recommendations and Questions (Study Groups V, VI).

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- definitions of specific terms used;
- supplements for information and documentary purposes.

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PRELIMINARY NOTE

In this Volume, the expression "Administration" is used for shortness to indicate both a telecommunication Administration and a recognized private operating agency.

PART I

Series Q Recommendations (Q.310 to Q.331)

SPECIFICATIONS OF SIGNALLING SYSTEM R1

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SIGNALLING SYSTEM R1

(The specifications of Signalling System R1 form Part XV of the Series Q Recommendations)

INTRODUCTION

PRINCIPLES OF SIGNALLING SYSTEM R1

General

The development of new exchanges, especially those utilizing stored programme control, has introduced new concepts in the division of functions between various components of signalling and switching systems. To allow the maximum freedom in incorporating new concepts which can contribute to the overall economy and efficiency of the system, the requirements as covered in this specification are for the combination of equipments necessary to provide a function. For example, the requirements for line signal receiving equipment as given here may be met by various subdivisions of functions between signal receiver, trunk relay sets and stored programme control.

System R1 may be applied for automatic and semi-automatic operation of one-way and both-way circuits, within an international region (world numbering zone). When utilized in an integrated world numbering zone (e.g. Zone 1) the numbering and routing plans and operating facilities of that zone should apply.

The system is applicable to all types of circuits (except TASI derived circuits)¹⁾ meeting CCITT transmission standards, including satellite circuits.

The signalling equipment used in System R1 consists of two parts:

- a) line signalling for line or supervisory signals; and
- b) register signalling for address signals.

a) *Line signalling*

1) *2600 Hz signalling*

Continuous tone type in-band line-signalling is used for the link-by-link transmission of all supervisory signals except the ring-forward (forward-transfer) signal which is a spurt signal. A single frequency, 2600 Hz, is used in each direction of the 4-wire transmission path, the presence or absence of this frequency indicates a specific signal dependent upon when it occurs in the signalling sequence and in certain cases upon its duration. When the circuit is idle, a low level signalling tone is continuously present in both directions.

¹⁾ Register signalling can be made compatible with TASI by providing a TASI locking tone.

2) *PCM signalling*

The 2600 Hz line signalling described in 1) is not normally applied to the speech paths of circuits working on PCM systems unless the PCM channels are connected in cascade with analogue channels to form a circuit. The signalling on PCM systems in the North American region is channel associated, in-slot, providing two signalling channels per speech channel, and utilizing bit stealing of the eighth bit of each channel every sixth frame.

b) *Register signalling*

Link-by-link multifrequency (MF) in-band pulse signalling is used for the transmission of address information. The signalling frequencies are 700 Hz to 1700 Hz, in 200 Hz steps, and combinations of two, and two only, determine the signal. The address information is preceded by a KP signal (start-of-pulsing) and terminated by an ST signal (end-of-pulsing). Either en bloc²⁾, or en bloc overlap²⁾, or overlap sending may apply. This register signalling arrangement is used extensively with other in-band and out-band line signalling systems.

Compondors may affect signalling, particularly short pulse compound register signals, due to pulse length distortion and the production of intermodulation frequencies. By virtue of the link-by-link signalling and the adopted duration of register and line signal pulses, System R1 functions correctly in the presence of compandors designed in accordance with CCITT recommendations.

²⁾ See Recommendation Q.151, note to 3.1.1 for an explanation of these terms.

SECTION 1

DEFINITION AND FUNCTION OF SIGNALS

Recommendation Q.310

1. DEFINITION AND FUNCTION OF SIGNALS ¹⁾

1.1 connect (seizing) signal (sent in the forward direction)

This line signal is transmitted at the beginning of a call to initiate circuit operation at the incoming end of the circuit to busy the circuit and to seize equipment for switching the call.

1.2 delay-dialling signal (sent in the backward direction)

This line signal is transmitted by the incoming exchange following the recognition of the connect (seizing) signal to verify receipt of the connect (seizing) signal and to indicate that the incoming register equipment is not yet attached or ready to receive address signals.

1.3 start-dialling (proceed-to-send) signal (sent in the backward direction)

This line signal is sent from the incoming exchange subsequent to the sending of a delay-dialling signal to indicate that the incoming register equipment has been connected and is ready to receive address signals.

1.4 KP (start-of-pulsing) signal (sent in the forward direction)

This register signal is sent subsequent to the recognition of a start-dialling signal and is used to prepare the incoming multifrequency register for the receipt of subsequent interregister signals.

1.5 address signal (sent in the forward direction)

This register signal is sent to indicate one decimal element of information (digit 1, 2, ..., 9 or 0) about the called party's number. For each call a succession of address signals is sent.

1.6 ST (end-of-pulsing) signal (sent in the forward direction)

This register signal is sent to indicate that there are no more address signals to follow. The signal is always sent in semi-automatic as well as automatic working.

¹⁾ In this part the North American designation for line signals is used. The designation of the signal in System No. 5 which most nearly corresponds to a particular North American signal is shown in parentheses. There is not always exact correspondence in function, e.g. the ring-forward signal can only be effective when a connection has been established through an incoming operator.

1.7 answer signal (sent in the backward direction) ^{2),3)}

This line signal is sent to the outgoing exchange to indicate that the called party has answered.

In semi-automatic working, the signal has a supervisory function.

In automatic working, it is used:

- to start metering the charge to the calling subscriber;
- to start the measurement of call duration for international accounting purposes, if this is desired.

1.8 hang-up (clear-back) signal (sent in the backward direction) ²⁾

This line signal is sent to the outgoing exchange to indicate that the called party has cleared. In the semi-automatic service it performs a supervisory function.

In automatic working, arrangements are made to clear the connection, stop the charging, and stop the measurement of call duration if within 10 to 120 seconds ⁴⁾ after recognition of the hang-up signal, the calling subscriber has not cleared. Clearing of the connection should preferably be controlled from the point where the charging is carried out.

1.9 ring-forward (forward-transfer) signal (sent in the forward direction)

This line signal is initiated by an operator to recall an operator at a point further ahead in the connection.

1.10 disconnect (clear-forward) signal (sent in the forward direction)

This line signal is sent in the forward direction at the end of a call when:

- a) in semi-automatic working, the operator at the outgoing exchange withdraws the plug from the jack, or when an equivalent operation is performed;
- b) in automatic working, the calling party hangs up, or when the time-out period of 10 to 120 seconds as discussed in 1.8 above occurs.

1.11 *Diagrams showing signal sequence*

Typical sequences of signals in semi-automatic and automatic working are shown in the Annex to these specifications.

²⁾ Notes on the answer and hang-up (clear-back) signals. — See corresponding notes in Recommendation Q.120, 1.8, Volume VI-2 of the *Green Book*.

³⁾ See Recommendation Q.27 for the actions to be taken to assure that answer signals, both national and international, are transmitted as quickly as possible.

⁴⁾ In world numbering Zone 1, 13 to 32 seconds is used.

SECTION 2

LINE SIGNALLING

Recommendation Q.311

2.1 2600 Hz LINE SIGNALLING

The line-signal coding arrangement is based on the application and removal of a single frequency tone (2600 Hz) as shown in Table 1.

TABLE 1 – Line signal code

Signal	Signal direction ^{1,2}	Transmitted (sending) duration	Transmitted state ^{5,6}	
			Originating end	Terminating end
Idle	↔	continuous	0	0
Connect (seizing)	→	continuous	1	0
Delay-dialling	←	continuous ³	1	1
Start-dialling (proceed-to-send)	←	continuous ³	1	0
Answer	←	continuous	1	1
Hang-up (clear-back)	←	continuous	1	0
Disconnect (clear-forward)	→	continuous	0	0 or 1
Ring-forward (forward-transfer)	→	65-135 ms	0 ⁴	0 or 1
Busy, re-order (congestion) ⁴	←	—	off	on

¹ →, → indicates forward signalling state 0 or 1, respectively.

² ←, ← indicates backward signalling state 0 or 1, respectively.

³ The duration of these signals are variable and depend upon when the succeeding signal occurs. To ensure proper registration of these signals, the transmitted signal durations should not be less than 140 ms.

⁴ Busy and re-order (congestion) conditions are indicated by audible tones.

⁵ 0: Tone on, or signalling bit state 0 in PCM systems.

⁶ 1: Tone off, or signalling bit state 1 in PCM systems.

By taking advantage of the fixed order of occurrence of specific signals, both tone-on and tone-off signals are used to indicate more than one signal condition. For example, in the backward direction tone-on is used to indicate start-dialling (proceed-to-send), and terminating end hang-up (clear-back) signals without conflict. The equipment must retain memory of the preceding signal states and the direction of signals in order to differentiate between tone-on and tone-off signals.

Recommendation Q.312

2.2 2600 Hz LINE SIGNAL SENDER ¹⁾ (TRANSMITTER)

2.2.1 *Signal frequency*

2600 \pm 5 Hz.

2.2.2 *Transmitted signal level of tone-on signals*

−8 \pm 1 dBm0 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 the level of the signal shall be reduced to −20 \pm 1 dBm0.

2.2.3 *Transmitted signal durations*

The transmitted signal durations are shown in Table 1 of Recommendation Q.311.

2.2.4 *Signal frequency leak*

The level of signal frequency leak power transmitted to the line should not exceed −70 dBm0, during the tone-off condition.

2.2.5 *Extraneous frequency components*

The total power of extraneous frequency components accompanying a tone signal should be at least 35 dB below the fundamental signal power.

2.2.6 *Transmitting line split*

The following splitting arrangements are required when transmitting line signals to prevent incorrect operation of the receiving equipment due to transients caused by the opening or closing of direct current circuits in the exchange at the transmitting end:

- a) when a tone-on signal is to be transmitted, the speech path from the exchange shall be split (disconnected), if not already split, within an interval from 20 ms before, to 5 ms ²⁾ after tone is applied to the line, and remain split for a minimum of 350 ms and a maximum of 750 ms;
- b) when a tone-off signal is to be transmitted, the speech path from the exchange shall be split (disconnected), if not already split, within an interval from 20 ms before to 5 ms after tone is removed from the line, and remain split for a minimum of 75 ms and a maximum of 160 ms after the tone is removed;

¹⁾ See also Recommendation Q.112.

²⁾ The 5 ms may be relaxed to 15 ms if tone is applied while tone is being received.

- c) when the signalling equipment is receiving and sending tones simultaneously the split shall be maintained until:
 - i) the transmitted tone is terminated, in which case the split must be removed in the interval from 75 to 160 ms after tone is removed [as in b)]; or
 - ii) the incoming tone ceases, in which case the split must be removed in the interval from 350 to 750 ms after tone ceases;
- d) when the signalling equipment is sending tone, a split shall be introduced, if not already split, within 250 ms of receipt of an incoming tone.

The above requirements given in a), b), c) and d) establish a transmitting path split at both ends of the circuit during the idle condition.

Recommendation Q.313

2.3 2600 Hz LINE SIGNAL RECEIVING EQUIPMENT³⁾

2.3.1 Operate limits (tone-on signals)

The receiving equipment shall operate on a received tone signal, in the presence of the maximum noise expected on an international circuit, -40 dBm0 uniform spectral energy over the range of 300 to 3400 Hz, that meets the conditions listed below:

- a) 2600 ± 15 Hz;
- b) to ensure proper operation in the presence of noise, the signal level of the initial portion of each tone-on signal shall be augmented by 12 dB (see 2.2.2).

As a result, the following requirement reflects both the augmented and steady-state signal levels. The absolute power level N of each signal is within the limits $(-27 + n \leq N \leq -1 + n)$ dBm where n is the relative power level at the input to the receiving equipment. The minimum absolute power level $N = (-27 + n)$ gives a margin of 7 dB on the steady-state nominal absolute power level of the received signal at the input to the receiving equipment. With augmentation the effective margin is increased from 7 to 19 dB.

The maximum absolute power level $N = (-1 + n)$ gives a margin of 7 dB on the augmented nominal absolute power level of the received signal at the input to the receiving equipment.

The above tolerances are to allow for variations at the sending end and variations in line transmission.

Note. — Since higher steady noise as well as impulsive noise may be encountered on intra-regional circuits especially over certain compandored carrier systems, the maximum expected noise within a region must be taken into account in the design of equipment for that region.

2.3.2 Non-operate limits

- 1) The receiving equipment shall neither operate on signals originating from subscriber stations (or other sources) if the total power in the band from 800 Hz to 2450 Hz equals or exceeds the total power present at the same time in the band from 2450 Hz to 2750 Hz, as measured at the station, nor degrade these signals. Allowances shall be made in the receiving equipment design to accommodate expected deviations from these values due to attenuation distortion and carrier frequency shift on the total transmission path between the station and the receiving equipment.

³⁾ See also Recommendation Q.112.

2) The receiving equipment shall not operate on any tone or signal whose absolute power level at the point of connection of the receiving equipment is $(-17 - 20 + n)$ dBm or less, n being the relative power level at this point.

2.3.3 Recognition of signals

1) System R1 must be protected against false signal recognition caused by:

- a) signal simulation of tone-on or tone-off signals by speech or other signals;
- b) signal simulation of tone-off signals by momentary interruptions of the transmission path.

The method of providing this protection is left to each Administration concerned to allow for maximum flexibility in the implementation of the signalling and switching system design. However, the overall system requirements given in 2) and 3) below shall be met.

2) The following requirements for signal recognition are specified in terms of signal duration at the input to the signal receiving equipment and further assumes that signal levels, frequency and accompanying noise are within the limits specified in 2.3.1:

- a) A tone-on signal lasting 30 ms or less must be rejected; that is, it must not be recognized as a signal.
- b) A tone-off signal lasting 40 ms or less must be rejected if the previous tone-on signal is 350 ms or longer; that is, it must not be recognized as a signal.
- c) Subsequent to establishing the cross office path, a tone-on ring-forward (forward-transfer) spurt signal lasting between 65 and 135 ms must be recognized as a valid signal.
- d) A tone-on forward signal lasting 300 ms or longer must be recognized as a valid disconnect (clear-forward) signal. Prior to attaching a register, a forward tone-on signal lasting 30 ms or longer may be recognized as a valid disconnect (clear-forward) signal.
- e) To protect against a momentary interruption in the transmission facility causing a continuous succession of false connect (seizing) and disconnect (clear-forward) signals, the incoming equipment should be arranged to delay responding to the second of two closely spaced connect (seizing) signals. The timed delay introduced should be started at the end of initial connect (seizing) signal or on recognition of the disconnect (clear-forward) signal. The delay introduced should be a function of the round trip signalling time. For satellite circuits the recommended time is 1300 ± 100 ms. For terrestrial circuits the recommended time is 500 ± 100 ms. If the second connect (seizing) signal persists beyond this timed interval, the signal should be considered valid and a delay dialling signal returned.
- f) Other tone-on and tone-off signals should be recognized as valid signals, subsequent to the minimum limits imposed by a) and b) above, as soon as possible.

Note. — Delays introduced by line signalling equipment should be held to a minimum consistent with the requirements covered herein to minimize signal transfer times. Minimizing the delay is especially important in the case of the answer signal and in the case of satellite circuit operation. In this latter case, if a hang-up (clear-back) signal has not been sent prior to recognition of a disconnect (clear-forward) signal, it is necessary that the idle tone-on signal, sent by the incoming exchange in response to the disconnect signal, be recognized by the outgoing exchange prior to the elapse of the guard timing specified in Recommendation Q.317, 2.7.1.

3) The following signal simulation rates shall not be exceeded.

- a) On the average not more than one false recognition of a disconnect (clear-forward) signal shall occur per 1500 call hours of speech, at the *minimum* disconnect recognition time, as selected according to 2.3.3, 2 c) and d). (In some older designs, this requirement may not be met, but for these cases the call hours figure must not be less than 500⁴⁾ call hours.)

⁴⁾ In the case when no answer signal is transmitted (non-charged calls), the simulation rates specified in 3a) and 3b) may, in some existing designs, be somewhat in excess of the values quoted.

- b) On the average, not more than one false ring-forward (forward-transfer) signal shall occur per 70⁴⁾ call hours of speech, at the *minimum* ring-forward recognition time.
- c) Speech or other electrical signals as audible-tone signals, with levels up to +10 dBm0 shall not cause any false simulation of answer signals.
- d) The number and characteristics of false splits of the speech path caused by speech or other signals shall not cause a noticeable reduction in the transmission quality of the circuit.

2.3.4 Receiving line split

To prevent line signals of the signalling system from causing disturbances to signalling systems on subsequent circuits, the receiving transmission path to the connected exchange should be split when the signal frequency is received to ensure that no portion of any signal exceeding 20 ms duration may pass out of the circuit. The use of a band-stop filter for splitting is necessary since in the case of non-charged calls a continuous signal tone persists in the return transmission path during conversation. The level of signal leak current transmitted to the subsequent circuit with the band-stop filter inserted should be at least 35 dB below the received signal level. In addition, the band-stop filter must not introduce more than 5 dB loss at frequencies 200 Hz or more above or below the midband frequency nor more than 0.5 dB loss at frequencies 400 Hz or more above or below the midband frequency.

The receiving line split must be maintained for the duration of the incoming tone signal, but must cease within 300 ms of tone removal.

Note. — In some existing designs, the initial cut may be a physical line disconnection but the filter must be inserted within 100 ms of tone reception.

Recommendation Q.314

2.4 PCM LINE SIGNALLING

Individual channel line signalling is provided in the format of the CCITT primary multiplex operating at 1544 kbit/s (Recommendation G.733). Designated signalling bits are marked 0 or 1 corresponding to tone-on, tone-off in the single frequency in-band arrangement as shown in Table 1 (Recommendation Q.311). As in the in-band system, the same signalling state is used to indicate more than one signal by taking advantage of the fixed order of occurrence of specific signals. The equipment must retain memory of the preceding signal states and the direction of signals in order to differentiate between like state 0 and state 1 signals.

Recommendation Q.315

2.5 PCM LINE SIGNAL SENDER (TRANSMITTER)

2.5.1 Signalling format

The primary multiplex format is shown in Figure 1/Q.315. Per channel, in-slot signalling is accomplished by utilizing bit No. 8 in each time slot of the designated frames (6, 12, etc.) for signalling purposes. Bit No. 8 of each time slot in the intervening frames (1-5, 7-11, etc.) is used for encoding speech. Two signalling channels per speech channel are provided in the format. The multiframe alignment required for signalling purposes is obtained by subdividing the 8 kbit/sec framing pulse stream into two 4 kbit/sec streams, one for terminal framing and one for signalling framing (S-bits). The relationship of the framing and multiframing signals to the signalling bits is given in Table 2. Since only one line signalling channel is required for System R1, the same signalling information is sent over both signalling channels A and B.

TABLE 2 – Multiframe structure

Frame number	Frame alignment signal	Multiframe alignment signal (S-bit)	Bit number(s) in each channel time slot		Signalling channel
			For character signal	For signalling	
1	1	—	1 to 8	—	A
2	—	0	1 to 8	—	
3	0	—	1 to 8	—	
4	—	0	1 to 8	—	
5	1	—	1 to 8	—	
6	—	1	1 to 7	8	
7	0	—	1 to 8	—	
8	—	1	1 to 8	—	
9	1	—	1 to 8	—	
10	—	1	1 to 8	—	
11	0	—	1 to 8	—	B
12	—	0	1 to 7	8	

Note 1. — The sequence shown is repetitive.

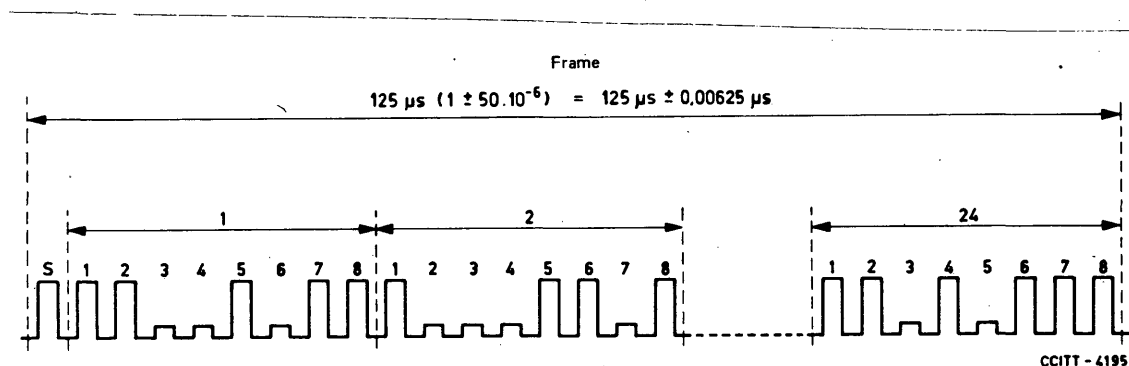
Note 2. — For System R1 the same signalling information is sent on signalling channels A and B.

2.5.2 Transmitted signal duration

The transmitted signal durations are given in Table 1 of Recommendation Q.311.

2.5.3 Transmitting line split

Since signalling is out-band, no transmitting line split is required.



Sampling frequency. $8000 (1 \pm 50 \times 10^{-6})$ Hertz = 8000 ± 0.4 Hertz
Output bit rate $1544 (1 \pm 50 \times 10^{-6})$ kbit/s = 1544 kbit/s ± 77 bit/s
Bits/frame 193
Time slots/frame 24
Signalling Eighth bit every sixth frame as shown in Table 2.
The 8 bits in each time slot are defined in Table 2.
The F-bit is time shared between terminal framing and signalling framing (S) as shown in Table 2.

FIGURE 1/Q.315 – Primary multiplex format

Recommendation Q.316**2.6 PCM LINE SIGNAL RECEIVER****2.6.1 Recognition of signals**

System R1 must be protected against false signal recognition caused by signal simulation due to momentary loss of synchronization of the PCM system. The method of providing this protection is left to each Administration concerned to allow for maximum flexibility in the implementation of the signalling and switching system design. However, the overall system requirements given below must be met.

- a) A state 0 signal lasting 30 ms or less must be rejected; that is, it must not be recognized as a signal.
- b) A state 1 signal lasting 40 ms or less must be rejected if the previous state 0 signal is 350 ms or longer; that is, it must not be recognized as a signal.
- c) Subsequent to establishing the speech path, a state 0 ring-forward (forward-transfer) signal lasting 65-135 ms must be recognized as a valid signal.
- d) A state 0 forward signal lasting 300 ms or longer must be recognized as a valid disconnect (clear-forward) signal. Prior to attaching a register, a forward state 0 signal lasting 30 ms or longer may be recognized as a valid disconnect (clear-forward) signal.
- e) To protect against a momentary fault causing a continuous succession of false connect (seizing) and disconnect (clear-forward) signals, the incoming equipment should be arranged to delay responding to the second of two closely spaced connect (seizing) signals. The time delay introduced should be started at the end of the initial connect (seizing) signal or on recognition of the disconnect (clear-forward) signal. The delay introduced should be a function of the round trip signalling time. For satellite circuits the recommended time is 1300 ± 100 ms. For terrestrial circuits the recommended time is 500 ± 100 ms. If the second connect (seizing) signal persists beyond this timed interval, the signal should be considered valid and a delay dialling signal returned.
- f) Other state 0 and state 1 signals should be recognized as valid signals subsequent to the minimum limits imposed by a) and b) above, as soon as possible.

Note. — Delays introduced by line signalling equipment should be held to a minimum consistent with the requirements covered herein to minimize signal transfer times. Minimizing the delay is especially important in the case of the answer signal and in the case of satellite circuit operation. In this latter case, if a hang-up (clear-back) signal has not been sent prior to recognition of a disconnect (clear-forward) signal, it is necessary that the idle state 0 signal, sent by the incoming exchange in response to the disconnect signal, be recognized by the outgoing exchange prior to the elapse of the guard timing specified in Recommendation Q.317, 2.7.1.

2.6.2 Receiving line split

Since signalling is out-band, no receiving line split is required.

2.6.3 Action on receipt of an alarm

When the PCM primary multiplex has detected a fault and given an alarm (see Recommendation G.733, 3.2) appropriate action shall be taken to remove automatically the affected circuits from service, and to terminate calls in progress, i.e. stop charging, release interconnected circuits, etc. When the alarm has been cleared the affected circuits should be automatically restored to service.

Recommendation Q.317**2.7 FURTHER SPECIFICATION CLAUSES RELATIVE TO LINE SIGNALLING**

2.7.1 Access to the outgoing circuits shall be denied (guarded) for 750 to 1250 ms (1050 ms to 1250 ms for satellite circuits) after initiation of the disconnect (clear-forward) signal to ensure sufficient time for the release of the equipment at the incoming exchange. [See also the note to 2.3.3, 2) of Recommendation Q.313 and to 2.6.1 of Recommendation Q.316.]

2.7.2 The disconnect (clear-forward) signal may be sent at any time in the call sequence.

2.7.3 The release of the chain of circuits in an established connection is only initiated from the originating exchange or the charge-recording exchange.

2.7.4 The start of metering the charge should be delayed by an appropriate time after recording of the answer signal to prevent false charging resulting from possible false recognition of an invalid answer signal.

Recommendation Q.318**2.8 DOUBLE SEIZING WITH BOTH-WAY OPERATION****2.8.1 General**

To minimize the probability of double seizing, the circuit selection at the two ends of both-way circuit groups should be such that, as far as possible, double seizing can occur only when a single circuit of the group remains free (e.g. by selection of circuits in opposite order at the two ends of the circuit group).

2.8.2 Unguarded interval

In general the unguarded interval is small, except in the case of satellite operation where the circuit propagation time is long. However, System R1 does provide a means of detecting double seizing.

2.8.3 Detection of double-seizing

In the event of double seizing, the incoming connect (seizing) signal is recognized at each end as a delay-dialling signal. If a start-dialling (proceed-to-send) signal is not received within the time-out interval (e.g. 5 seconds) double seizing is assumed.

In this event, either of the following arrangements may apply:

- a) an automatic repeat attempt to set up the call; or
- b) a recorder indication is given to the operator or to the calling subscriber and no automatic repeat attempt is made.

With either method, means must be provided to ensure positive release of the double seized circuit. To achieve the release it is recommended that the office which first assumes (based on timing) that dual seizure has occurred transmits a tone-on (0 state) signal followed by a tone-off (1 state) signal before the final tone-on (0 state) signal (disconnect) is sent. The duration of initial tone-on (0 state) signal should be a minimum of 100 ms and a maximum of 200 ms. The tone-off (1 state) signal should be recognized as an unexpected tone-off (1 state) signal at the distant end, after which the action specified in 3.6.2, 1c) of Recommendation Q.325 applies.

Recommendation Q.319**2.9 SPEED OF SWITCHING IN INTERNATIONAL EXCHANGES**

2.9.1 It is recommended that the equipment in international exchanges shall have a high switching speed so that the switching time may be as short as possible.

2.9.2 At the outgoing, transit and incoming international exchanges, the seizing of the circuit and the setting up of the connection should take place as soon as possible after receipt of the digits of the address that are necessary to determine the routing.

2.9.3 At international exchanges the delay-dialling signal should be returned as soon as possible after recognition of the connect (seizing) signal. The start-dialling (proceed-to-send) signal should be returned as soon as possible but in any case, the return should be before the time-out of the outgoing register. [See 3.6.2, 1a) and b) of Recommendation Q.325.]

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SECTION 3

REGISTER SIGNALLING ¹⁾

Recommendation Q.320

3.1 SIGNAL CODE FOR REGISTER SIGNALLING

3.1.1 General

- 1) Either semi-automatic working (with automatic machine or direct operator access), or automatic working (with automatic machine access) may be used for outgoing traffic. With automatic machine access the incoming address signals are stored in a register until sufficient address information is received to route the call properly, at which time a free circuit may be selected and a connect (seizing) line signal sent. Subsequent to the recognition of a delay-dialling line signal and a start-dialling (proceed-to-send) line signal a KP (start-of-pulsing) signal followed by the address and ST (end-of-pulsing) signals are transmitted. The KP signal, which is nominally 100 ms in duration, prepares the receiving equipment to accept subsequent register signals. The transmission of the KP signal should be delayed by a minimum of 140 ms, but not more than 300 ms, after recognition of the start-dialling line signal.
- 2) Link-by-link register signalling applies.
- 3) Register signalling is in a forward direction only and shall be in accordance with the two-out-of-six multifrequency code shown in Table 3. Three of the 15 possible codes are unused in international service and are available for special purposes.
- 4) The receiving equipment must furnish a two-and-two only frequency check on each received signal to ensure its validity.

3.1.2 Sending sequence of register signals

- 1) The sending sequence of address signals conforms to the sequence indicated in Recommendation Q.107. However, for traffic within an integrated world numbering zone (e.g. Zone 1) the language or discriminating digit and country codes may have no application and may not be sent. In Zone 1, the sequence of signals sent from the operator or subscriber is as follows:
 - a) *Semi-automatic working for calls to a subscriber within Zone 1:*
 - i) KP;
 - ii) national (significant) number of the called subscriber;
 - iii) ST.

¹⁾ As used in this Section the term register includes traditional registers in electromechanical exchanges and also the equivalent receiving device, memory and logic in stored programme exchanges.

- b) *Semi-automatic working for calls to operators within Zone 1:*
- i) KP;
 - ii) special decimal numbers;²⁾
 - iii) ST.
- c) *Automatic working for calls to a subscriber within Zone 1:*
- i) national (significant) number of the called subscriber.
- 2) The sending sequence of register signals shall conform to Table 3, noting the following:
- a) a KP (start-of-pulsing) signal shall precede the sequence of signals in all cases;
 - b) the ST (end-of-pulsing) signal shall follow the sequence of signals in all cases.

TABLE 3 – Register signal code of System R1

Signals	Frequencies (compound) Hz
KP (start-of-pulsing)	1100 + 1700
Digit 1	700 + 900
Digit 2	700 + 1100
Digit 3	900 + 1100
Digit 4	700 + 1300
Digit 5	900 + 1300
Digit 6	1100 + 1300
Digit 7	700 + 1500
Digit 8	900 + 1500
Digit 9	1100 + 1500
Digit 0	1300 + 1500
ST (end-of-pulsing)	1500 + 1700
Spare	700 + 1700
Spare	900 + 1700
Spare	1300 + 1700

Recommendation Q.321

3.2 END-OF-PULSING CONDITIONS – REGISTER ARRANGEMENTS CONCERNING ST SIGNAL

3.2.1 The register signalling arrangements shall provide for the sending of an ST signal for both semi-automatic and automatic operation; the arrangements in the outgoing international register for recognizing the ST (end-of-pulsing) signal condition may vary as follows:

a) *Semi-automatic operation*

The ST condition is determined by the receipt of the end-of-pulsing signal initiated by the operator.

²⁾ The special numbers used to reach operators are by agreement between Administrations.

b) *Automatic operation*

- i) Where the ST condition is determined by the originating national network, an ST signal is transmitted to the outgoing international register. No further arrangements are necessary in that register for this purpose.
- ii) Where the ST condition is not received from the originating national network, the outgoing international register will be required to determine the ST condition. (See for example the requirements for System No. 5, Recommendation Q.152, *Green Book*.)

Recommendation Q.322**3.3 MULTIFREQUENCY SIGNAL SENDER**

3.3.1 Signalling frequencies 700, 900, 1100, 1300, 1500 and 1700 Hz. A signal shall consist of a combination of any two of these six frequencies. The frequency variation shall not exceed $\pm 1.5\%$ of each nominal frequency.

3.3.2 Transmitted signal level -7 ± 1 dBm0 per frequency. The difference in transmitted level between the two frequencies comprising a signal shall not exceed 0.5 dB.

3.3.3 Signal frequency leak and modulation products. The level of the signal leak current transmitted to the line should be at least:

- a) 50 dB below the single frequency level when a multifrequency signal is not being transmitted;
- b) 30 dB below the transmitted signal level of either of the two frequencies when a multifrequency signal is being transmitted. The modulation products of a signal shall be at least 30 dB below the transmitted level of either of the two frequencies comprising the signal.

3.3.4 *Signal durations*

KP signal: 100 ± 10 ms.

All other signals: 68 ± 7 ms.

Interval between all signals: 68 ± 7 ms.

3.3.5 *Compound signal tolerance*

The interval of time between the moments when the two frequencies comprising a signal are sent must not exceed 1 ms. The interval of time between the moments when the two frequencies cease must not exceed 1 ms.

Recommendation Q.323**3.4 MULTIFREQUENCY SIGNAL RECEIVING EQUIPMENT**3.4.1 *Operate limits*

The signal receiving equipment must operate satisfactorily on any combination of two of the frequencies received as a single pulse or train of pulses in the presence of maximum expected noise on an international circuit, -40 dBm0 uniform spectral energy over the range of 300 to 3400 Hz, that meets the conditions listed below:

- a) each frequency of the received signal is within $\pm 1.5\%$ of the nominal signalling frequency;

- b) the absolute power level N of each received frequency is within the limits

$$(-14 + n \leq N \leq +0 + n) \text{ dBm}$$

where n is the relative power level at the signal receiver input. Assuming a nominal circuit loss of 0 dB these limits give a margin of ± 7 dB on the nominal absolute level of each received signal. Considering that a single equipment may serve circuits whose designed loss (nominal loss) is greater than 0 dB (e.g., circuits that are not equipped with echo suppressors) account must be taken of the highest circuit loss in the design of the receiving equipment (e.g., by increasing must-operate sensitivity) to ensure that the minimum margin is 7 dB;

- c) the difference in level between the frequencies comprising a received signal is less than 6 dB;
- d) the signal receiving equipment must accept signals meeting the following conditions:
- i) signals within the limits specified in a), b), and c) above in the presence of maximum expected noise and subject to the maximum expected delay distortion;
 - ii) the duration of each frequency comprising a signal is 30 ms or greater; and
 - iii) the silent interval preceding the signal is 20 ms or greater.

The tolerances given in a), b), and c) are to allow for variations at the sending end and in line transmission.

The test values indicated in d) are less than the working values. The difference between the test value and the working values will allow for pulse distortion, variations in registration devices, etc.

Note. — Since higher steady noise as well as impulsive noise may be encountered on intraregional circuits, especially over certain compandored carrier systems, the maximum expected noise within a region must be taken into account in the design of equipment for that region.

3.4.2 Non-operate limits

- 1) The receiving equipment shall not operate on any signal whose absolute power level at the point of the receiving equipment is 9 dB or more below the must-operate sensitivity required to satisfy the conditions established in 3.4.1 b).
- 2) The receiving equipment shall release when the signal level falls 1 dB below the level established in 1) above.
- 3) Operation of the receiving equipment shall be delayed for a minimum period necessary to guard against false operation due to spurious signals generated internally on reception of any signal.
- 4) The receiving equipment should not operate on a pulse signal of 10 ms or less. This signal may be of a single frequency or two frequencies received simultaneously. Likewise, after operation the equipment shall ignore short interruptions of the signal frequencies.

3.4.3 Input impedance

The value of the input impedance should be such that the return loss over a frequency range of 500 to 2700 Hz against a 600-ohm non-inductive resistor in series with a two-microfarad capacitor is greater than 27 dB.

Recommendation Q.324

3.5 ANALYSIS OF ADDRESS INFORMATION FOR ROUTING

In the application of System R1 to intraregional networks, the routing plan of that network shall apply. The routing plan is such that analysis is limited to a maximum of six digits.

Recommendation Q.325**3.6 RELEASE OF REGISTERS****3.6.1 Normal release conditions**

- 1) An outgoing register shall be released when it has transmitted the ST signal.
- 2) An incoming register shall be released on the forward transmission of the ST signal to the next exchange, or when all pertinent information has been transferred to an outgoing register.

3.6.2 Abnormal release conditions

- 1) An outgoing register shall release in any of the following situations:
 - a) on failure to recognize a delay-dialling signal within 5 seconds of circuit seizure unless a longer interval is preferred for particular traffic conditions;
 - b) on failure to recognize a start-dialling (proceed-to-send) signal within 5 seconds of recognition of the delay-dialling signal unless a longer interval is preferred for particular traffic conditions;
 - c) on recognition of an unexpected tone-off (0 state) line signal subsequent to the recognition of a start-dialling (proceed-to-send) signal, but prior to completion of outpulsing. This signal sequence will occur in the event of double seizing and therefore a repeat attempt may be invoked and as a result the register may not be released prior to completion of the second attempt. (See Recommendation Q.318.)
 - d) on exceeding overall register timing of 240 seconds.
- 2) An incoming register shall release in any of the following situations:
 - a) on failure to receive the KP signal within 10 to 20 seconds of register seizure;
 - b) on failure to receive the 1st through 3rd digits within 10 to 20 seconds of the registration of the 3rd digit;
 - c) on failure to receive the 4th through 6th digits within 10 to 20 seconds of the registration of the 3rd digit;
 - d) on failure to receive the remaining digits and ST signal within 10 to 20 seconds of registration of the 6th digit;
 - e) on error detection such as receipt of one or more than two frequencies in a pulse;
 - f) on failure to gain access to associated switching equipment within appropriate intervals of time.

The timing intervals given in 1) and 2) above are representative values but need not necessarily apply to all types of switching systems or all traffic loads.

An abnormal release of an outgoing register on failure to receive a delay-dialling signal as discussed in 1a) above, shall result in the circuit being locked out which maintains the tone-off (1 state) condition toward the distant end. The maintenance personnel should be alerted.

Abnormal releases should result in the return of an audible re-order (congestion) tone toward the originating end. If this condition (re-order) persists for more than 1 to 2 minutes, maintenance personnel should be alerted.

Recommendation Q.326**3.7 SWITCHING TO THE SPEECH POSITION**

At all exchanges, the circuit shall be switched to the speech position when the registers (incoming or outgoing) are released.

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SECTION 4

TESTING ARRANGEMENTS

Recommendation Q.327

4.1 GENERAL ARRANGEMENTS

The guiding principles for the maintenance of automatic circuits as covered in Part V of Series Q Recommendations (Recommendations Q.70 to Q.79) are in general applicable to testing of System R1.

Recommendation Q.328

4.2 ROUTINE TESTING OF EQUIPMENT (LOCAL MAINTENANCE)

4.2.1 Test equipment for routine testing of individual items of equipment such as circuit equipment, connecting circuits, registers, etc., should be provided in every international exchange. Routine tests should be made in accordance with the practice followed in each country for the local maintenance of switching equipment and may be made with suitable semi-automatic or automatic test equipment if available.

4.2.2 The testing equipment must conform to the following principles:

- a) an item of equipment must not be taken for test until it is free;
- b) an item of equipment taken for test will be marked engaged (busy) for the duration of the test. Before a circuit equipment is taken for test, the circuit will be withdrawn from service at both international exchanges;
- c) as an alternative to b), a like item of equipment, known to be properly adjusted, may be switched in, and the item of equipment to be tested is switched out during the test.

4.2.3 Testing of the circuit and signalling equipment should include a check that the specifications of System R1 are met in regard to the following:

- a) *2600 Hz line signalling system:*
 - signal frequency;
 - transmitted signal levels;
 - signal frequency leak;
 - receiving equipment operate and non-operate limits;
 - receiving-end line split;
 - sending-end line split;
 - sending duration of signals.
- b) *PCM line signalling equipment:*
 - receiving equipment operate and non-operate limits;
 - sending duration of signals.

c) *Register signalling system:*

- signal frequencies;
- transmitted signal levels;
- signal frequency leak;
- sending duration of signals;
- receiving equipment operate and non-operate limits;
- operation of the receiving equipment in response to a series of pulses;
- error checking features.

Recommendation Q.329

4.3 MANUAL TESTING

4.3.1 *Functional testing of signalling arrangements*

Functional tests from one end of the circuit to the other can be made by verification of satisfactory signal transmission by initiating a test call to:

- a) technical personnel at the distant-end international exchange; or
- b) a test call signal testing and answering device, if such equipment is available at the distant-end international exchange.

4.3.2 *Test calls*

1) Steps in the verification of satisfactory transmission of signals, involved in the completion of test calls (manual method):

- a) place a call to the technical personnel at the distant international exchange;
- b) on completion of the connection the audible ringing tone should be heard and the answer signal should be received when the call is answered at the distant end;
- c) request distant end to initiate a hang-up (clear-back) signal, followed by a re-answer signal;
- d) a hang-up (clear-back) signal should be received and recognized when the distant end hangs up and a second answer signal should be received and recognized when the distant end re-answers the call;
- e) initiate a ring-forward (forward-transfer) signal which should be recognized at the distant end;
- f) terminate the call and observe that the circuit restores to the idle condition.

2) If incoming signalling testing devices are available at the distant international exchange, the signal verification tests should be made using this equipment to the extent that the applicable features indicated in 1) above are available.

Recommendation Q.330

4.4 AUTOMATIC TRANSMISSION AND SIGNALLING TESTING

Considering that automatic transmission and signalling testing of international circuits is extremely desirable, Administrations using or intending to use System R1 are encouraged to provide for this type of testing. Existing automatic testing equipment presently in use in world numbering Zone 1, may be used. When the automatic transmission measuring and signalling testing equipment (ATME) No. 2 becomes available, it may be used as an alternative by agreement of the Administrations concerned.

Recommendation Q.331**4.5 TEST EQUIPMENT FOR CHECKING EQUIPMENT AND SIGNALS****4.5.1 General**

For local checks of correct equipment operation and for readjusting the equipment, international exchanges should have test equipment available which includes:

- a) line and register signal generators;
- b) signal-measuring apparatus.

4.5.2 Signal generators

The signal generators should be able to simulate all line and register signals. The generators may be part of test equipment which cycles the equipment to be tested through actual signalling sequences, in a manner which enables rapid complete testing to determine whether the equipment meets system specifications.

1) Line signal generator characteristics as follows:

- a) signal frequency should be within ± 5 Hz of the nominal signal frequency and shall not vary during the time required for testing;
- b) signal levels should be variable between the limits given in the specification and be able to be set within ± 0.2 dB;
- c) signal durations should be long enough so that the signals can be recognized. See Recommendation Q.313, 2.3.3.

2) Register signal generator characteristics as follows:

- a) signal frequencies should be within $\pm 1.5\%$ of the nominal signal frequency or frequencies and shall not vary during the time required for testing;
- b) signal levels should be variable between the limits given in the specification and be able to be set within ± 0.2 dB;
- c) signal durations and intervals between signals shall be within the limits given in the specification in Recommendation Q.322, 3.3.4, for normal operate values and in Recommendation Q.323, 3.4.1 d), for test operate values.

4.5.3 Signal-measuring equipment

Equipment capable of measuring signal frequencies, signal levels, signal durations and other significant signal time intervals may be part of the test equipment referred to in 4.5.2, or separate instruments.

1) Line signal measuring equipment characteristics as follows:

- a) signal frequency between the extreme limits given in the specification should be measured with an accuracy of ± 1 Hz;
- b) level of the signal frequency measured over the range given in the specification should be measured with an accuracy of ± 0.2 dB;
- c) signal durations, and other significant time intervals as given in the specification should be measured with an accuracy of ± 1 ms or $\pm 1\%$ of the nominal duration, whichever yields the higher value.

- 2) *Register signal measuring equipment characteristics as follows:*
- a) signal frequency or frequencies between the extreme limits given in the specification, should be measured with an accuracy of ± 1 Hz;
 - b) level of the signal frequency or frequencies over the range given in the specification should be measured with an accuracy of ± 0.2 dB;
 - c) signal duration and intervals between signals as given in the specification should be measured with an accuracy of ± 1 ms.
- 3) In regard to measuring time intervals a recorder having a minimum of two input channels may be useful. The recorder characteristic should conform with the accuracy requirements quoted in 1) and 2) above and be easily connected to the circuit under test. The recorder input characteristic should be such as to have a negligible effect on circuit performance.

ANNEX TO THE SPECIFICATIONS OF SIGNALLING SYSTEM R1

SIGNAL SEQUENCES

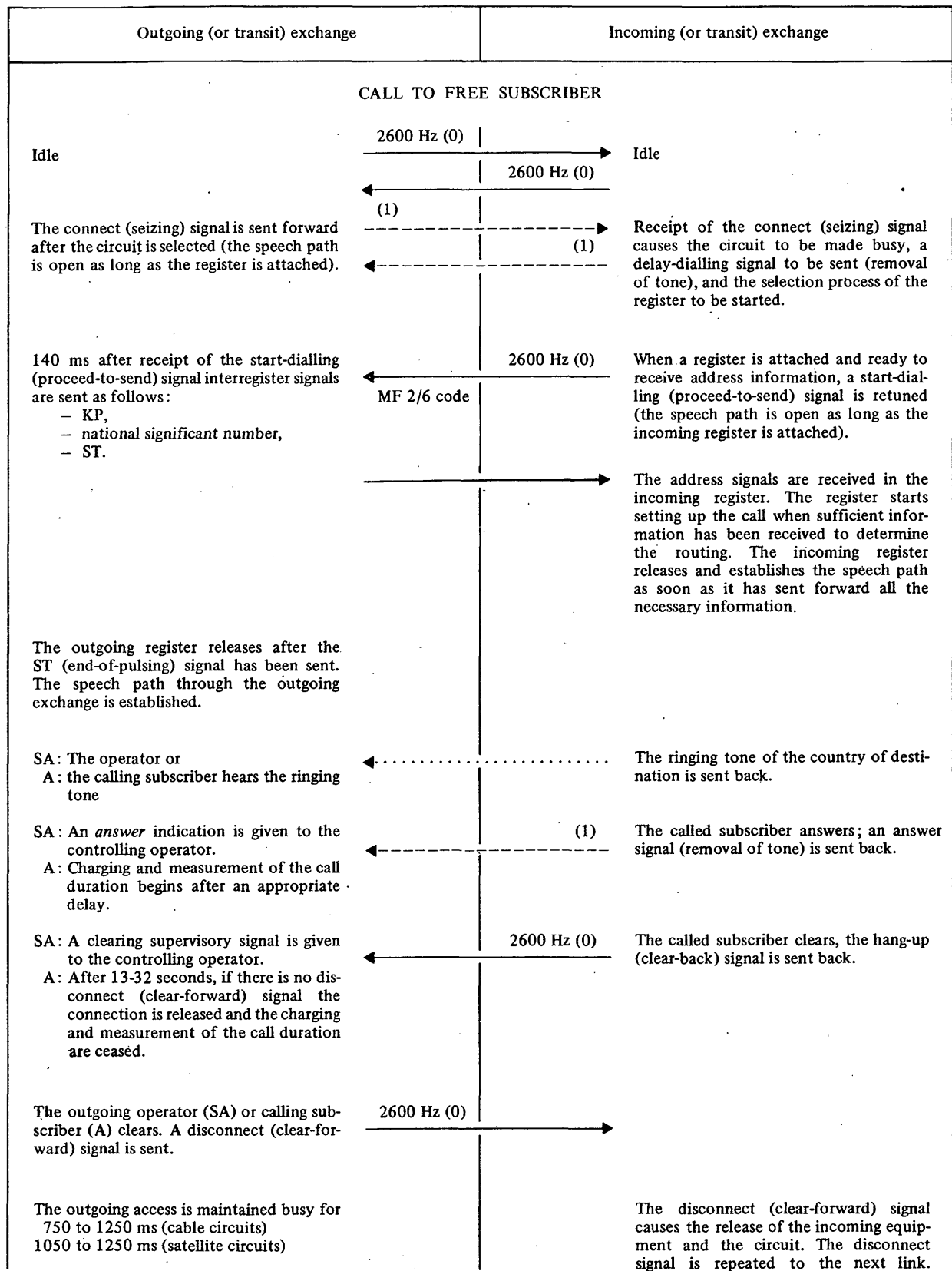
Table 1. — Semi-automatic (SA) and automatic (A) traffic in Zone 1.

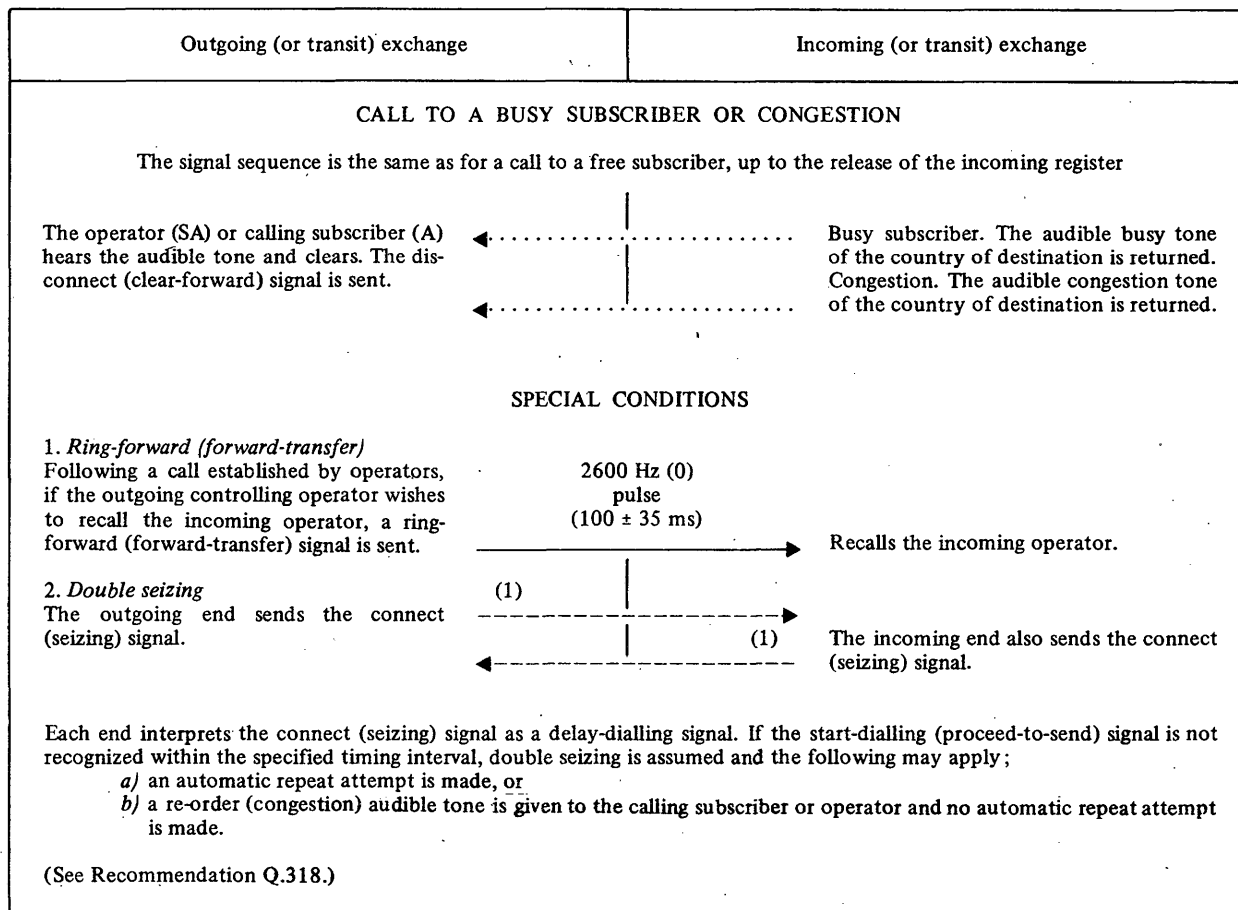
In this table the arrows have the following meanings:

- ▶ transmission of a signalling frequency (permanent or pulse emission).
- - ▶ end of transmission of the signalling frequency in the case of its permanent transmission.
- · · ▶ transmission of an audible tone.

ANNEX

TABLE 1 – Semi-automatic (SA) and automatic (A) traffic in zone 1





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PART II

Series Q Recommendation (Q.332)

INTERWORKING OF SIGNALLING SYSTEM R1 WITH OTHER STANDARDIZED SYSTEMS

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Recommendation Q.332**5. INTERWORKING**

(The specifications of the interworking of Signalling System R1
with other standardized systems form Part XV *bis* of the Series Q Recommendations)

5.1 General

System R1 is capable of interworking with any of the CCITT standardized signalling systems.
Specifications on interworking of System R1 with other CCITT signalling systems are not yet available.
Typical information is found in Recommendation Q.180 of the *Green Book*.

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PART III

Series Q Recommendations (Q.400 to Q.480)

SPECIFICATIONS OF SIGNALLING SYSTEM R2

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SPECIFICATIONS OF SIGNALLING SYSTEM R2

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SIGNALLING SYSTEM R2

(The specifications of Signalling System R2
form Part XVI of the Series Q Recommendations)

INTRODUCTION

General

Signalling System R2 is used as an international signalling system within international regions (world numbering zones). Moreover, System R2 can be used for integrated international/national signalling if it is employed, in conformity with the present specifications, as a signalling system in the national networks of the region concerned. Suitable for both automatic and semi-automatic working it offers a high reliability in transmission of the information necessary for setting up a call. It allows for rapid call set-up and provides sufficient signals in both directions to permit the transmission of numerical and other information relating to the called and calling subscribers' lines and to increase routing facilities.

System R2 is specified for one-way and both-way operation and distinction is made between line signalling (supervisory signals) and interregister signalling (call set-up control signals). Versions of line signalling are specified for use on 4-wire carrier or PCM circuits. Nevertheless, the interregister signalling specified can also be used on 2-wire circuits. Although studies have not been completed System R2 is suitable for restricted use on satellite links. (See Annex 3 to the present specifications.) It is not yet designed for use on 3 kHz spaced carrier or TASI circuits ¹⁾.

The interregister signalling is a compelled multifrequency code system. This offers the possibility of end-to-end signalling and to take advantage of modern switching systems by providing a sufficient number of signals in both directions.

System R2 is capable of normal interworking with other CCITT signalling systems.

Line signalling

Two versions of line signalling are specified:

- line signalling for carrier systems called the analogue version;
- line signalling for PCM systems called the digital version.

Since multifrequency signalling permits exchange of a large amount of information between registers, the quantity of information that has to be transmitted in the form of line signals is small. The versions of line signalling for System R2 have been designed accordingly. The analogue line signalling version standardized originally for use on international circuits is also suitable for national working. The digital line signalling version was designed for national working but may also be used for international working. Although these versions do not include a forward-transfer signal, forward-transfer signalling may be introduced for international working by bilateral agreement.

¹⁾ The following items are under study :
— satellite application of System R2;
— line signalling system for 3 kHz submarine cables;
— line signalling for two-wire national links.

The *analogue version* is link-by-link using an out-band, low-level continuous tone-on-idle signalling method. Signal transfer simply involves the transition from one signalling condition to the other, except for the clearing sequence which is based on additional timing criteria. It is necessary to have a device for protection against the effect of interruption in the signalling channel since interruption of the signalling frequency simulates a false seizure or answer signal (interruption control). The signalling frequency is transmitted at a low level which avoids overloading of the transmission system when the frequency is sent continuously in both directions on all idle circuits. The exchange line-signalling equipment of the analogue version can also be used over certain digital links (see Recommendation Q.421).

The *digital version* is link-by-link using two signalling channels in each direction of transmission per speech circuit. The signalling channels are two of the four provided for channel associated signalling in a 2048 kbit/s primary multiplex (see Recommendation G.732). Protection against the effects of faulty transmission is provided by a *Transmission Fault Control*.

Interregister signalling

The interregister signalling is performed end-to-end using a 2-out-of-6 in-band multifrequency code with forward and backward compelled signalling. The signalling frequencies do not therefore overlap with the line signalling frequency and differ according to the direction of transmission with a view to possible use of the multifrequency part of the system on 2-wire circuits.

System R2 is designed to use six signalling frequencies (1380, 1500, 1620, 1740, 1860 and 1980 Hz) in the forward direction and six signalling frequencies (1140, 1020, 900, 780, 660 and 540 Hz) in the backward direction. Nevertheless for national application less signalling frequencies may be used.

End-to-end signalling is a method for signalling between registers over two or more links in tandem without signal regeneration in intermediate exchanges (see Figure 1).

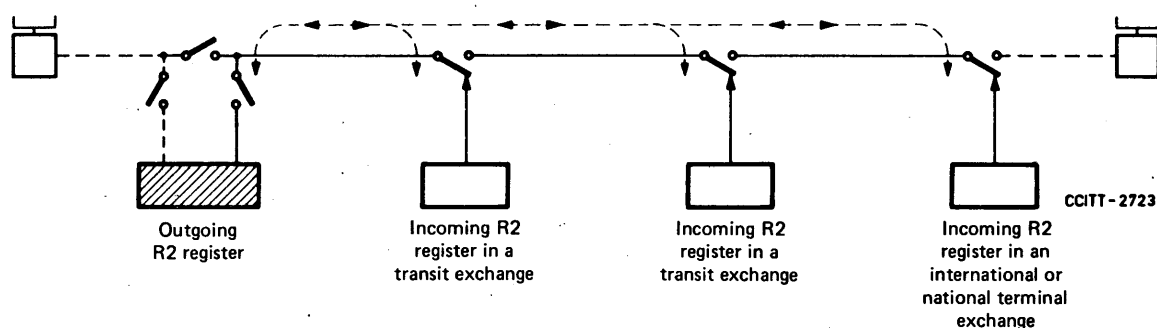


FIGURE 1 – Principle of end-to-end R2 interregister signalling

With this signalling method, in general only the address information needed for routing the call through an intermediate (transit) exchange is transferred from the outgoing register to the incoming register. In the intermediate exchange the speech path is immediately through-connected and the incoming register released. Then the outgoing register can exchange information directly with the incoming register of the next exchange. Such end-to-end signalling is advantageous as it reduces the interregister signalling equipment needed and minimizes the holding time of registers in transit exchanges.

System R2 has been designed to allow end-to-end interregister multifrequency signalling over several links in tandem. However, in circumstances where transmission conditions do not comply with the requirements specified for System R2 and might consequently jeopardize the exchange of the interregister signals, the overall multi-link connection is divided into sections, each with its individual interregister signalling (signals being then relayed and regenerated by a register at the point where the division is made).

Generally transmission conditions in a national network comply with the requirements specified for System R2 and as such allow end-to-end signalling over complete connections between local exchanges.

In the case of international System R2 working transmission conditions impose division into at least two signalling sections, when both the outgoing and incoming countries use System R2 in the national network. The division must be made in an exchange in the outgoing country. The relaying or regenerating register situated at the point where the division is made is called *the outgoing international R2 register*. In the case when System R2 is not used in the outgoing country the outgoing international R2 register receives address information via a national signalling system and it controls the call set-up over the outgoing System R2 signalling section.

The outgoing R2 register is generally defined as a register situated at the outgoing end of a signalling section on which System R2 interregister signalling, according to the present specifications, is used. It controls the call set-up over the whole signalling section. It sends forward interregister signals and receives backward interregister signals. The outgoing R2 register receives information via the preceding links of the connection in a form used by the signalling system applied over the last of these links; this system may be System R2, a decadic pulse system, or any other system. The preceding link may also be a subscriber's line.

When an *R2 register in a transit exchange* is working according to the definition above it is also called an *outgoing R2 register*. *The outgoing international R2 register* is the special case of the outgoing R2 register when the outgoing signalling section comprises at least one international link.

The incoming R2 register is defined as a register situated at the incoming end of a link on which System R2 interregister signalling, according to the present specification, is used. It receives forward interregister signals via the preceding link(s) and sends backward interregister signals. The information received is used completely or in part for the control of selection stages and may be sent in its entirety or in part to the succeeding equipment, in which case the signalling used for retransmission is never System R2. Interworking then takes place between System R2 and the other System. Thus every register not situated at the outgoing end of a System R2 signalling section is called an incoming R2 register independently of the exchange type.

The following operational features are provided by using all the 15 forward and 15 backward combinations of the multifrequency code:

- capability of transferring address information for automatic, semi-automatic and maintenance calls;
- indicators in order to identify transit and maintenance (test) calls;
- language digits or discriminating digit(s) for international calls;
- transfer of the next digit or repetition of the last but one, the last but two, or the last but three digit on request by the register at the incoming end;
- forward and backward signals for control of echo suppressors;
- request of the outgoing register by means of a backward signal to send the international code indicating the identity of the originating international exchange;
- information concerning the nature and the origin of the call (calling party's category) can be transferred to the register at the incoming end i.e. whether national or international, whether from an operator or from a subscriber, whether from data-transmission, maintenance or other equipment, etc.;
- information on congestion, unallocated number and on the condition of the called subscriber's line can be transferred to the outgoing register i.e. whether free, busy or out of service, etc.;
- a restricted number of signals left to the discretion of Administrations for allocation of national meanings.

The interregister signalling specified for System R2 can also be used together with any non-standardized line signalling system. The resulting combination is not considered to be System R2.

System R2 gives potential for a short post-dialling delay using *overlap operation* with dialling and end-to-end signalling. The outgoing R2 register starts call set-up as soon as it has received the minimum requisite information. Therefore signal transfer starts before the complete address information is received, i.e. before the caller finishes dialling. This practice particularly applies at an outgoing R2 register where the complete address information from a subscriber or operator is stored (e.g. local registers). This is in contrast to *en bloc* register signalling i.e. the transmission of all the address information as a whole in one sequence starting only after complete reception of the address information.

Unused signalling capacity provides potential for development and allows for future requirements yet undefined. This spare capacity may be used for increasing the number of signals and signalling procedures e.g. for new services to be offered to subscribers.

SECTION 1

DEFINITIONS AND FUNCTIONS OF SIGNALS

Recommendation Q.400

DEFINITIONS AND FUNCTIONS OF SIGNALS

1.1 FORWARD LINE SIGNALS

1.1.1 seizing signal

A signal sent at the beginning of the call to initiate transition of the circuit at the incoming end from idle to busy. At the incoming exchange it causes the association of equipment capable of receiving register signals.

1.1.2 clear-forward signal

A signal sent to terminate the call or call attempt and to release in the incoming exchange and beyond it all switching units held on the call.

The signal is sent when:

- a) in semi-automatic working the operator of the outgoing international exchange takes the plug out or performs an equivalent operation;
- b) in automatic working, the calling subscriber clears or performs an equivalent operation.

This signal is also sent by the outgoing international exchange upon receiving a backward register signal requesting the outgoing international R2 register to clear the connection, or in the case of forced release of the connection as mentioned in Recommendation Q.118. This signal may also be sent as the result of abnormal release of the outgoing international R2 register.

1.1.3 forward-transfer signal ¹⁾

A signal sent on semi-automatic calls when the outgoing international exchange operator wants the help of an operator at the incoming international exchange. The signal will usually bring an assistance operator (see Recommendation Q.101) into the circuit. If the call is completed via an incoming or delay operator at the incoming international exchange, the signal indicates that recall of this operator is wanted.

¹⁾ This signal is not provided in either the analogue or digital version of System R2 line signalling. Information about possible arrangements for such a signal and signalling procedures involved are contained in Annex 1 to the present Specifications.

1.2 BACKWARD LINE SIGNALS

1.2.1 seizing-acknowledgement signal ²⁾

A signal sent to the outgoing exchange to indicate the transition of the equipment at the incoming end from idle to busy. Receipt of the seizing-acknowledgement signal at the outgoing end terminates seizure of the circuit.

1.2.2 answer signal

A signal sent to the outgoing international exchange to indicate that the called party has answered the call (see Recommendation Q.27). In semi-automatic working this signal has a supervisory function.

In automatic working this signal is used:

- to start metering the charge to the calling subscriber, unless the register signal indicating no charge has been sent previously;
- to start measurement of the call duration for international accounting purposes.

1.2.3 clear-back signal

A signal sent to the outgoing international exchange to indicate that the called party has cleared. In semi-automatic working, this signal has a supervisory function. In automatic working, arrangements must be made in accordance with Recommendation Q.118, and the notes of Recommendation Q.120, 1.8 also apply.

1.2.4 release-guard signal

A signal sent to the outgoing exchange in response to a clear-forward signal to indicate that the latter has been fully effective in returning the switching units at the incoming end of the circuit to idle condition. An international circuit is protected against subsequent seizure as long as the release operations initiated by the clear-forward signal have not been completed at the incoming end.

1.2.5 blocking signal

A signal sent on an idle circuit to the outgoing exchange to cause engaged conditions (blocking) to be applied to this circuit, guarding it against subsequent seizure.

1.3 FORWARD REGISTER SIGNALS

1.3.1 address signal

A signal containing one element of information (digit 1, 2...9 or 0, code 11, code 12 or code 13) about the called or calling party's number or the end of pulsing indication (code 15).

For each call a series of address signals is sent (see Recommendations Q.101 and Q.107).

²⁾ This signal is only used in the digital version of System R2 line signalling.

1.3.2 country-code and echo-suppressor indicators

Signals indicating:

- whether or not the country-code is included in the address information (international transit or terminal call);
- whether or not an outgoing half-echo suppressor should be inserted in the first international exchange reached;
- whether or not an incoming half-echo suppressor should be inserted (an outgoing half-echo suppressor having already been inserted in the connection).

1.3.3 language or discriminating digit

A numerical signal occupying a predetermined position in the sequence of address signals indicating:

- in semi-automatic working, the service language to be used in the incoming international exchange by the incoming, delay and assistance operators when they come in the circuit (language digit);
- the automatic working or any other special characteristic of the call (discriminating digit).

1.3.4 test call indicator

A signal occupying the position of the language digit when the call is originating from test equipment.

1.3.5 end-of-pulsing signal

An address signal sent indicating (in semi-automatic service) that no other address signal will follow or (in automatic service) that the transmission of the code identifying the origin of the call is completed.

1.3.6 calling party's category signals

A special group of signals providing, in addition to the information contained in the language or discrimination digit, supplementary information concerning the nature of the call (i.e. whether national or international) and its origin.

Typical categories are:

- operator capable of sending the forward-transfer signal;
- ordinary subscriber or operator with no forward-transfer facility;
- subscriber with priority;
- data transmission call;
- maintenance call.

1.3.7 *Signals for use on the national network*

Some of the Group II forward signals (see Recommendation Q.441, 4.2.3.2) have been allocated for national use. When the outgoing international R2 register receives them it must react as specified in Recommendation Q.480.

1.4 BACKWARD REGISTER SIGNALS

1.4.1 *Signals requesting transmission of address signals*

Five backward signals without particular names are provided; four of them are interpreted with reference to the latest address signal sent:

- signal requesting the transmission of the address signal following the latest address signal sent;
- signal requesting repetition of the address signal preceding the latest address signal sent (last but one);
- signal requesting the repetition of the last but two address signal sent;
- signal requesting the repetition of the last but three address signal sent;
- signal requesting the transmission or repetition of the language or discrimination digit.

1.4.2 *Signals requesting information about the call or calling party*

Four backward signals without particular names are provided for this purpose:

- signal inquiring the calling party's category;
- signal requesting the repetition of the country-code indicator;
- signal inquiring the origin of the call (location of outgoing international R2 register);
- signal inquiring whether or not incoming half-echo suppressor should be inserted.

1.4.3 *Congestion signals*

Two congestion signals are provided:

- a signal indicating international congestion, i.e. that the call set-up attempt has failed owing to congestion of the group of international circuits, or congestion in the international switching equipment, or to time-out or abnormal release of an incoming R2 register in an international transit exchange;
- a signal indicating national congestion, i.e. that the call set-up attempt has failed owing to congestion in the national network (excluding a busy called subscriber's line) or to time-out or abnormal release of an incoming R2 register in a terminal international exchange or a national exchange.

1.4.4 *address-complete signals*

Signals indicating that it is no longer necessary to send another address signal, and

- either cause immediate passage to the speech position to enable the calling subscriber to hear a tone or a recorded announcement of the national incoming network;
- or announce the transmission of a signal indicating the condition of the called subscriber's line.

1.4.5 *Signals indicating the condition of the called subscriber's line*

Six signals sent in the backward direction are provided to give information about the called subscriber's line and to indicate the end of interregister signalling. These signals are:

- **send special information tone**
a signal indicating that the inquiry service should be called. In general it indicates that the national number received has ceased to be used and that the subscriber to whom it was allocated must be reached via another number;
- **subscriber line busy** a signal indicating that the line or lines connecting the called subscriber to the exchange are busy;
- **unallocated number**
a signal indicating that the number received is not in use (e.g. an unused country code or an unused trunk code or subscriber number that has not been allocated);
- **subscriber line free, charge**
a signal indicating that the called subscriber's line is free and that the call is to be charged on answer;
- **subscriber line free, no charge**
a signal indicating that the called subscriber's line is free and that the call is not to be charged on answer. This signal is used only for calls to special destinations;
- **subscriber line out of order**
a signal indicating that the subscriber's line is out-of-service or faulty.

1.4.6 *Signals for use in the national network*

Some of the backward signals have been allocated for national use. Since not all incoming registers can know the origin of the connection and since end-to-end signalling is used, it may happen that the above-mentioned signals are sent to the outgoing international R2 register. When this register receives them it must react as indicated in Recommendations Q.474 and Q.480.

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SECTION 2

LINE SIGNALLING, ANALOGUE VERSION

Recommendation Q.411

2.1 ANALOGUE LINE SIGNALLING CODE

2.1.1 General

The System R2 line signalling, analogue version, is intended for use on carrier circuits. The line signals are transmitted link-by-link. The code for the transmission of line signals is based on the *tone-on-idle* signalling method. It is required that the circuits on which the system is employed are equipped in each direction of transmission with a signalling channel outside the speech frequency band. When the circuit is idle, a low-level signalling tone is sent continuously in both directions over the signalling channels. The tone is removed in the forward direction at the moment of seizure and in the backward direction when the called subscriber answers.

The connection is released when the signalling tone is restored in the forward direction; release causes the tone to be restored in the backward direction. If the called party is the first to clear, the signalling tone is restored in the backward direction first. It is then restored in the forward direction either when the caller clears or when a certain interval has elapsed after recognition of the signalling tone in the backward direction. This signalling method, requiring only simple equipment, provides rapid signal recognition and retransmission. The signal transfer speed provided by continuous type signalling compensates for the need of signal repetition inherent in link-by-link transmission.

The signalling system is specified for one-way operation of 4-wire carrier circuits. Both-way operation is also possible (see 2.2.5 below) but requires more complicated equipment. For conditions of use, see Recommendation Q.108.

2.1.2 Line conditions

Tone-on or tone-off denotes a certain signalling state. The line thus has two possible states in each direction, i.e. a total of four signalling states. Taking into account the time sequence, the circuit will have the six characteristic operating conditions shown in the following table:

Operating condition of the circuit	Signalling states	
	Forward	Backward
1. Idle	Tone-on	Tone-on
2. Seized	Tone-off	Tone-on
3. Answered	Tone-off	Tone-off
4. Clear-back	Tone-off	Tone-on
5. Release	Tone-on	Tone-on or off
6. Blocked	Tone-on	Tone-off

The transition from one signalling state to another corresponds to the transfer of a line signal according to the definitions in Section 1. To change from *release* to *idle* additional criteria (timing) are necessary to ensure a defined sequence corresponding to the transfer of the release-guard signal (see 2.2.2.6 below).

Recommendation Q.412

2.2 CLAUSES FOR EXCHANGE LINE-SIGNALLING EQUIPMENT¹⁾

2.2.1 Recognition time for transition of signalling state

The recognition time t_r for a changed state (transition from tone-on to tone-off or vice-versa) is 20 ± 7 ms²⁾. The recognition time is defined as the minimum duration that the presence or absence of a direct current signal must have at the output of the signal receiver in order to be recognized as a valid signalling state by the exchange equipment. Thus the specified value does not include the response time t_{rs} of signalling receivers (see Recommendation Q.415). However, it is determined on the assumption that there is interruption control (see Recommendation Q.416).

2.2.2 Normal operating conditions

2.2.2.1 Seized

The outgoing end removes the tone in the forward direction. If seizure is immediately followed by release, removal of the tone must be maintained for at least 100 ms to make sure that it is recognized at the incoming end.

2.2.2.2 Answered

The incoming end removes the tone in the backward direction. When another link of the connection using tone-on-idle continuous signalling precedes the outgoing exchange, the tone-off condition must be established on this link immediately after it is recognized in this exchange. When another signalling system is used on the preceding link, the rules for interworking are applicable.

2.2.2.3 Clear-back operating condition

The incoming end restores the tone in the backward direction. When another link of the connection using tone-on-idle continuous signalling precedes the outgoing exchange the *tone-on* state must be established on this link immediately after it is recognized in this exchange. When another signalling system is used on the preceding link, the rules for interworking are applicable. The provisions set forth in 2.2.2.6 below must also be taken into consideration.

2.2.2.4 Clear-forward operation condition

The outgoing end restores the tone in the forward direction (see 2.2.2.1 above). The forward connection is released and the release-guard sequence begins as soon as the changed signalling state is recognized at the incoming end. In the outgoing exchange the circuit remains blocked until the release-guard sequence is terminated (see 2.2.2.6 below).

2.2.2.5 Blocked

At the outgoing exchange the circuit stays blocked so long as the tone remains off in the backward direction.

Restoration of the tone in the backward direction — accompanied by the presence of the tone in the forward direction — restores the circuit to idle. The circuit may then be seized for a new call.

¹⁾ Although the signalling state (tone-on or tone-off) physically only appears in transmission equipment, it is used in this section as a reference criterion to specify functions of exchange equipment.

²⁾ A possible increase of this recognition time to $t_r = 40 \pm 10$ ms is under study.

2.2.2.6 Release and release-guard operating conditions

Release-guard must be ensured whatever the operating condition of the circuit at the moment the clear forward signal is sent — seized prior to answer, answered or cleared by the called party. It may also happen that answering or clearing by the called party occurs when release has already begun at the outgoing exchange. The cases are described below and shown in the Figures 2/Q.412 to 4/Q.412. The exact timing is shown in Figure 5/Q.412.

a) Release prior to answered condition

The clear-forward signal is sent from the outgoing end by restoring the tone in the forward direction (see Figure 2/Q.412). Recognition of this tone has the following consequences at the incoming end:

- i) the tone in the backward direction is removed;
- ii) the release of the switching units is initiated;
- iii) the release-guard sequence starts.

When release operations at the incoming end are complete, but not before an interval T_2 equal to 450 ± 90 ms has elapsed after the removal, the tone is again restored at the incoming end in the backward direction.

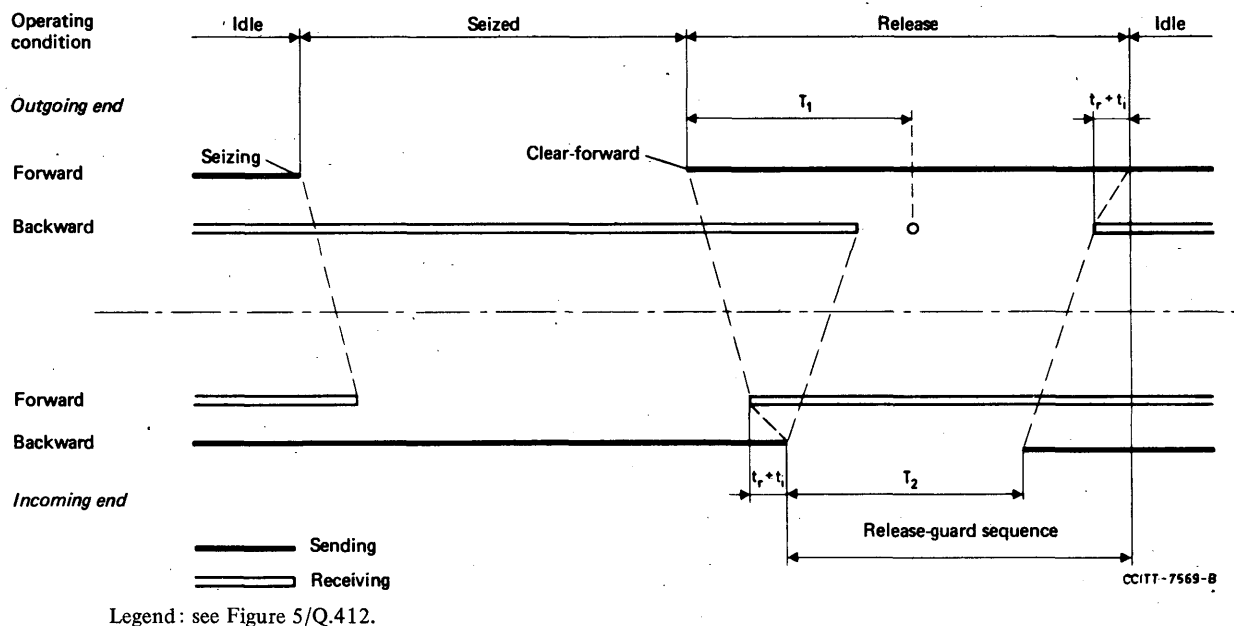


FIGURE 2/Q.412 — Release prior to answered condition

When T_1 has elapsed the outgoing end must recognize that the tone-off state in the backward direction is established. After this recognition the restoring of the tone in the backward direction returns the circuit to idle and completes the release-guard sequence.

At the incoming end the sending of an answer signal can only be prevented after the clear-forward signal has been recognized. To avoid any false operation should answer coincide with release, transition from *tone-on* to *tone-off* in the backward direction must not be interpreted, at the outgoing end, as part of the release-guard sequence during an interval T_1 equal to 250 ± 50 ms. The interval T_1 starts with the sending of the tone in the forward direction. It is long enough to make quite sure that the clear-forward signal is recognized and the *tone-off* state established at the incoming end.

For the calculation of the intervals T_1 and T_2 see 2.2.2.7 below.

b) *Release in answered condition*

In this case, the release operations differ only from a) above in so far as i) does not apply. At the incoming end, however, sending of a clear-back signal can only be prevented after the clear-forward signal has been recognized. Should there be a clear-back signal the specified interval T_1 enables any resultant difficulties to be obviated (see Figure 3/Q.412).

c) *Release in clear-back condition*

The release operations are identical to those described in a) above. Should there be a second answer signal, the specified interval T_1 enables any resultant difficulties to be obviated (see Figure 4/Q.412).

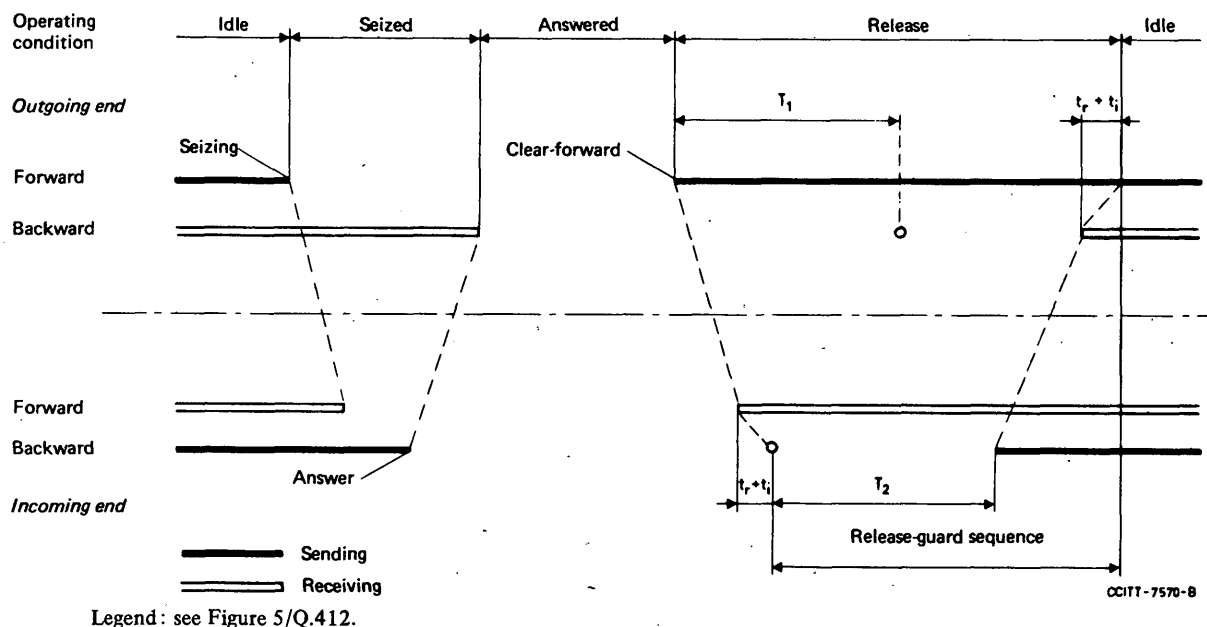


FIGURE 3/Q.412 – Release in answered condition

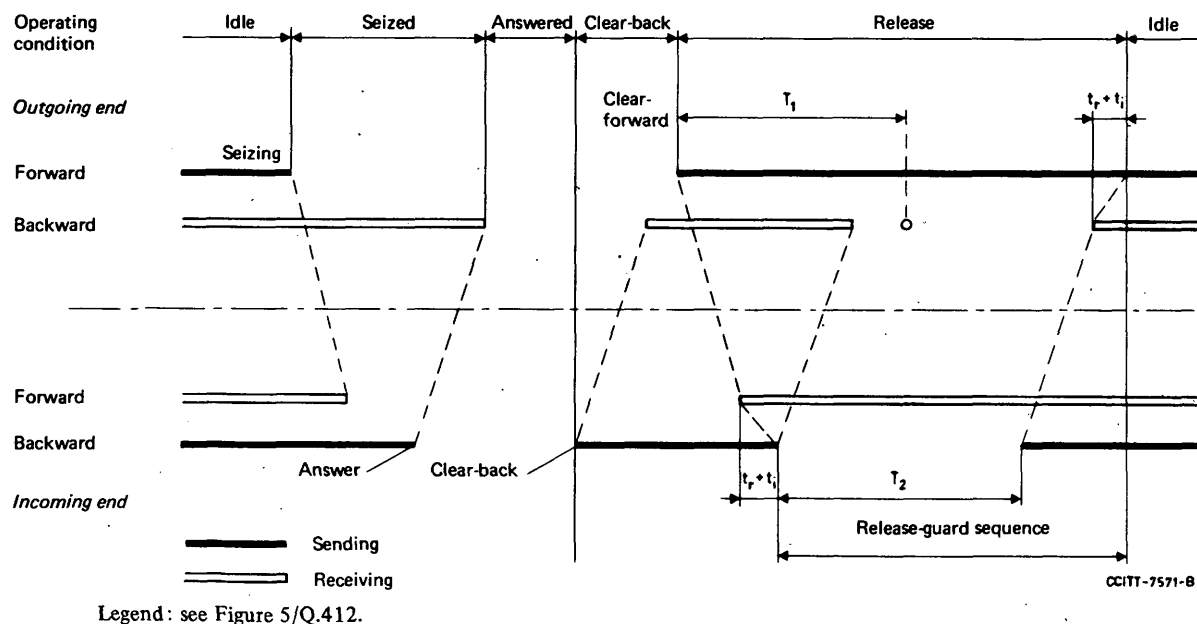
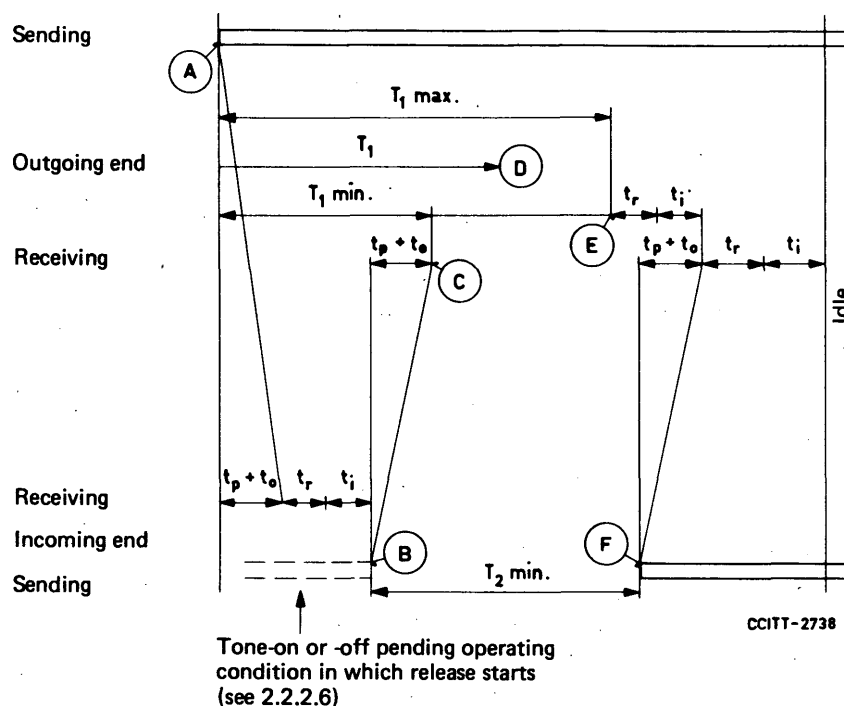


FIGURE 4/Q.412 – Release in clear-back condition

2.2.2.7 Calculation of the intervals T_1 and T_2 specified for release and release-guard operations

Figure 5/Q.412 shows the factors involved in calculating the intervals T_1 and T_2 . The calculation is based on a maximum one-way transmission delay of 30 ms for a circuit. Thus, for circuits on high-velocity transmission systems via terrestrial lines (including submarine cables) the maximum operating range of the specified line signalling system is 4800 km³⁾.



Legend

- t_p : propagation time
 t_o : overall response time of signalling sender and receiver
 t_r : recognition time
 t_i : internal operating time

Values used for the calculation of T_1 and T_2

- $0 < t_p < 30$ ms
 $0 < t_o < 30$ ms (see 2.3.2.4)
 13 ms $< t_r < 27$ ms
 $0 < t_i < 20$ ms

Calculation of intervals T_1 and T_2

$$T_1 > \overline{AC} \quad T_1 > 2(t_p + t_o) \text{ max.} + t_r \text{ max.} + t_i \text{ max.}$$

$$T_1 > 2 \times 60 + 27 + 20 \text{ ms}$$

$$T_1 > 167 \text{ ms}$$

$$T_1 = 250 \pm 50 \text{ ms}$$

$$T_2 > \overline{BF} \quad T_2 > T_1 \text{ max.} + t_r \text{ max.} + t_i \text{ max.} - 2(t_p + t_o) \text{ min.} - t_r \text{ min.} - t_i \text{ min.}$$

$$T_2 > 300 + 27 + 20 - 0 - 13 - 0$$

$$T_2 > 334 \text{ ms}$$

$$T_2 = 450 \pm 90 \text{ ms}$$

FIGURE 5/Q.412 – Release-guard sequence

At the outgoing end when the interval T_1 has elapsed (Figure 5/Q.412, point D) the *tone-off* state in the backward direction can be expected and recognized with certainty in all cases mentioned in 2.2.2.6 above. Similarly, the interval T_2 preceding the restoring of the tone in the backward direction may be applied in all cases. To avoid false operation in the event of coinciding forward and backward signals or an irregular sequence of signals, the time interval T_2 must also be observed with the release operation [see 2.2.2.6 b) above].

³⁾ See Volume III, Recommendation G.114, b), *Orange Book*.

The minimum value of T_1 is the sum of the maximum values of the times required for the various operations which take place between application of the tone in the forward direction and recognition of the absence of tone in the backward direction. Allowing a safety margin of 33 ms and a tolerance of $\pm 20\%$, the specified value of T_1 is 250 ± 50 ms.

T_2 delays release of the circuit. It must therefore be as short as possible. However, it must be long enough to ensure recognition of the *tone-off* condition in the backward direction at the outgoing end when T_1 is at its maximum, even when this condition begins as early as possible. Allowing a safety margin of 26 ms and a tolerance of $\pm 20\%$, the specified value of T_2 is 450 ± 90 ms.

2.2.3 *Abnormal conditions*

The situations described below are those in which interruption control of signalling channels (see Recommendation Q.416) does not function and which occur only during interruptions of individual channels or in the event of a fault in a line-signalling equipment. In addition, the situations described in 2.2.3.3 and 2.2.3.4 below may also result from operation of interruption control at the incoming end of the circuit. In that case the circuit automatically returns to normal at the command of interruption control.

2.2.3.1 If an exchange erroneously recognizes an answer signal (i.e. tone-off state in the backward direction) before the outgoing R2 register has received a signal A-6 or a Group B-signal, the connection must be released. Congestion information is then sent backwards or a repeat attempt is made to set up the call.

2.2.3.2 In the case of non-reception of the answer signal, of delay in clearing by the calling subscriber in automatic working, or of non-reception of the clear-forward signal by the incoming exchange after the clear-back signal has been sent, the provisions of Recommendation Q.118 apply.

2.2.3.3 If, in cases 2.2.2.6 a) or c) above, the tone in the backward direction is not removed, the circuit will remain blocked, since it cannot return to idle condition of its own accord. The action to be taken in such cases is described in Annex 1 to Question 13/XI (Contribution COM XI, No. 1, 1977-1980).

2.2.3.4 If after sending of the clear-forward signal the signalling tone in the backward direction is not restored, the circuit stays blocked, as described in section 2.2.2.5 above. The same occurs when, in the idle position, the signalling tone in the backward direction is interrupted by a fault.

2.2.3.5 When the signalling tone in the forward direction of an idle circuit is interrupted owing to a fault, the incoming end recognizes a seizure and connects multifrequency signalling equipment, but no interregister signalling follows.

- a) When the interruption is greater than the incoming R2 register time-out (see Recommendation Q.476) the register will release and the circuit must be brought into blocked condition by removal of the signalling tone in the backward direction. As soon as the fault is cleared and the tone in the forward direction consequently restored, the circuit returns to idle in accordance with 2.2.2.6 b) above.
- b) When the interruption is shorter than the time-out, restoration of the signalling tone in the forward direction will return the circuit to idle in accordance with 2.2.2.6 a) above.

2.2.4 *Alarms for technical staff*

According to Recommendation Q.117, an alarm should in general be given to technical staff as soon as an abnormal condition is recognized as probably due to a fault.

It is recommended that a delayed-action alarm should be operated at the outgoing end for the conditions described in 2.2.2.5, 2.2.3.3 and 2.2.3.4 above, i.e. when the circuit does not revert to idle after sending of the clear-forward signal or receipt of the blocking signal.

Arrangements for the operation of the alarm will be made by each Administration.

At both the outgoing and the incoming end, when interruption control (see Recommendation Q.416) functions, alarm condition must first be established for the transmission equipments. However, in this case a delayed-action alarm may also be given to the technical staff of the exchange.

2.2.5 *Both-way working*

In principle the System R2 is specified for one-way working. The following additional clauses therefore apply only to cases where Administrations have undertaken by bilateral agreement to use both-way working.

Equipment which must be equally usable in both-way and in one-way operation should be so designed that it can be easily adapted to the requirements of either mode of operation.

A peculiarity of both-way working with the system under consideration is that a blocking signal cannot be distinguished from a seizing signal at either end of a circuit, since the transition of the signalling state corresponding to these signals is the same, namely from *tone-on* to *tone-off*.

When a both-way circuit is seized simultaneously at both ends, the signalling tone is disconnected in both directions of transmission; this is the criterion for detecting the double-seizure situation.

The special arrangements required for both-way working relate to the two cases mentioned above. For all other signalling phases the specifications for one-way working remain valid without modification.

2.2.5.1 *Normal conditions*

a) *Double seizure*

When the signalling equipment at one end of a both-way circuit seizes that circuit by disconnecting the signalling tone, it must verify that cessation of the signalling tone in the opposite direction does not occur within 250 ± 50 ms of the disconnection of the signalling tone in the forward direction. If the signalling equipment detects the removal of the signalling tone within that interval then a double-seizure situation is recognized. Each end must return to the idle condition after sending the clear-forward signal and recognizing *tone-on* state on the signalling channel.

However, each end must, even if immediately seized for an outgoing call, maintain *tone-on* state for at least 100 ms on the outgoing signalling channel to ensure that the end of the double seizure situation is recognized at the other end.

Although a double seizure has been recognized, the *tone-off* state in the backward direction is passed on backwards. This will be regarded as an erroneous answer signal and lead to the release of the connection in accordance with 2.2.3 above. However, as specified in 2.2.5.2 a) below the clear-forward signal (*tone-on* state) must not be sent until the *tone-off* state has been maintained for at least 1250 ± 250 ms. Each end after sending of the clear-forward signal returns to the idle condition when the time interval 250 ± 50 ms (see 2.2.2.6 above) has elapsed, and the sending of the *tone-on* state from the other end has been recognized.

In the sense of preventive action it is recommended that an opposite order of circuit selection is used by each exchange of a both-way circuit group to minimize double seizure.

b) *Minimum duration of idle condition after release-guard*

When a both-way circuit is released, the end which acted as the incoming end must, even if immediately seized for a call in the opposite traffic direction, maintain the *tone-on* state for at least 100 ms to ensure that the release-guard sequence is recognized at the other end.

c) *Blocking*

When a both-way circuit is blocked manually in its idle condition at one end (A), the blocking signal, must be transmitted to the other end (B), where it will nevertheless be interpreted as a seizing signal. This will mean that an incoming R2 register is seized, but is not receiving any interregister signal. After the lapse of this register's time-out delay the circuit must be kept blocked locally (at end B) against all calls in the B-A direction so long as the *tone-off* state persists in A-B direction.

To avoid certain difficulties [see 2.2.5.2 a) and b) below] and in contrast to specification 2.2.3.5 above the *tone-off* signalling state is not applied in the opposite direction (B-A) to the blocking direction (A-B).

When the blocking is removed at end A the signalling tone is again transmitted in direction A-B and the B-end interprets the onset of the signalling tone as a clear-forward signal, thereby initiating the release-guard sequence in the B-A direction.

2.2.5.2 *Abnormal conditions*

The cases described below relate to interruption of the individual signalling channels or to faults in the individual line-signalling equipment. Interruption control does not function in these cases.

In any circuit the interruption of one or both signalling channels can bring about signalling sequences different from those described in 2.2.3 above for one-way working.

a) When an interruption of the signalling channel in one of the two directions brings about a signalling state corresponding to blocking, the release-guard sequence will be initiated the moment the interruption ends [see 2.2.5.1 c)].

The release-guard sequence implies that the signalling tone in the backward direction be disconnected for an interval 450 ± 90 ms. In both-way working this *tone-off* signalling state must not be interpreted as seizing. To avoid a repetition of the exchange of release-guard sequences certain precautions must be taken.

The following additional requirements should then be met:

- when the *tone-off* signalling state has lasted for an interval of less than 750 ± 150 ms the return to *tone-on* signalling state must not initiate a release-guard sequence;
- once the signalling state corresponding to seizing has been established, it must be maintained for at least 1250 ± 250 ms (this is a deviation to the requirement in 2.2.2.1 above).

When the interruption of one of the signalling channels has brought about blocking of the circuit at one end (B), as described above, that circuit can be seized at the other end (A). The end A will not have received the blocking signal from end B [see 2.2.5.1 c)] because that would cause permanent blocking of the circuit, which would then no longer be able to restore itself to normal functioning. Should a seizing now occur, this will lead to loss of a call; but subsequently, since the clear-forward signal cannot be transmitted, the circuit will remain blocked at end A. The whole further signalling sequence for reverting the circuit under consideration to idle follows the specification for one-way circuits.

b) An interruption of both signalling channels on any circuit will be interpreted by the equipment at each end of the line as seizing and the equipments will be blocked after the lapse of the time-out delay of the incoming R2 registers.

If, after an interruption, only one signalling channel is restored, the equipment at the incoming end in relation to that signalling channel will interpret the signalling state *tone-on* as a clear-forward signal and therefore bring into operation the release-guard sequence. The terminal equipment at that end will revert to idle, while the terminal equipment at the other end remains blocked. This is the situation envisaged in a) above.

When both signalling channels are simultaneously restored, the terminal equipment at both ends will interpret the onset of the signalling tone as a clear-forward signal and this will bring the release-guard sequence into operation. The result will be that the terminal equipment at both ends will again recognize the *tone-off* signalling state for a brief interval.

The following additional clause must be observed, to avoid permanent blocking of the circuit in this condition:

- When, after blocking, the line-signalling equipment at one end (A) of a both-way circuit has recognized the clear-forward signal, it must complete the release-guard sequence and restore the signalling tone after 450 ± 90 ms in the direction A-B, even if the tone in direction B-A is interrupted. If such interruption (in direction B-A) lasts for less than 750 ± 150 ms, the circuit returns to idle when the signalling tone is restored in both directions. If the interruption is longer than 750 ± 150 ms, restoration of the signalling tone in direction B-A will initiate a new release-guard sequence in direction A-B [see a) above].
- c) If an abnormal condition according to 2.2.3.3 above occurs at one end of a both-way circuit, this end is blocked for outgoing traffic. Such blocking should, however, not prevent the circuit being used in the other traffic direction.

2.3 CLAUSES FOR TRANSMISSION LINE-SIGNALLING EQUIPMENT

Recommendation Q.414

2.3.1 SIGNAL SENDER

2.3.1.1 *Signalling frequency*

The nominal value of the signalling frequency is 3825 Hz. Measured at the sending point, the frequency variation from the nominal value must not exceed ± 4 Hz.

2.3.1.2 *Send level*

The send level of the signalling frequency, measured at the group distribution frame or an equivalent point, must be -20 ± 1 dBm0.

2.3.1.3 *Leaks*

The level of the signal frequency which may be transmitted to line as a leak current (e.g. when static modulators are used), must be at least 25 dB below the level of the signalling tone.

2.3.1.4 *Phase distribution of the signalling frequencies*

As the signalling frequency is sent on any circuit in idle condition, the addition of these tones in moments of low traffic may give rise to the following phenomena on certain transmission systems:

- high peak voltage on the line caused by the signalling tones and involving the possibility of overloading the system;
- intelligible crosstalk due to third-order intermodulation;
- unwanted tones coming from second-order intermodulation products and occurring within sound-programme circuits.

The following special measures must be taken to avoid these effects:

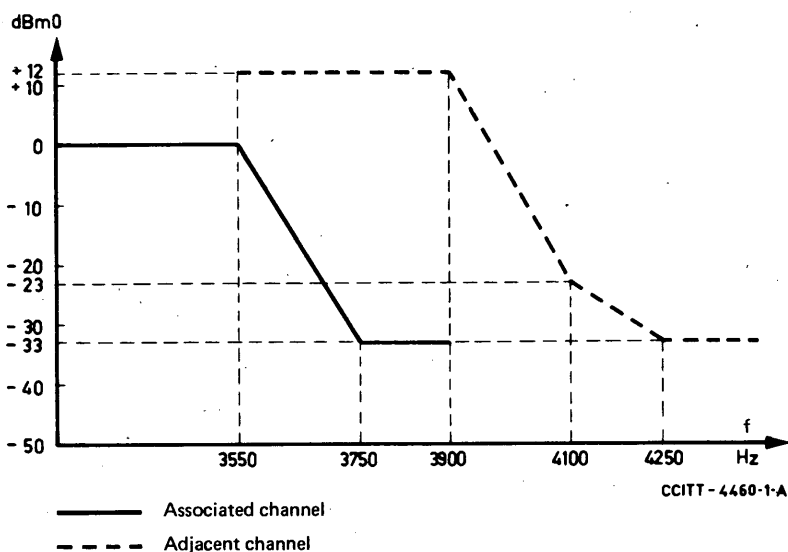
One method recommended is to inject the signalling frequencies with random 0 and π radian phases in the channels. An equivalent method is to use carrier frequencies of which the phases are randomly distributed 0 and π radians. With these methods the probability of occurrence of 0 and π radian phases should be 0.5 ⁴⁾.

Other methods may be used provided they give comparable results.

2.3.1.5 Protection of the signalling channel at the sending end

This signalling channel must be protected at the sending end against disturbance from the associated and the adjacent speech channel.

When a sine wave at 0 dBm0 level is applied to the audio-frequency input of the associated channel, the level measured at the group distribution frame or at an equivalent point must not exceed the levels shown in Figure 6/Q.414.



Note. — The frequency of the virtual carrier of the associated speech channel is the origin of the frequency scale (zero frequency).

FIGURE 6/Q.414 — Protection of the signalling channel at the sending end

When a sine wave of frequency f is applied to the audio-frequency input of the adjacent channel it produces two signals that appear on the frequency scale of Figure 6/Q.414 as having the frequencies $(4000 + f)$ and $(4000 - f)$. The level of the $(4000 + f)$ signal, measured at the group distribution frame or at an equivalent point, shall not be higher than -33 dBm0 when the sine wave with frequency f is applied to the audio-frequency input of the adjacent channel at a level shown in Figure 6/Q.414 for the frequency of $(4000 + f)$. The level of the $(4000 - f)$ signal, measured at the group distribution frame or at an equivalent point, shall not be higher than -33 dBm0 when the sine wave with frequency f is applied to the audio-frequency input of the adjacent channel at any level below the value shown in Figure 6/Q.414 for the frequency $(4000 - f)$.

⁴⁾ For further details on the method of random distribution of the phases of frequency 3825 Hz, see: Ekholm, O. and Johannesson, N. O.: "Loading Effects with Continuous Tone Signalling", English edition of *TELE*, No. 2, 1969. For further details on a systematic method of phase distribution, see: Rasch, J. and Kagelmann, H.: "On Measures for Reducing Voltage Peaks and Distortion Noise on Carrier Transmission Paths with Single Channel Supervision", *Nachrichtentechnische Zeitschrift (NTZ)*, 22 (1969), No. 1, pp. 24-31.

When the Go path is looped to the Return path at the group distribution frame or an equivalent point, the signal receiver must not change condition when:

- the click generator shown in Figure 7/Q.414 is connected to the associated speech channel or to the adjacent speech channel at the very point where this channel is connected to the switching equipment;
- to take the most difficult circumstances possible, the channel level adjusting devices are set to such values encountered in practice which give rise to the worst disturbance;
- gain is introduced in the loop at the group distribution frame or at the equivalent point, so that the receive level at the point in question is + 3 dBm0.

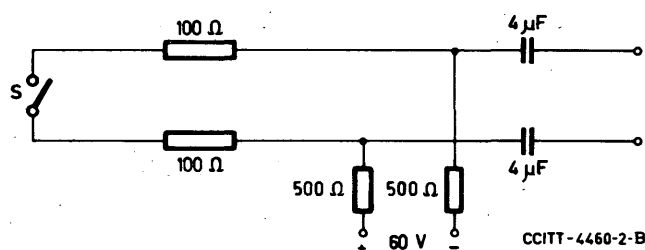


FIGURE 7/Q.414 – Click generator

2.3.1.6 Response time

The response time of the signal sender is defined as the interval between the instant when the change signalling state command is applied to the sender and the instant at which the envelope of the signalling frequency, measured at the group distribution frame or at an equivalent point, reaches half of its value in the steady state. For each of the two possible changes of signalling state the response time must be less than 7 ms.

Recommendation Q.415

2.3.2 SIGNAL RECEIVER

2.3.2.1 Recognition of the tone-on state

The receiver must have assumed or assume the *tone-on* state when at the group distribution frame or at an equivalent point:

- the level of the received frequency has risen to – 27 dBm0 or more;
- its frequency lies between 3825 ± 6 Hz.

The level of – 27 dBm0 specified above does not preclude the use of individual adjustments in the channel translating equipment to compensate for constant level deviations.

2.3.2.2 Recognition of the tone-off state

The receiver must have assumed or assume the *tone-off* state when the level of the test frequency, at the group distribution frame or at an equivalent point, has dropped to the values shown in Figure 8/Q.415.

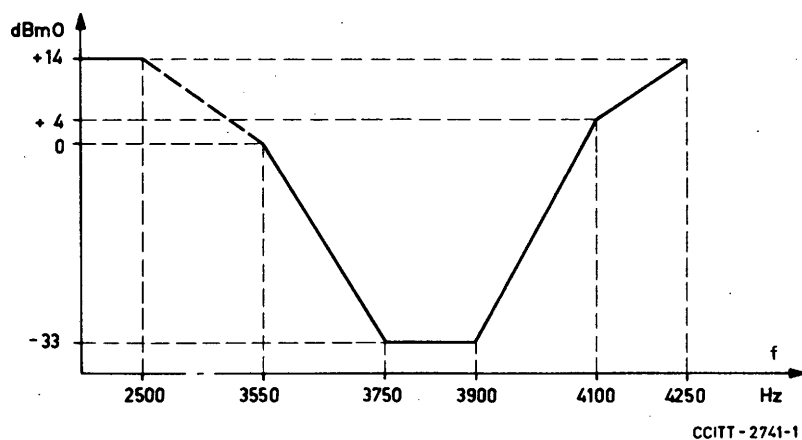


FIGURE 8/Q.415 – Level limits for recognition of the “tone-off” condition

2.3.2.3 Protection against near-end disturbances

The signal receiver must not change state when any one of the following disturbing signals is applied at the 4-wire output of the associated speech channel looped at the group distribution frame or at an equivalent point:

- a sinusoidal signal whose level as a function of the frequency is shown in Figure 9/Q.415,
- a transient signal produced by the click generator (described in 2.3.1.5 above) applied at the point where the channel is connected to the switching equipment, all level adjusting devices being set to such values encountered in practice which give rise to the worst disturbance.

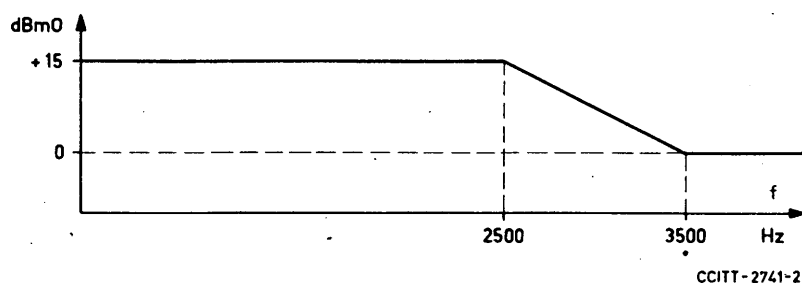


FIGURE 9/Q.415 – Level limit for a sinusoidal disturbance signal to which the signalling receiver must remain insensible

2.3.2.4 Overall response time of signal sender and receiver

When the modulation equipment is looped at the group distribution frame or at an equivalent point, the overall response time is defined as the interval between the instant when a change signalling command is applied to the sender and the moment when the changed signalling state appears at the receiver output. For each of the two possible changes of signalling state, the overall response time must be less than 30 ms.

2.3.2.5 *Interference by carrier leaks*

The requirements stated in 2.3.2.1, 2.3.2.3 and 2.3.2.4 above must be fulfilled in the presence of carrier leaks.

It is assumed that:

- when the receive level of the signalling tone is at its nominal value at the group distribution frame or an equivalent point, each carrier leak is present at a level of -26 dBm0;
- the level of the carrier leak varies proportionally with any variations in the level of the signalling tone.

2.3.2.6 *Interference by pilots*

The specified signalling system is not intended to work in the presence of those pilots specified by CCITT having a frequency differing by 140 Hz from the nearest multiple of 4 kHz.

On the other hand, the requirements stated in 2.3.2.1, 2.3.2.2, 2.3.2.3, 2.3.2.4 and 2.3.2.5 above must be met in the presence of any other pilot recommended by the CCITT.

It is assumed that variations in level of the pilot and of the signalling tones are correlated.

Recommendation Q.416

2.4. INTERRUPTION CONTROL

2.4.1 *General*

In System R2 removal of the tone corresponds to the sending of the seizing and answer signals. Steps must be taken, therefore, to guard against unwanted interruption of the signalling channels resulting in false signalling. Special devices monitor a number of circuits and transmit an indication to each individual equipment as soon as an interruption occurs. The whole protection system against the effect of interruptions is designated by the term *interruption control*.

In each case, the response time of the interruption control must be based on the time required to recognize the signalling state.

The interruption control systems in the two directions of transmission operate independently of each other.

The interruption control specified uses the group pilot to detect interruptions.

2.4.2 *Mode of operation of interruption control*

For each direction of transmission of a carrier circuit connection the equipment for interruption control comprises:

- a group pilot generator at the outgoing end;
- a pilot receiver and a wiring system for signalling the interruption at the incoming end.

In principle, the existing pilots of the carrier system will be used.

The receiver at one end supervises the pilot transmitted by the other end. When a considerable fall in the level of the pilot is detected it is assumed that an interruption has occurred on the signalling channels associated with the carrier circuits. The interruption control equipment then reacts to prevent the unwanted transmission of certain signals on those circuits which have already been seized or to ensure that idle circuits are blocked.

Figure 10/Q.416 shows functionally an arrangement where the pilot receiver controls the relay sets of interrupted circuits.

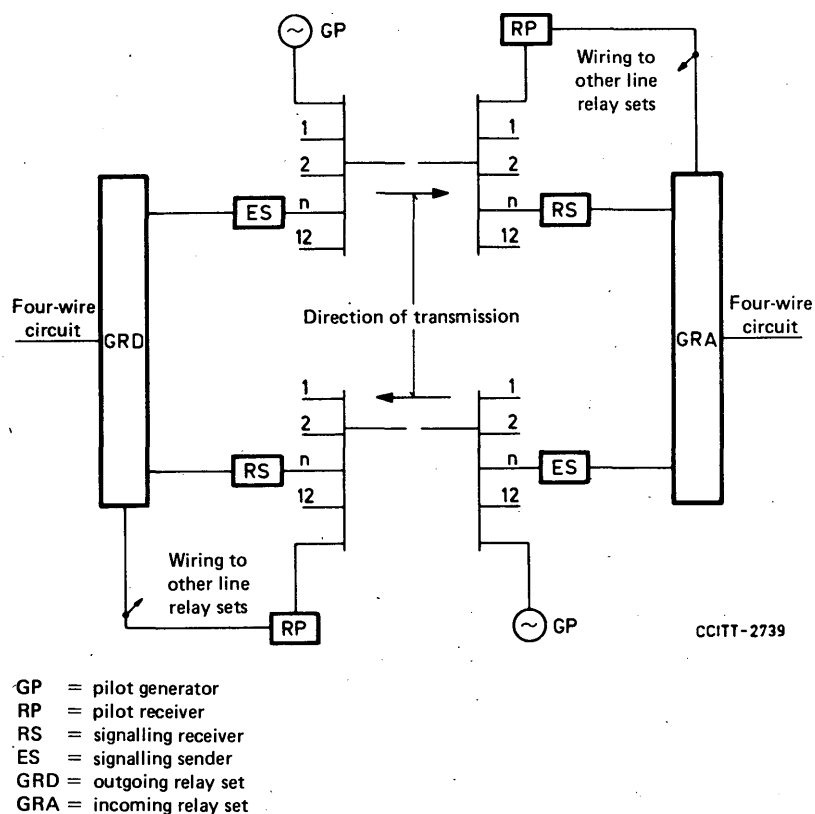


FIGURE 10/Q.416 – Protection from the effect of interruptions (interruption control)

To ensure proper interruption control, it is essential that the individual transmission or switching equipments should not react to any change of signalling state due to a fault. The action initiated by the interruption control must therefore be completed in less time than the sum of the response time of the signalling receiver and the recognition time for the *tone-off* signalling state caused by interruption of the signalling channel. Again, to prevent the unwanted transfer of certain signals, interruption control, during re-establishment of the pilot, must return to *alarm off* after an interval long enough for the signalling equipment to revert to normal.

To operate independently for each direction of transmission the incoming end interruption control supervises only the forward direction and, if necessary, initiates an operation at the outgoing end via the line-signalling system. Conversely, interruption control at the outgoing end supervises the backward direction of transmission only.

Blocking of a circuit at the outgoing end therefore takes place in two different ways:

- immediate blocking by intervention of interruption control at the outgoing end;
- blocking on recognition in the backward direction of the *tone-off* signalling state caused by interruption control intervention at the incoming end.

When the transmission system is re-established, interruption control reverts to its normal condition and the signalling equipment must automatically revert to normal operating.

Since the action to be taken on the individual circuits differs according to their operating condition at the time the fault occurs, the different possibilities are dealt with in detail below.

2.4.2.1 *Mode of operation of interruption control at the incoming end* (transmission interrupted in the forward direction)

a) *Circuit in idle condition*

Transition of interruption control to alarm brings about:

- (i) removal of the tone in the backward direction by locking of the sending unit in the *tone-off* state;
- (ii) locking of the receiving unit in its position, i.e. in the *tone-on* state.

The effect of operation (i) is to block the circuit at the outgoing end against possible seizing; operation (ii) prevents incorrect recognition of seizing of the incoming circuit.

Return of interruption control to normal ensures return to idle of the circuits affected by the fault, by switching transmitting units at the incoming end to the *tone-on* state.

b) *Circuit seized prior to answer*

Transition of interruption control to alarm brings about:

- (i) locking of the sending unit in its position, i.e. in the *tone-on* state;
- (ii) locking of the receiving unit in its position, i.e. in the *tone-off* state;
- (iii) start of a time-out device which after a certain interval clears the chain beyond the faulty circuit; this timing arrangement may be the one specified in Recommendation Q.118, 4.3.3.

Operation (i) prevents the incorrect transfer of an answer signal after interruption control has come into action. If the called subscriber, after lifting the receiver during the time-out delay mentioned in (iii), has cleared, the part of the connection beyond the faulty circuit must be released without waiting for this time-out delay to elapse. Operation (iii) prevents blocking of the called subscriber's line if the fault persists; short breaks, on the other hand, have no effect.

When the caller clears, operations (i) and (ii) block the faulty circuit against any new seizure even when the backward signalling channel is still intact; since the release-guard signal has not been sent the outgoing circuit cannot return to idle.

When interruption control reverts to normal before the called subscriber has answered, the call may still mature normally, provided the caller is holding. Similarly, if at the moment when interruption control reverts to normal, the called subscriber has just answered and the caller is still connected the answer signal may be sent. If at the moment when interruption control reverts to normal the called subscriber has already cleared, operation (ii) ensures that in all cases the release-guard sequence takes place as in 2.2.2.6 a) above (either immediately if the outgoing exchange has already sent the clear-forward signal or when the caller clears). If, on the other hand, the called subscriber is still holding and the outgoing exchange is already sending the clear-forward signal when interruption control reverts to normal the circuit returns to idle at the outgoing end as described in 2.2.2.6 b) above.

c) *Circuit in answered condition*

Transition of interruption control to alarm brings about:

- (i) locking of the sending unit in its position, i.e. in the *tone-off* state;
- (ii) locking of the receiving unit in its position, i.e. in the *tone-off* state.

When the caller clears, operation (i) blocks the faulty circuit against any new seizure, even when the backward signalling channel is still intact; since the release-guard signal has not been sent, the outgoing circuit cannot return to idle.

When the called subscriber clears, the part of the connection beyond the faulty circuit (including the called subscriber's line) must be released immediately.

When interruption control reverts to normal with both subscribers still on the line, the connection is maintained.

When the caller has already cleared by the time the interruption control reverts to normal, the release-guard sequence is carried out as in 2.2.2.6 b) or c) above.

d) *Circuit in clear-back condition*

Transition of interruption control to alarm causes:

- (i) locking of the sending unit in its position, i.e. in the *tone-on* state;
- (ii) locking of the receiving unit in its position, i.e. in the *tone-off* state;
- (iii) immediate release of the part of the connection beyond the faulty circuit (including the called subscriber's line).

When interruption control reverts to normal, the release-guard signal is sent as in 2.2.2.6 c) above as soon as the clear-forward signal is recognized.

e) *Circuit in release*

When interruption control functions after a clear-forward signal has been recognized at the incoming end, it causes:

- (i) locking of the sending unit in the *tone-off* state; if at the instant interruption control operates, the *tone-on* state exists in the backward direction, it will be switched to the *tone-off* state following recognition of the clear-forward signal and locking in the *tone-off* state can take place as prescribed;
- (ii) locking of the receiving unit in its position, i.e. in the *tone-on* state.

The effect of operation (i) is to guard the faulty circuit from a new seizure at the outgoing exchange.

Operation (ii) ensures the release of the part of the connection beyond the faulty circuit (including the called subscriber's line).

When interruption control reverts to normal the *tone-on* state is established in the backward direction and causes the circuit at the outgoing exchange to return to idle.

2.4.2.2 *Mode of operation of interruption control at the outgoing end* (transmission in the backward direction interrupted)

a) *Circuit in idle condition*

Transition of interruption control to alarm is immediately followed by blocking of the outgoing circuit.

b) *Circuit seized but not in answered condition*

- (i) Transition of interruption control to alarm causes locking of the receiving unit in its position, i.e. the *tone-on* state. This operation prevents recognition of an answer signal or return to the *answered* condition should the called subscriber have cleared.
- (ii) As soon as a clear-forward signal is sent on the part of the connection preceding the faulty circuit, it must be retransmitted; the tone must therefore be established in the forward direction to ensure, assuming that the forward signalling channel is left intact, that the part of the connection beyond the faulty circuit is released.
- (iii) When interruption control reverts to normal, the tone may already have been sent in the forward direction as a clear-forward signal. If the forward signalling channel has remained intact, recognition at the incoming end of the *tone-on* state will have caused generation of the release-guard sequence which, because of the fault, will not have been received at the outgoing end. Exceptionally, therefore, return of the outgoing circuit to the idle condition must take place simply on recognition of the *tone-on* state in the backward direction.

c) *Circuit in answered condition*

In this case transition of interruption control to alarm does not cause immediate action. A clear-forward signal sent on the part of the connection preceding the faulty circuit must be repeated forward to ensure that, if the forward signalling channel is left intact, the part beyond the faulty circuit is cleared.

Once the interruption control reverts to normal the connection is maintained provided the caller and the called subscriber are still holding. On the other hand, by the time the interruption control reverts to normal the clear-forward signal may already have been sent and the situation will be the one described in 2.4.2.2 b), (iii).

d) *Circuit in release*

[See 2.4.2.2 b), (iii).]

2.4.2.3 *Special conditions for both-way working*

a) As soon as an operating condition has been established on a both-way circuit and the outgoing and incoming ends of the circuit have been determined with certainty, the interruption control specifications for one-way working become equally applicable to both-way circuits.

b) When a both-way circuit is idle, transition to alarm of the interruption control of one direction of transmission must bring about operations to ensure that the signalling state existing at that moment on the signalling channel of the opposite direction is maintained — in contrast to specification 2.4.2.1 a), (i) above for one-way working. This precaution obviates a permanent blocking of a both-way circuit when interruption of the signalling channels occurs simultaneously in both directions. It does not ensure immediate blocking of the circuit; this will not occur until the circuit has been seized by the next call.

c) In all operating conditions intermediate between *idle* and the condition at the moment when the direction of seizure of the both-way circuit is determined (see above), the line-signalling equipment at both ends will be locked by interruption control in the condition in which it was before interruption control passed to alarm.

2.4.3 *Clauses on interruption control equipment*

Adoption of thresholds with widely differing levels makes for economy in the design of interruption control equipment. Against this must be set the fact that the device cannot cope with the effects of certain slow drops in level. However, the probability of these occurring in practice is very small.

2.4.3.1 *Pilots*

Interruption control uses the 84.08 kHz group pilot or by bilateral agreement and, at the request of the receiving end country, the 104.08 kHz group pilot.

However, if the ends of the supergroup link coincide with the end of the five group links it is carrying, the supergroup pilot may also be used.

2.4.3.2 *Alarm-on threshold*

Interruption control must pass to *alarm-on* when the pilot level, measured at the group distribution frame or at an equivalent point, drops to -29 dBm0.

2.4.3.3 *Alarm-off threshold*

Interruption control must revert to *alarm-off*, i.e. normal when the pilot level, measured at the group distribution frame or at an equivalent point, rises to -24 dBm0.

2.4.3.4 *Response time for a drop in level*

Interruption control must pass from normal to alarm-on within an interval t_{\downarrow} such that:

$$5 \text{ ms} \leq t_{\downarrow} \leq t_{rs \text{ min.}} + 13 \text{ ms}$$

when the pilot level, measured at the group distribution frame or at an equivalent point, suddenly drops from its nominal level to -33 dBm0.

In the above formula, $t_{rs \min.}$ is the minimum response time of the signalling receiver for a drop in level, taking into account a possible variation of ± 3 dB in the signalling tone level from its nominal value, the level being measured on the receiving side of the group distribution frame or at an equivalent point.

The figure of 13 ms in the above formula is derived on the assumption that the output of the interruption control equipment acts upon the input of the device which regulates the recognition time for the *tone-on* and *tone-off* states (20 ± 7 ms) i.e. absence of a direct current signal at this input for a period of up to 13 ms has no relevance.

2.4.3.5 Response time for rise in level

Interruption control must revert from the alarm-on to normal in an interval t_{\uparrow} such that:

$$t_{rs \max.} - 13 \text{ ms} \leq t_{\uparrow} \leq 500 \text{ ms}$$

when the pilot level, measured at the group distribution frame or at an equivalent point, suddenly rises from -33 dBm0 to its nominal value.

In the above formula, $t_{rs \max.}$ is the maximum response time of the signalling receiver for a rise in level, taking into account a possible variation of ± 3 dB in the signalling tone level from its nominal value, the level being measured on the receiving side of the group distribution frame or at an equivalent point.

The figure of 13 ms in the above formula is derived on the assumption that the output of the interruption control equipment acts upon the input of the device which regulates the recognition time for *tone-on* and *tone-off* condition (20 ± 7 ms) i.e. absence of a direct current signal at this input for a period of up to 13 ms has no relevance.

2.4.3.6 Precautions against noise

An interruption may produce increased noise on the group link. Interruption control must be capable of distinguishing between the pilot itself and a high level noise simulating the pilot.

Interruption control must not revert to normal in the presence of white noise having a spectral power density of not more than -47 dBm0 per Hz.

To facilitate the design of interruption control equipment operating satisfactorily at high noise levels, the upper limit of 500 ms for t_{\uparrow} has been specified.

SECTION 3

LINE SIGNALLING, DIGITAL VERSION

Recommendation Q.421

3.1 DIGITAL LINE SIGNALLING CODE

3.1.1 General

In the out-band low level continuous line signalling system, specified for FDM systems, only one signalling channel (providing two signalling conditions) in each direction of transmission is available per speech circuit. Therefore it was necessary to achieve some signals by introducing timing conditions.

The continuous line signalling scheme specified for FDM systems may also be used for PCM systems utilizing one signalling channel only in each direction. In this case relay sets designed for the continuous line signalling system on FDM channels can be used provided that the functions specified for the interruption control on FDM circuits are performed (see Recommendation Q.416) by use of the transmission fault alarm facility (see 3.3.3 below).

PCM multiplexes (see Recommendations G.732 and G.733) economically provide more than one signalling channel per speech circuit in each direction of transmission. By making use of this increased signalling capacity, it follows that a simplification of the outgoing and incoming switching equipments can be achieved. For this reason, a digital version of System R2 line signalling without timing conditions is recommended for use on PCM systems and is specified below.

The digital version of System R2 line signalling uses two signalling channels in each direction of transmission per speech circuit. With respect to call set-up these signalling channels are referred to as a_f and b_f for the forward direction and a_b and b_b for the backward direction.

The a_f channel identifies the operating condition of the outgoing switching equipment; as this condition is under the control of the calling party, this a_f channel also reflects the condition of the calling subscriber's line (*on* or *off* position of the switch hook).

The b_f channel provides a means for indicating a failure in the forward direction to the incoming switching equipment [see 3.2.4.2 b)].

The a_b channel reflects the condition of the called subscriber's line (*on* or *off* position of the switch hook).

The b_b channel indicates the idle or seized condition of the incoming switching equipment.

Due to this specific allocation, decoding of a_b and/or b_f signalling channels can in some cases be avoided. Direct retransmission of *answer* and *clear-back* signals beyond the considered link is therefore simplified with a consequent saving in circuitry.

The digital version of System R2 line signalling also specifies a means for appropriate action in the case of abnormal transmission conditions on the PCM multiplex [transmission fault control (TFC), see Recommendation Q.424.]

In the following, any signalling code mentioned refers to the signalling code on the PCM line except where otherwise stated.

3.1.2 Signalling code

The signalling code on the PCM line is:

Operating condition of the circuit	Code			
	Forward		Backward	
	a_f	b_f^*	a_b	b_b
Idle	1	0	1	0
Seizing	0	0	1	0
Seizing acknowledged	0	0	1	1
Answered	0	0	0	1
Clear-back	0	0	1	1
Clear-forward	1	0	0	1
			or	
Release-guard = idle	1	0	1	1
Blocked	1	0	1	0
			1	1

Note 1. – The signalling code corresponding to state 1 on the PCM line of the a and b receive signalling channels, is also used locally for alarm purposes (see Recommendation Q.424).

**Note 2.* – For all supervisory signals $b_f = 0$; a change to $b_f = 1$ indicates a fault [see 3.2.4.2 a) and 3.2.3.1 to 3.2.3.3 below].

Recommendation Q.422

3.2 CLAUSES FOR EXCHANGE LINE SIGNALLING EQUIPMENT

3.2.1 Recognition time for a transition on a signalling channel

The recognition time for a transition from state 0 to 1 or vice versa on a signalling channel is 20 ± 10 ms. This value presupposes the existence of protection against the effects of abnormal transmission conditions on the PCM multiplex (see Recommendation Q.424).

The recognition time is defined as the minimum duration that the signals representing 0 or 1 must have at the output of the terminal equipment of a signalling channel in order to be recognized as a valid signalling state by the exchange equipment.

3.2.2 Signal transmit time tolerance

The transmit time difference between two transitions intended to be applied simultaneously on two signalling channels in the same direction of transmission must not exceed 2 ms.

3.2.3 Normal operating conditions

3.2.3.1 Idle

In the forward direction, $b_f = 0$ is established permanently. This state $b_f = 0$ must at the incoming end result in $b_b = 0$ in the backward direction, provided that the switching equipment at the incoming end of the circuit is in the idle operating condition.

3.2.3.2 *Seizing operating condition*

Seizing should occur only if $a_b = 1$, $b_b = 0$ is received. The outgoing end changes $a_f = 1$ into $a_f = 0$. The state $a_f = 0$ must be maintained until the seizing acknowledgement signal is received (3.2.3.3 below). In this way the outgoing switching equipment will only be able to send the clear-forward signal after the seizing acknowledgement signal has been recognized: until then the outgoing switching equipment remains blocked against new seizure should the calling subscriber clear.

3.2.3.3 *Seizing acknowledged*

After having been seized the incoming end establishes the state $b_b = 1$.

3.2.3.4 *Answered*

The answered condition of the called subscriber's line provokes the incoming switching equipment to change from $a_b = 1$ to $a_b = 0$. This simple change of state on only one signalling channel makes it possible at the outgoing end to transfer the answer signal to the preceding link, without decoding of the two signalling channels.

The answered operating condition must be established on the preceding link immediately after it is recognized; see also 3.2.3.7 below.

3.2.3.5 *Clear-back operating condition*

When the called subscriber clears, the state $a_b = 0$ in the backward direction is changed to $a_b = 1$. The clear-back operating condition must be established on the preceding link immediately after it is recognized; see also 3.2.3.7 below.

3.2.3.6 *Clear-forward operating condition*

The cleared condition of the calling subscriber's line or the release of the outgoing switching equipment will normally cause $a_f = 0$ to change to $a_f = 1$. The outgoing switching equipment will remain blocked until recognition of the release-guard signalling state in the backward direction; see also 3.2.3.2, 3.2.3.7, 3.2.4.2 and 3.3.3.

3.2.3.7 *Release-guard operating condition*

Release-guard must be ensured whatever may be the operating condition of the circuit at the instant of sending the clear-forward signal: answering or clearing by the called party also occur when release has already been initiated at the outgoing exchange.

Recognition of the clear-forward signal in the incoming switching equipment initiates the release of the succeeding link. Upon complete release of the incoming switching equipment $b_b = 1$ is changed to $b_b = 0$. This state, which corresponds to the idle signalling condition, will cause the outgoing switching equipment to become available for another call.

3.2.3.8 *Blocked*

Blocking of the circuit to new calls at the outgoing end must occur for as long as $b_b = 1$.

The change-over from $b_b = 1$ to $b_b = 0$ restores the outgoing switching equipment to idle so that the circuit can be seized again.

3.2.4 *Abnormal conditions*

3.2.4.1 *Special release arrangements*

a) If an exchange erroneously recognizes an answer signal before the outgoing R2 register has received an address-complete signal A-6 or a Group B signal, the connection must be released. Congestion information is then sent backward or a repeat attempt is made to set up the call.

b) In the case of non-reception of the answer signal, of delay in clearing by the calling subscriber in automatic working, or of non-reception of the clear-forward signal by the incoming exchange after the clear-back signal has been sent, the provisions of Recommendation Q.118 apply.

3.2.4.2 *Safeguard against failures*

The PCM equipment and the exchange line signalling equipment should be designed in such a way that at least those faults which are the most likely to occur in these equipments or in the interconnecting cables result in blocking of the circuit at the outgoing end and the ultimate clearing of the connection beyond the incoming switching equipment (fail-safe operation).

The following specification aims at achieving fail-safe operation as far as possible:

a) *Supervision by means of the b signalling channels*

The switching equipment shall be designed in such a way that for a circuit in the idle operating condition $b_f = 0$ results in $b_b = 0$.

If in the idle condition due to a fault b_f changes to 1, b_b must be changed to 1.

With specific meaning allocated to the b_b changes (see 3.1.1 above) and according to the signalling code, $b_b = 1$ will result in blocking of the outgoing switching equipment against new seizures.

b) *State on line under fault conditions*

As only the b channels are involved in the supervision function, this feature can only be fully effective if it is ensured that any man-made interruption in the speech channel and/or the a signalling channels (e.g. when an incoming or outgoing relay set is taken out of service) always also interrupts the associated b signalling channels.

Therefore, the switching equipment and the PCM equipment shall be designed in such a way that likely faults as far as possible result in the transmission on line to the distant exchange of the states $a = 1$ and $b = 1$.

It follows that a fault at the outgoing end results in the sending of the clear-forward signal ($a_f = 1$) and consequently in the ultimate clearing of the connection beyond the incoming switching equipment. According to a) above, $b_f = 1$ will result in blocking of the outgoing switching equipment, immediately for circuits in the idle operating condition and upon clearing by the calling subscriber for circuits in the seized or answered operating conditions.

In order to clear a connection in speech condition, only under the control of the called subscriber both the a_f and b_f signalling channels must be evaluated.

It also follows that a fault at the incoming end results in the blocking of the outgoing switching equipment ($b_b = 1$). For circuits in the answered operating condition $a_b = 1$ has the meaning of clear-back.

c) *Correspondence between signalling channel state on line and states in the equipments*

The correspondence between a passive state in the equipments (e.g. open wire, low voltage) and the state 1 on both signalling channels on line is an important means of ensuring the fail-safe operation.

Such a correspondence is particularly recommended for a possible interface between the exchange signalling equipment and the PCM equipment.

Undue removal of parts of the equipment by maintenance personnel can also be guarded against by that correspondence and through proper layout and/or wiring.

3.2.5 *Alarms for technical staff*

According to Recommendation Q.117, an alarm must in principle be given to the technical staff upon recognition of abnormal conditions possibly caused by faults. It is recommended that a delayed alarm at the outgoing end for the condition described under 3.2.3.8 above (blocked) or for any other condition when the circuit does not return to idle after the clear-forward signal has been transmitted be given.

It is also recommended that a delayed alarm upon operation of the transmission fault control device (TFC) as specified in Recommendation Q.424 is given. Arrangements for the alarms are to be specified by the Administrations.

3.2.6 Both-way working

The System R2 is specified for one-way working. The clauses in 3.2.6.1 and 3.2.6.2 below therefore apply only to cases where the interested Administrations have undertaken by bilateral agreement to use both-way working.

In principle the line signalling code detailed in Recommendation Q.421 is also suitable for use on both-way circuits. However, for both-way working the additional specifications for exchange signalling equipment detailed below must be observed. Alterations to the line signalling code, given in Recommendation Q.421, to enable both-way working are given in 3.2.6.2.

3.2.6.1 Normal conditions

a) Double seizing

Double seizing is assumed if the outgoing equipment is in a seized condition and the signalling state $a_b = 0$, $b_b = 0$ is recognized of $a_b = 1$, $b_b = 1$ (seizing acknowledged). In such a situation the connection must be released at both ends and congestion information sent to the calling subscriber or a repeat attempt must be made. On recognition of double seizing the line signalling equipment at both ends must maintain the seizing signalling state for a minimum of 100 ms after which the clear-forward state ($a_f = 1$, $b_f = 0$) must be established. After sending the clear-forward signal, each end may return to idle on recognition of $a_b = 1$, $b_b = 0$.

The clear-forward signalling state must be maintained for at least 100 ms, even if the circuit is seized immediately for another call, to ensure clear-forward is recognized at the other end.

In the sense of preventive action it is recommended that an opposite order of circuit selection is used by each exchange of a both-way circuit group to minimize double seizing.

b) Minimum duration of release-guard signalling state

When a both-way circuit is released, the end which acted as the incoming end must, even if seized immediately for a call in the opposite traffic direction, maintain the release-guard signalling state for at least 100 ms to ensure that the release-guard signal is recognized at the other end.

c) Blocking

When a both-way circuit is blocked manually in its idle condition at one end (e.g. end B) the blocking signalling condition must be established so that the other end (A) recognizes $a_b = 1$, $b_b = 1$. The circuit must then be kept blocked locally (at end A) against all calls in the A to B traffic direction as long as the blocking signalling condition persists in the B to A direction.

In order to avoid permanent blocking, end A should maintain the idle signalling state in the traffic direction A to B. This condition differs from that given in 3.2.4.2 a) above.

When the blocking signalling state is removed end B must transmit the clear-forward signal for at least 100 ms, even if immediately seized for a call.

3.2.6.2 Special condition

If realization of the signalling equipment allows the outgoing relay-set to be removed at one end (e.g. end A) without preventing the circuit from being used in the other traffic direction (B to A) it is only necessary to block the circuit locally (at end A). Under these conditions the blocking signal should not be sent to end B.

Recommendation Q.424

3.3 PROTECTION AGAINST THE EFFECTS OF FAULTY TRANSMISSION

3.3.1 Introduction

Faulty transmission conditions in PCM systems can lead to degradation of the speech channels and erroneous signalling. In order to minimize these effects the System R2 line signalling, digital version, is protected by a *transmission fault control* (TFC) against such transmission conditions. The TFC at both PCM terminals acquires the state *transmission faulty* when frame alignment, multi-frame alignment and/or any other important function fails at the terminal considered or at the distant terminal.

To achieve this, the alarm conditions at one end must be made known at the other end.

For the fault conditions and consequent actions (alarms) for primary PCM multiplex equipment operating at 2048 kbit/s see Recommendation G.732. As in the worst case, signalling may be mutilated during the 7 ms before the loss of multiframe alignment is recognized, and taking into account the minimum value of 10 ms of the recognition time specified in Recommendation Q.422, a time limit of 3 ms must be set for the working of the TFC after loss of multi-frame alignment has been recognized. It is, however, desirable that the TFC acts as quickly as possible.

3.3.2 Working of the switching equipment upon operation of the TFC

When the TFC acquires the state *transmission faulty* the state corresponding to state 1 on the PCM line must be established on all the *receive* signalling wires at the interfaces between the PCM equipment and the switching equipment both at the incoming and outgoing side.

As the state $a_r = 1$, $b_r = 1$ on the PCM line corresponds to a failure, the incoming switching equipment and the succeeding link should be released. However, in order to avoid the release of the connection upon losses of multi-frame alignment of short duration, the release of the incoming switching equipment must not occur when the called subscriber's line is in the answered condition. The outgoing switching equipment interprets the state $a_b = 1$, $b_b = 1$ on the PCM line as a blocking signal, or as a clear-back signal, or as a seizing acknowledgement signal. This means that all idle circuits of the affected primary PCM multiplex will be blocked against seizure and that the seized circuits will go to or remain in the seizing acknowledged or the clear-back operating condition. In the case of a seized circuit, it becomes blocked when the calling subscriber clears.

3.3.3 Transmission fault alarm

According to Recommendation G.732 the 2048 kbit/s primary PCM multiplex equipment provides a local alarm indicating a transmission failure. The indication must have the form of a steady electrical condition which may be used for:

- removal from service of the faulty circuits (in addition to the action of the TFC);
- providing interruption control according to Recommendation Q.416 when relay sets designed for System R2 line signalling, analogue version, are used on PCM channels.

SECTION 4

INTERREGISTER SIGNALLING

Recommendation Q.440

4.1 GENERAL

Interregister signals are of the multifrequency type using a 2-out-of-6 in-band code in both directions. The multifrequency combinations are sent and received by multifrequency signalling equipment which is assumed to be associated with the registers used to control the switching equipment at both ends of the inter-exchange link.

4.1.1 End-to-end signalling method

In System R2 interregister signalling is generally performed end-to-end by a compelled procedure between the outgoing register and the incoming registers which come into action one after another. Signalling takes place over one or more links in tandem without signal regeneration in intermediate exchanges. With this signalling method only the address information needed for routing the call through an intermediate exchange is transferred from the outgoing register to the incoming registers. In an intermediate exchange the speech path is immediately through-connected and the incoming register released, then the outgoing register can exchange information directly with the incoming register of the next exchange (see Figure 11/Q.440). If any intermediate exchange has to carry out charging operations, additional address information can be transferred from the outgoing register to the incoming register of that exchange as required.

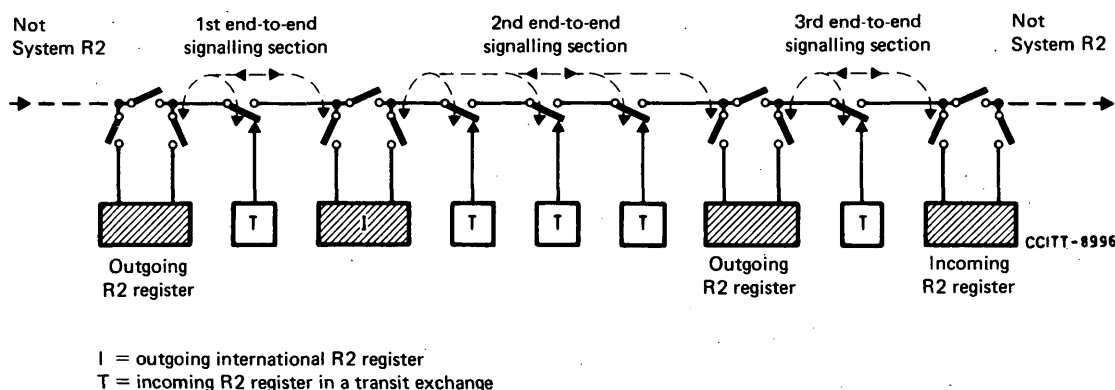


FIGURE 11/Q.440 – An international three-section multi-link connection

In circumstances where transmission conditions do not comply with the requirements specified for System R2 (see Recommendation Q.457) and do not permit the exchange of the interregister signals over the complete System R2 connection, the overall multi-link connection is divided into end-to-end signalling sections.

In this case and if the number of multifrequency combinations available is not the same on all parts of the connection, the division should be made at an exchange between links having different numbers of multifrequency combinations to improve the transfer of information.

The outgoing R2 register is situated at the outgoing end of a signalling section on which System R2 interregister signalling according to the present specifications is used. It controls the call set-up over the whole signalling section. It sends forward interregister signals and receives backward interregister signals.

The outgoing R2 register receives information via the preceding links of the connection in a form used by the signalling system applied over the last of these links; this system may be System R2, a decadic pulse system, or any other system. The preceding link may also be a subscriber's line. When an R2 register in a transit exchange is working according to this definition, it is also called an *outgoing R2 register*.

A special case of the outgoing R2 register is the outgoing international R2 register (see 4.1.2).

The incoming R2 register is situated at the incoming end of a link on which System R2 multifrequency interregister signalling according to the present specification is used. It receives forward interregister signals via the preceding link(s) and sends backward interregister signals. The information received is used completely or in part for the control of selection stages and may be sent in its entirety or in part to the succeeding equipment, in which case the signalling used for retransmission is never System R2. Interworking then takes place between System R2 and the other system. Thus every register not situated at the outgoing end of a System R2 signalling section is called an *incoming R2 register* independently of the exchange type.

The term *incoming R2 register* may be applied also to devices controlling one or more selection stages, for example *markers* etc. It should be noted that in such equipment no provision is made for further transfer of the information received.

4.1.2 International end-to-end working

The inclusion of a special *outgoing international R2 register* as shown in Figure 11/Q.440 is dictated by a number of considerations. An outgoing international R2 register is an outgoing R2 register which controls the call set-up on a signalling section which comprises at least one international link and possibly national links in tandem.

Even when System R2 is used in the national network of the originating country an outgoing international R2 register must always be provided in the country of origin to divide the connection into two signalling sections for the following reasons:

- to prevent the maximum number of links in a signalling section over which System R2 can function from being exceeded on international calls;
- to permit the use of fewer signalling frequencies in the country of origin (e.g. 5 forward and 5 or 4 backward signalling frequencies);
- to enable non-standardized meanings to be allocated to the spare national multifrequency combinations for use solely in the country of origin;
- to provide criteria for distinction, at the incoming end, between national and international calls;
- to have the facilities for routing and charging of international calls concentrated in one place if it is more economical than to equip every normal outgoing R2 register to perform these functions.

In general the outgoing international R2 register is situated at the outgoing international exchange. However, it may be situated in a national exchange preceding the international exchange provided that the transmission requirements specified are fulfilled.

End-to-end signalling from the outgoing international R2 register can be extended beyond the incoming international exchange even if a reduced number of signalling frequencies is used. However such international/national end-to-end signalling requires:

- that the transmission conditions in the national destination network comply with the System R2 specifications, and
- that the routing principles employed in the national destination network are compatible with the System R2 signalling procedures for end-to-end transmission of address digits from the outgoing international R2 register to an incoming R2 register in a national exchange.

4.1.3 Register requirements

Apart from signalling procedures specified in Section 5 the following characteristics of R2 registers are specified.

4.1.3.1 Outgoing R2 registers

The multifrequency signalling equipment associated with outgoing R2 registers in national exchanges may be of the 2-wire or 4-wire type (see Recommendation Q.451).

The multifrequency signalling equipment associated with outgoing international R2 registers must be of the 4-wire type. This is dictated by transmission constraints (see Recommendation Q.452).

The outgoing R2 register controlling a given multi-link signalling section must be able to recognize at least all the backward signals used on that section.

The outgoing international R2 register must be able to send all 15 forward multifrequency combinations with the meanings specified for international working. It must be able to receive all 15 backward multifrequency combinations and act upon the received information in the specified manner. In the case when System R2 is used on the preceding link the calling party's category signals have to be translated by the outgoing international R2 register as specified (see Recommendation Q.480).

The outgoing R2 register must start call set-up as soon as it has received the minimum requisite information. Therefore signal transfer starts before the complete address information is received, i.e. before the caller finishes dialling. This *overlapping interregister signalling* particularly applies at an outgoing R2 register where the complete address information from a subscriber or operator is stored (e.g. local registers). This is in contrast to *en bloc register signalling* i.e. the transmission of all the address information as a whole in one sequence starting only after the complete reception of the address information.

4.1.3.2 Incoming R2 registers

The multifrequency signalling equipment associated with incoming R2 registers may be of the 2-wire or 4-wire type (see Recommendation Q.451).

The multifrequency signalling equipment associated with the incoming R2 register in an international exchange must be of the 4-wire type and equipped to send and receive all 15 multifrequency combinations.

Every incoming R2 register in a multi-link signalling section must be able to recognize at least the forward signals used on that section and directed to that register.

4.1.4 System R2 compelled signalling method

The compelled signalling operates as follows (see Figure 11/Q.440):

- on seizure of a link, the outgoing R2 register automatically starts sending the first forward interregister signal;
- as soon as the incoming R2 register recognizes this signal, it starts sending a backward interregister signal which has its own meaning and at the same time serves as an acknowledgement signal;
- as soon as the outgoing R2 register recognizes the acknowledging signal, it stops sending the forward interregister signal;
- as soon as the incoming R2 register recognizes the cessation of the forward interregister signal, it stops sending the backward interregister signal;
- as soon as the outgoing R2 register recognizes the cessation of the acknowledging backward interregister signal it may, if necessary, start sending the appropriate next forward interregister signal.

When the duration of the forward and backward signals is not controlled by the compelling mechanism described above, it is either limited by the time-out delay for release of the register or determined by the nature of the pulse imposed on them (see Recommendation Q.442).

Figure 12/Q.440 shows a basic compelled signalling cycle.

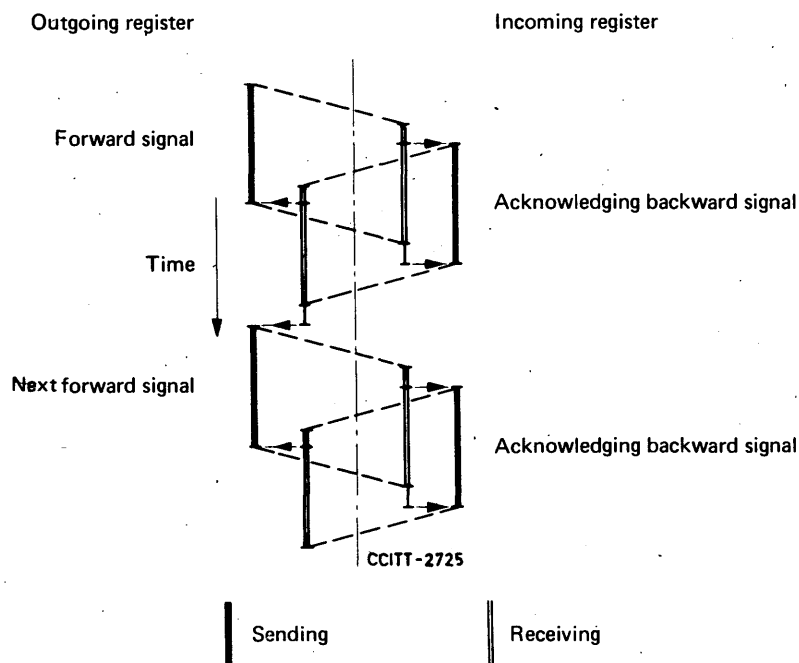


FIGURE 12/Q.440 – Compelled signalling cycle

Figure 18/Q.457 shows in detail the build-up and time sequence of a compelled signalling cycle, including the operating and release times of multifrequency signalling equipment and other internal operating times of exchange equipment.

Besides being a functional part of the compelled procedure, the acknowledging backward signals serve to convey special information concerning the required forward signals, to indicate certain conditions encountered during call set-up or to announce switchover to changed meanings of subsequent backward signals. Changeover to secondary meanings allows information concerning the state of the called subscriber's line to be transferred (see Recommendation Q.441, backward signals). Therefore a choice of acknowledging backward signals is provided.

Recommendation Q.441

4.2 SIGNALLING CODE

4.2.1 Multifrequency combinations

Each interregister signal consists of the simultaneous sending of 2 out of a range of 6, 5 or 4 in-band frequencies (multifrequency combination). The band of the interregister signalling frequencies does not overlap with the frequency band generally used for line-signalling.

This 2-out-of- n code allows erroneous signals consisting of less or more than two frequencies to be detected and identified as faulty.

To make the system suitable for application on 2-wire links, two different sets of 6 frequencies are defined for the composition of the forward and the backward signals.

Table 1 shows all multifrequency combinations which can be derived from the maximum of 6 signalling frequencies per direction provided by the system. For reference purposes each multifrequency combination of a given direction is identified by a serial number. The numerical value of this serial number can be calculated by adding the respective index and weight allocated to the two frequencies making up the combination.

The number of multifrequency combinations depends upon the number of signalling frequencies used. When the maximum of 6 signalling frequencies are used, 15 multifrequency combinations are available.

TABLE 1 – Multifrequency combinations

Combinations		Frequencies (Hz)						
No.	Numerical value = $x + y$	Forward direction (signals of Groups I and II)	1380	1500	1620	1740	1860	1980
		Backward direction (signals of Groups A and B)	1140	1020	900	780	660	540
		Index (x)	f_0	f_1	f_2	f_3	f_4	f_5
		Weight (y)	0	1	2	4	7	11
1	0 + 1		x	y				
2	0 + 2		x		y			
3	1 + 2			x	y			
4	0 + 4		x			y		
5	1 + 4			x		y		
6	2 + 4				x	y		
7	0 + 7		x				y	
8	1 + 7			x			y	
9	2 + 7				x		y	
10	3 + 7					x	y	
11	0 + 11		x					y
12	1 + 11			x				y
13	2 + 11				x			y
14	3 + 11					x		y
15	4 + 11						x	y

The following versions might be considered :

- a) 6 forward frequencies (15 multifrequency combinations) and 5 backward frequencies (10 multifrequency combinations);
- b) 6 forward frequencies (15 multifrequency combinations) and 4 backward frequencies (6 multifrequency combinations);
- c) 5 forward frequencies (10 multifrequency combinations) and 5 backward frequencies (10 multifrequency combinations);
- d) 5 forward frequencies (10 multifrequency combinations) and 4 backward frequencies (6 multifrequency combinations).

In the forward direction the highest signalling frequency may be omitted (i.e. multifrequency combinations 1 to 10 remain). In the backward direction either the lowest or both the lowest and next lowest signalling frequency may be omitted (i.e. multifrequency combinations 1 to 10 or 1 to 6, respectively, remain).

System R2 is designed for operation on international links with 15 multifrequency combinations in each direction. However, it can be used in national networks with a reduced number of signalling frequencies and still permit international/national end-to-end working of System R2 signalling in the case of incoming international traffic (see Figure 13/Q.441).

The reduction naturally cuts the number of multifrequency combinations available but has the economic advantage of effecting savings in equipment. The resulting reduction in facilities is of less importance in automatic than semi-automatic service.

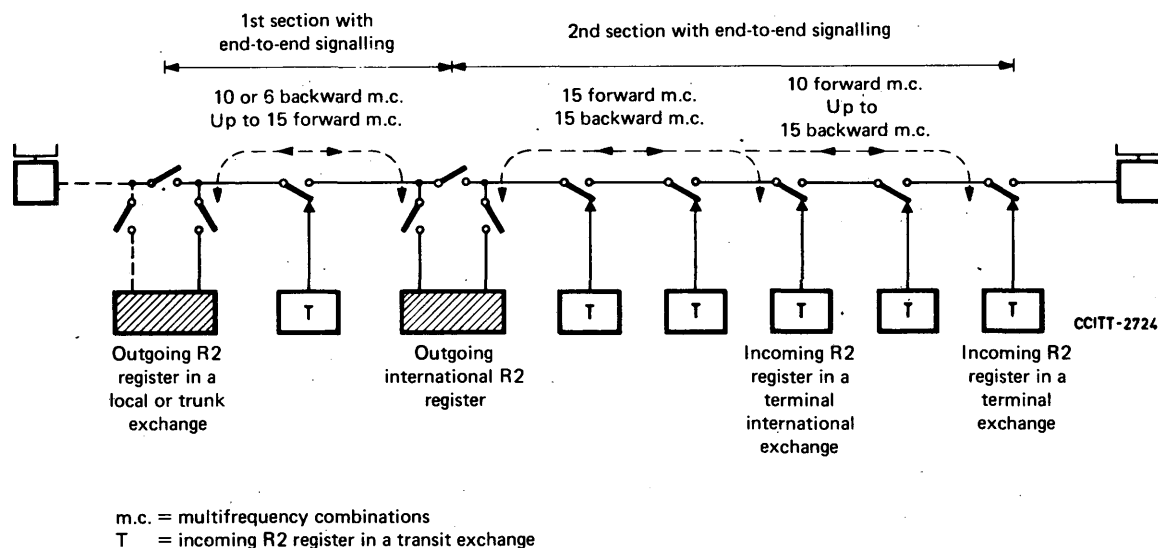


FIGURE 13/Q.441 – An international two-section multi-link connection

4.2.2 Allocation of interregister signals

The signal coding consists of the association of the defined meaning of interregister telephone signals to the multifrequency combinations transmitted over the links. Certain combinations are left spare for the allocation of national or international signals. (For signalling procedures, see Recommendations Q.460 to Q.480.)

4.2.2.1 Multiple meaning

The meaning of both the forward and backward multifrequency combinations can change after transmission of certain backward signals. The changed meaning is specific to the signal which caused or announced the change. In certain cases a change back to the original meaning is possible. The meaning of certain forward multifrequency combinations may also vary depending on their position in the signalling sequence.

4.2.2.2 Meanings of the forward multifrequency combinations

There are two groups of meanings allocated to the forward multifrequency combinations. The Group I meanings are indicated in Table 2 and the Group II meanings in Table 3. The change from Group I to Group II meanings takes place when requested by the backward signals A-3 or A-5. Change back to Group I meanings is only possible when the change to Group II meanings was in response to signal A-5.

The first forward signal transmitted in international working is used for additional routing information. It enables a distinction to be made between terminal and transit calls. In the case of terminal calls it carries the language or discriminating digit whereas, for transit calls, it serves the dual purpose of providing a country code indicator and to indicate whether an echo suppressor is required or not.

The above arrangements obviate the need for two different seizing signals (line signals) to distinguish between transit and terminal traffic on links terminated in a transit exchange.

4.2.2.3 Meanings of the backward multifrequency combinations

There are two groups of meanings allocated to the backward multifrequency combinations. The Group A meanings are indicated in Table 4 and the Group B meanings in Table 5. The change to Group B meanings is announced by the backward signal A-3. No change back is possible once a change to the Group B meanings of the backward multifrequency combinations has been indicated.

4.2.2.4 Integration of national and international signalling codes

The utilization of Signalling System R2 in national networks is facilitated by the provision, in the specified signalling code, of signals specially assigned for national use. Under the specified code, specific national meanings are allocated to some of these signals, others are available for the allocation of national meanings at the discretion of each Administration.

National allocations must not conflict with the present specifications in order to ensure end-to-end interregister signalling i.e. the direct dialogue between the outgoing international R2 register (in the originating country) and incoming R2 registers, in the national network of the destination country.

The specified signalling code allows for a reduction of signalling frequencies in national networks (see 4.2.1 above).

4.2.3 Forward signals

4.2.3.1 Group I forward signals

Compelled interregister signalling must always begin with a Group I forward signal. For the signal codes see Table 2.

TABLE 2 – Group I forward signals

Combination (a)	Designation of the signal (b)	Meaning of the signal		Remarks (e)
		(c)	(d)	
1	I-1	Language digit: French	Digit 1	Col. (c) – These signals make up the first signal transmitted on an international link when it terminates in the country of destination of the call. When a link terminates in an international transit centre, however, these signals may be transmitted on the link after the country code indication and the country code. See also Recommendation Q.107.
2	I-2	Language digit: English	Digit 2	
3	I-3	Language digit: German	Digit 3	
4	I-4	Language digit: Russian	Digit 4	
5	I-5	Language digit: Spanish	Digit 5	
6	I-6	Spare (language digit)	Digit 6	
7	I-7	Spare (language digit)	Digit 7	
8	I-8	Spare (language digit)	Digit 8	
9	I-9	Spare (discriminating digit)	Digit 9	
10	I-10	Discriminating digit	Digit 0	
11	I-11	Country code indicator, outgoing half-echo suppressor required	Access to incoming operator (Code 11)	Col. (c) – First signal on an international link when it terminates in an international transit centre. Col. (d) – Other than the first signal on an international link.
12	I-12	Country code indicator, no echo suppressor required	i) Access to delay operator (Code 12) ii) Request not accepted	
13	I-13	Test call indicator (call by automatic test equipment)	Access to test equipment (Code 13)	
14	I-14	Country code indicator, outgoing half-echo suppressor inserted	Incoming half-echo suppressor required	
15	I-15	Signal is not used	i) End-of-pulsing (Code 15) ii) End of identification	

The signals I-1 to I-10 are numerical signals indicating:

- a) the *address* required for setting up the call (country code, national significant number); such address signals are sent by an outgoing R2 register or an outgoing international R2 register, either spontaneously and immediately after the seizure of the link or in response to one of the backward signals A-1, A-2, A-7 or A-8.
- b) the country code (and possibly the area code as well) of the *location of the outgoing international R2 register*, in response to signals requesting the origin of the call. For national traffic, the telephone number of the calling subscriber's line (see Recommendation Q.480).
- c) for automatic working the *discriminating digit* or, in the case of semi-automatic working, the service language to be used by the operator (i.e. *language digit*).

The signal I-11 is a non-numerical address signal. The meaning of the signal is dependent on its position within the sequence of address signals specified in Recommendation Q.468.

- a) *Country code indicator, outgoing half-echo suppressor required*

When signal I-11 is transmitted as the first forward signal it indicates that:

- (i) a country code will follow (international transit);
- (ii) the call requires echo suppressors;
- (iii) the outgoing half-echo suppressor has to be inserted.

The use of this signal in international working is subject to bilateral agreement and is made in conformity with Recommendation Q.479.

- b) *Access to incoming operator (code 11)*

When signal I-11 is preceded by the language digit (and possibly by one further address digit) it indicates the address of the incoming operator's position and is then always followed by signal I-15 alone.

For international working this signal is to be used only in conformity with Recommendation Q.468. It can be used in national traffic only if the incoming R2 registers are equipped to receive all six forward frequencies. The necessary specifications are then the responsibility of the Administration concerned.

The signal I-12 is a non-numerical address signal. The meaning of the signal is dependent on its position in the sequence of address signals specified in Recommendation Q.468.

- a) *Country code indicator, no echo suppressor required*

When signal I-12 is transmitted as the first forward signal it indicates that:

- (i) a country code will follow (international transit);
- (ii) the call does not require any echo suppressor.

- b) *Access to delay operator (code 12)*

When signal I-12 is preceded by the language digit (and possibly by one further address digit) it indicates that the call must be routed to the delay operator's position, either to a particular operator, or one of those operating a particular group of positions. It is then followed by further digits and the signal I-15 or by the signal I-15 alone.

In international working this signal is to be used in conformity with Recommendation Q.468. It can be used in national traffic only if the incoming R2 registers are equipped to receive all six forward frequencies. The necessary specifications are then the responsibility of the Administrations concerned.

- c) *Request not accepted*

An outgoing international R2 register which receives a signal A-9 or A-10, the use of which is exclusively national, or which receives by signal A-13 a request to identify to which it is unable to reply, should indicate by transmitting signal I-12 that it cannot answer the query (see Recommendation Q.480). This signal may be similarly used in national traffic to indicate that response to signal A-9 or A-10 is not possible.

The *signal I-13* is in general a non-numerical address signal indicating a test call.

a) *Test call indicator*

When in international working the signal I-13 is transmitted as the first forward signal it occupies the position of the language or discriminating digit. It serves then as a test call indicator and must be followed by the complete test equipment address information as specified in j) below.

b) *Access to test equipment (code 13)*

To access automatic test equipment the second signal I-13 (the address digit) must be followed by two digits *xy* and the signal I-15.

The meaning of the non-numerical *signal I-14* is dependent on its position in the sequence of address signals specified in Recommendation Q.468.

a) *Country code indicator, outgoing half-echo suppressor inserted*

When signal I-14 is transmitted as the first forward signal it indicates that:

- (i) a country code will follow (international transit);
- (ii) the call requires echo suppressors;
- (iii) the outgoing half-echo suppressor has already been inserted.

This signal is to be used in international working and only in conformity with Recommendation Q.479.

b) *Incoming half-echo suppressor required*

In response to signal A-14, the meaning of the signal I-14 is that an incoming half-echo suppressor is necessary.

The non-numerical *signal I-15* indicates the end of a sequence of forward interregister signals. It is never sent as the first signal on an international link.

a) *End-of-pulsing*

In international working signal I-15 is used in semi-automatic operation to indicate that there are no more address signals to follow (see Recommendations Q.468 and Q.473).

b) *End of identification*

In international traffic signal I-15 is used to indicate (in response to signal A-13) that transmission of the sequence identifying the location of the outgoing international R2 register is terminated (see Recommendation Q.480).

4.2.3.2 *Group II forward signals*

The Group II forward signals are calling party's category signals sent by outgoing R2 registers or by outgoing international R2 registers in reply to the backward signals A-3 or A-5 and give information whether national or international working applies. For the signal codes see Table 3.

It is useful to identify calls according to type or function:

- (i) to indicate whether the forward transfer facility is required in international traffic;
- (ii) for adequate control of switching operations;
- (iii) to enable any additional meanings for the signals A-5 used in a national network but not internationally accepted (for example, to change the meanings of one or more following signals, forward or backward) to be made inoperative for incoming international calls;
- (iv) for maintenance purposes.

The meanings of the calling party's category signals are detailed below:

a) The *signal II-1, subscriber without priority* indicates that the call is set up from a subscriber's line and is non-priority.

b) The *signals II-2 and II-9, subscriber with priority* indicate that the call is set up from a subscriber's line to which priority treatment of calls has been accorded. Signal II-2 is specified for national working only since there are no Recommendations regarding priority calls in automatic international working (see Recommendation Q.480).

- c) The *signal II-3, maintenance equipment* indicates that the call comes from maintenance equipment.
- d) The *signal II-5, operator* indicates that the call is set up from an operator's position.
- e) The *signals II-6 and II-8, data transmission* indicate that the call will be used for data transmission.
- f) The *signal II-7, subscriber* indicates that the call is set up from a subscriber's line, an operator's position or from maintenance equipment and that no forward transfer signal will be used.
- g) The *signal II-10, operator with forward transfer facility* indicates that the call is set up from an operator's position with possibility of recourse to the forward transfer facility. Its use must be subject to bilateral agreement (see Annex 1 to the present specifications).

The signal II-4 and the signals II-11 to II-15 are spare. The meaning of signal II-4 will be decided later by international agreement.

TABLE 3 – Group II forward signals

Combination (a)	Designation of the signal (b)	Meaning of the signal (c)	Remarks (d)
1 2 3 4 5 6	II-1 II-2 II-3 II-4 II-5 II-6	Subscriber without priority Subscriber with priority Maintenance equipment Spare Operator Data transmission	These signals are solely used for national working
7 8 9 10	II-7 II-8 II-9 II-10	Subscriber (or operator without forward transfer facility) Data transmission Subscriber with priority Operator with forward transfer facility	
11 12 13 14 15	II-11 II-12 II-13 II-14 II-15	Spare for national use	

Note. – Signals II-7 to II-10 are used solely for international working. The rest of the Group II signals only apply for national working and are translated to signals II-7 to II-10 in the outgoing international R2 registers (see Recommendation Q.480). This enables the System R2 register at an incoming exchange to distinguish between national and international calls.

4.2.4 Backward signals

4.2.4.1 Group A backward signals

Group A backward signals (for signal codes see Table 4) are required to acknowledge Group I forward signals and under certain conditions, Group II forward signals. Besides that functional part of the compelled procedure, the Group A signals convey signalling information as detailed below:

TABLE 4 – Group A backward signals

Combination (a)	Designation of the signal (b)	Meaning of the signal (c)
1	A-1	Send next digit ($n + 1$)
2	A-2	Send last but one digit ($n - 1$)
3	A-3	Address-complete, change over to reception of Group B signals
4	A-4	Congestion in the national network
5	A-5	Send calling party's category
6	A-6	Address-complete, charge, set-up speech conditions
7	A-7	Send last but two digit ($n - 2$)
8	A-8	Send last but three digit ($n - 3$)
9	A-9	} Spare for national use
10	A-10	
11	A-11	Send country code indicator
12	A-12	Send language or discriminating digit
13	A-13	Send location of outgoing international R2 register
14	A-14	Request for information on use of an echo suppressor (is an incoming half-echo suppressor required?)
15	A-15	Congestion in an international exchange or at its output

a) The *signal A-1, send next digit ($n + 1$)* requests transmission of the next digit ($n + 1$) after reception of digit n . The latest address signal sent is assumed to have the rank n within the signal sequence specified in Recommendation Q.468.

b) The *signal A-2, send last but one digit ($n - 1$)* requests the transmission of digit ($n - 1$) after reception of digit n . The latest address signal sent is assumed to have the rank n within the signal sequence specified in Recommendation Q.468.

c) The *signal A-3, address complete, changeover to reception of Group B signals* indicates that the incoming R2 register at the incoming end is at the stage when it is about to go over to transmission of a Group B signal conveying information about the condition of the equipment at the incoming exchange or the condition of the called subscriber's line (see Recommendation Q.442).

d) The *signal A-4, congestion in the national network* indicates:

- (i) congestion of national links;
- (ii) congestion in selection stages of terminal international or national exchanges;
- (iii) occurrence of time-out or abnormal release of a system R2 register produced for any reason.

For exception to these rules see n) below. See also signal B-4, Recommendation Q.442 and Annex 2 to this specification.

e) The *signal A-5, send calling party's category* requests transmission of a Group II signal.

f) The *signal A-6, address-complete, charge – set-up speech conditions* indicates that the R2 register at the incoming end needs no additional digit, but will not send Group B signals. The call has to be charged on answer (see Recommendation Q.442).

g) The *signal A-7, send last but two digit ($n - 2$)* requests the sending of digit ($n - 2$) after reception of digit n . The latest address signal sent is to have the rank n within the signal sequence specified in Recommendation Q.468.

h) The *signal A-8, send last but three digit ($n - 3$)* requests the sending of digit ($n - 3$) after reception of digit n . The latest address signal sent is to have the rank n within the signal sequence specified in Recommendation Q.468.

i) The *signals A-9 to A-10* are spares available for allocation of national meanings. The use of signals A-9 and A-10 in national networks can be decided by each Administration.

j) The *signal A-11, send country code indicator* requests the country code indicator (transit indication) in acknowledgement of any forward signal. The signal is used in international transit calls only (see Recommendation Q.462).

k) The *signal A-12, send language or discriminating digit* requests the language digit or the discriminating digit in acknowledgement of any forward signal.

l) The *signal A-13, send location of outgoing international R2 register* requests start or continuation of the identification procedure (in acknowledgement of any forward signal, see Recommendation Q.480.

m) The *signal A-14, request for information on use of echo suppressor* (is an incoming half-echo suppressor required?) indicates that an incoming international exchange acknowledges the discrimination digit or the language digit and that it is possible to insert an incoming half-echo suppressor in that incoming international exchange if required.

n) The *signal A-15, congestion in an international exchange or its output* indicates:

(i) congestion on international links;

(ii) congestion in selection stages at an international transit exchange or at a terminal international exchange and/or its outgoing links;

(iii) occurrence of time-out or abnormal release of a System R2 register produced for any reason.

See Recommendation Q.442.

4.2.4.2 Group B backward signals

Any Group B backward signal (for signal codes see Table 5) acknowledges a Group II forward signal and is always preceded by the address-complete signal A-3 which indicates that the incoming R2 register has received all the Group I forward signals it requires from the outgoing international R2 register. Besides that functional part of the compelled procedure the Group B signals convey information about the condition of switching equipment in the incoming exchange, or about the condition of the called subscriber's line, to the outgoing international R2 register which can then take the necessary action as specified in Recommendation Q.474.

TABLE 5 – Group B backward signals

Combination (a)	Designation of the signal (b)	Meaning of the signal (c)
1	B-1	Spare for national use
2	B-2	Send special information tone
3	B-3	Subscriber line busy
4	B-4	Congestion (encountered after changeover from Group A signals to Group B signals)
5	B-5	Unallocated number
6	B-6	Subscriber's line free, charge
7	B-7	Subscriber's line free, no charge
8	B-8	Subscriber's line out of order
9	B-9	} Spare for national use
10	B-10	
11	B-11	} Spare for international use
12	B-12	
13	B-13	
14	B-14	
15	B-15	

The following Group B signals are specified:

a) The *signal B-1 is spare* for national use and its meaning must be compatible with that of signal B-6 (see Recommendation Q.474).

b) The *signal B-2, send special information tone* indicates that the call could not be set up and that none of other Group B signals applies. In general it indicates that the national number received has ceased to be used and that the subscriber to whom it was allocated must be reached via another number.

c) The *signal B-3, subscriber's line busy* indicates that the line or lines connecting the called subscriber to the exchange are engaged.

d) The *signal B-4, congestion* indicates that congestion condition is encountered after the changeover from Group A signals to Group B signals. The signal B-4 shall be sent in the conditions specified for signal A-4 [see 4.2, 4.1 d) and Recommendation Q.474, 5.3, 5.1].

e) The *signal B-5, unallocated number* indicates that the number received is not in use (e.g. an unused country code, an unused trunk code or subscriber number that has not been allocated).

f) The *signal B-6, subscriber's line free, charge* indicates that the called party's line is free and that the call has to be charged on answer.

g) The *signal B-7, subscriber's line free, no charge* indicates that the called party's line is free but is not to be charged on answer. This signal permits non-chargeable calls without the need for transferring "no charge" information by line signals.

h) The *signal B-8, subscriber's line out of order* indicates that the subscriber's line is out-of-service or faulty.

i) *Signals B-9 and B-10* are spare for national use. Their meaning must not be incompatible with the sending of special information tone to the calling party (see Recommendation Q.474).

j) *Signals B-11 to B-15* are spare for use in the international network. Meanings will be allocated as required.

Recommendation Q.442

4.3 PULSE TRANSMISSION OF BACKWARD SIGNALS A-3, A-4, A-6 OR A-15

Under certain conditions it may prove necessary or desirable to send one of the *signals A-3, A-4, A-6 or A-15* without prior reception of a forward signal. This can occur when the incoming R2 register, after acknowledging a recognized forward signal, is unable to complete the call (for example during congestion) and the next forward signal does not appear on the line; or when the address-complete signal must be sent after the last forward address signal has been acknowledged. It may be desirable to deliberately suspend compelled signalling by acknowledging the last address digit, and signal I-15 if received, with signal A-1 to avoid prolonging the transmission time of certain interregister signals. Such a course should certainly be considered when there is a possibility that a relatively long period may elapse between reception of the last digit and detection of the condition of the called subscriber's line. The average duration of such periods during the busy hour must be limited to 3 seconds in view of the load on the carrier systems in the case of international calls.

The following conditions must be observed in transmitting pulsed interregister signals (see Figure 14/Q.442):

- the minimum delay between the end of transmission of the last signal of the compelled cycle and the start of transmission of the pulse signal must be 100 ms;
- the pulse duration must be 150 ± 50 ms.

Reception of a pulse signal must cause interruption of any forward signal in course of transmission at the outgoing R2 register. It is sometimes impossible, however, to prevent a forward signal from being sent by the outgoing R2 register at the very moment when one of the backward signals A-3, A-4, A-6 or A-15 is sent in pulse form by the register at the incoming end.

To reduce the operating difficulties which may result, the incoming R2 register must be so designed that no forward multifrequency combination can be recognized during and after the transmission of signals A-4, A-6 or A-15 in pulse form or during 300 ± 100 ms from the start of transmission of the address-complete signal A-3 in pulse form (see Figures 14/Q.442 and 15/Q.442). When the end of a pulse signal A-3 has been recognized in the outgoing R2 register, a Group II signal must be sent forward. The incoming R2 register will acknowledge this signal by a Group B signal.

On recognizing signal A-4, A-6 or A-15 no forward signal is sent by the outgoing R2 register. The end of these backward signals must cause the dismissal of the outgoing and incoming R2 registers in accordance with Recommendation Q.475.

The conditions under which pulse transmission of the backward signals A-3, A-4, A-6 or A-15 apply are specified in Section 5.

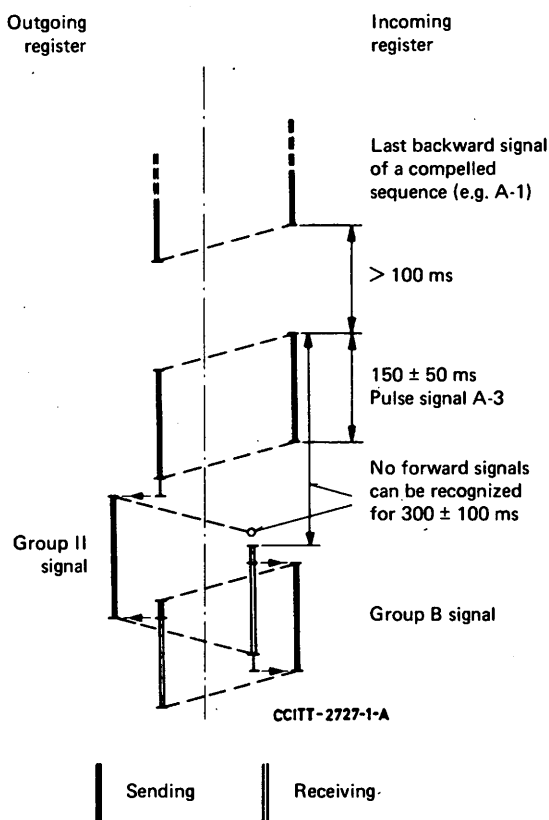


FIGURE 14/Q.442 – Pulse transmission of signal A-3

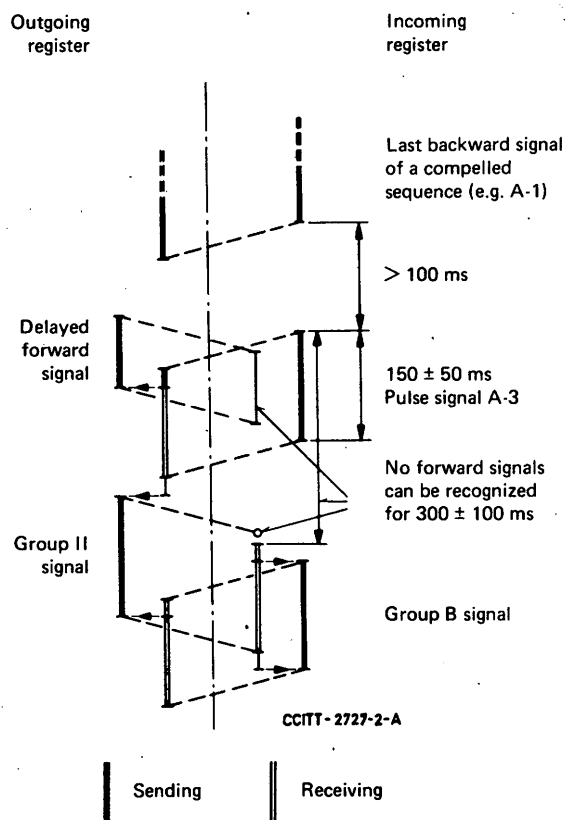


FIGURE 15/Q.442 – Pulse transmission of signal A-3 when delayed forward signal appears

4.4 MULTIFREQUENCY SIGNALLING EQUIPMENT

Recommendation Q.450

4.4.1 GENERAL

Since System R2 can provide, in international working, end-to-end signalling from the outgoing international R2 register to an incoming R2 register at the called subscriber's local exchange (see Recommendation Q.440), the specifications for multifrequency signalling equipment take account of transmission conditions in both the international and national networks. The incoming national network may include both 4-wire and 2-wire links.

However, it is assumed in the following specifications for multifrequency signalling equipment for outgoing international R2 registers and incoming R2 registers in international exchanges including the incoming international exchange that the registers are directly connected by four wires to the virtual switching

points of the links. The registers thus contain a multifrequency signalling equipment with a transmitting part and a receiving part, each separately connected to the GO and RETURN path of the 4-wire circuit respectively (see Figure 16/Q.451).

When the outgoing international R2 register is situated in a national exchange preceding the outgoing international exchange, or when the incoming R2 register is situated in a national exchange following the incoming international exchange, special conditions apply (see Recommendation Q.457).

The upper and lower limits specified for the sending level and for the national extension attenuation leave a degree of freedom, thus simplifying the problem of interworking among different networks. The outgoing international R2 register relays the interregister signals by the method described in Recommendation Q.478. The present specification ensures that the system has an adequate range.

Recommendation Q.451

4.4.2 DEFINITIONS

4.4.2.1 *Multifrequency signalling equipment*

During the exchange of multifrequency combinations the link or multi-link section is terminated at both ends by equipment allowing multifrequency combinations to be sent and received under mutual, compelled control, as indicated in Recommendation Q.440. Generally speaking, the equipment involved in the signal transfer at each end of the multi-link section has the following functions:

- reception of multifrequency combinations;
- protection against disturbances (e.g. 2-out-of- n -check, 0-out-of- n -check, see Recommendation Q.458);
- transfer of signals to and from the registers or equivalent equipment;
- sending of multifrequency combinations.

This equipment as a whole can be considered as a single functional unit, henceforth called the multifrequency signalling equipment.

The functions of the multifrequency signalling equipment may be distributed among a number of sub-units, according to the design principles adopted in each particular case; these, within certain limits, are open to choice.

For the purpose of the present specification, the multifrequency signalling equipment is divided into a sending part and a receiving part.

a) *Four-wire multifrequency signalling equipment*

Multifrequency signalling equipment connected to the speech path by two pairs of wires is called 4-wire multifrequency signalling equipment (see Figure 16/Q.451). In such cases, the speech path itself is generally 4-wire too.

In Figure 16/Q.451, point B is the output of the sending part and point C the input to the receiving part of the 4-wire multifrequency signalling equipment. The latter includes the devices for protection against disturbances and the equipment for transferring signals to the register or equivalent equipment.

b) *Two-wire multifrequency signalling equipment*

Because different frequencies are used for interregister signalling in the two directions of transmission, a single pair of wires connecting the speech path to the multifrequency signalling equipment can be used for simultaneous sending and reception of multifrequency combinations.

Multifrequency signalling equipment connected to the speech path by a single pair of wires is called 2-wire multifrequency signalling equipment (see Figure 17/Q.451).

In Figure 17/Q.451, point A is the output of the sending part and, at the same time, the input to the receiving part. The latter includes the devices for protection against disturbances and for transferring signals to the register or equivalent equipment.

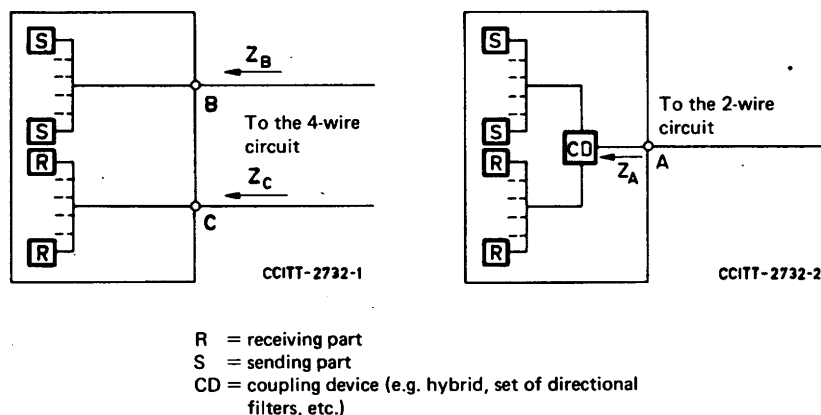


FIGURE 16/Q.451 – 4-wire multifrequency signalling equipment

FIGURE 17/Q.451 – 2-wire multifrequency signalling equipment

4.4.2.2 Operate and release times of the receiving part of the signalling equipment

The speed and reliability of the compelled interregister signal transfer is dependent on the operation and release times T_0 , T_R , T'_0 and T'_R defined below. These times include the minimum recognition times referred to in 4.4.5.3 below.

a) Operation time

If the two frequencies making up a multifrequency combination are applied simultaneously to the input of the receiving part of the multifrequency signalling equipment, the time interval between the application of both frequencies and recognition of the multifrequency combination is called operation time T_0 .

If one of the two frequencies making up a multifrequency combination is applied to the input of the receiving part of the multifrequency signalling equipment somewhat after the other frequency, the time interval between the application of the second frequency and recognition of the multifrequency combination is called operation time T'_0 .

b) Release time

If the two frequencies making up a multifrequency combination are simultaneously cut off from the input of the receiving part of the multifrequency signalling equipment, the time interval between the cut-off and recognition of the end of the multifrequency combination is called release time T_R .

If one of the two frequencies making up a multifrequency combination is cut off from the input of the receiving part of the multifrequency signalling equipment somewhat after the other frequency, the time interval between the cut-off of the second frequency and recognition of the end of the multifrequency combination is called release time T'_R .

4.4.2.3 Internal operation time

a) If the equipment at a switching centre has to analyse one or more of the signals received and if it has to carry out routing and switching operations before being able to determine which backward signal should be sent, it can delay completion of the compelled signalling cycle. Such delay depends on the function the centre has and on the design of the switching equipment used in it. The delay cannot therefore be specified.

The time required by an incoming R2 register to determine which backward signal to send in reply to a forward signal is denoted as $T_{int 1}$. The duration of the cycle is increased by the whole of this time, which must therefore be kept to a minimum. Its value will be zero if the signal to be sent is already determined.

b) An outgoing R2 register sends a forward signal after interpreting the backward signal it has received. The time required to determine the appropriate signal is denoted as $T_{int 2}$.

c) At the end of a forward signal the incoming R2 register may have to perform certain functions in order to be ready to receive the next signal. The time required for these functions is denoted as $T_{int 3}$.

Recommendation Q.452

4.4.3 REQUIREMENTS RELATING TO TRANSMISSION CONDITIONS

4.4.3.1 Impedances

The impedance Z_A measured at the terminals A (see Figure 17/Q.451) of a 2-wire multifrequency signalling equipment will have a nominal value equal to the nominal terminating impedance Z_T of the links at the exchange under consideration and will be balanced to earth. In most cases this value Z_T will be 600 ohms non-reactive. The impedance Z_A will then satisfy the conditions:

$$20 \log \left| \frac{600 + Z_A}{600 - Z_A} \right| \geq 10 \text{ dB} \quad (1)$$

in the 300-3400 Hz band, and

$$20 \log \left| \frac{600 + Z_A}{600 - Z_A} \right| \geq 16 \text{ dB} \quad (2)$$

in the 520-1160 Hz and 1360-2000 Hz bands.

The impedances Z_B and Z_C measured at the terminals B and C (see Figure 16/Q.451) of a 4-wire multifrequency signalling equipment will have a nominal value equal to the nominal terminating impedance Z_T at the exchange under consideration and will be balanced to earth. In most cases this value Z_T will be 600 ohms non-reactive. The impedances Z_B and Z_C will then satisfy condition (1) above in the 300-3400 Hz band and condition (2) above in the 520-1160 Hz or 1360-2000 Hz bands, according to the set of frequencies generated by the equipment concerned.

All the above requirements must be met, whether signalling frequencies are being transmitted or not.

4.4.3.2 *Echoes*

The balance return loss presented to the international link by different national networks varies considerably. Recommendation G.122 gives the desirable values based on transmission requirements and these values could hardly be improved on simply in order to facilitate signalling, especially as the balance return loss would then have to be very high.

The multifrequency signalling equipment must therefore function with an echo signal. Allowance is made for this in the test conditions (see Recommendation Q.455).

In order to eliminate disturbing and unwanted double-echo effects, outgoing international R2 registers must be provided with 4-wire signalling equipment; the 4-wire loop will then remain open at the outgoing end of the multi-link section during signalling.

For the same reason, it is recommended that 4-wire signalling equipment be provided whenever 4-wire switching equipment is used.

4.4.3.3 *Location and connection of multifrequency signalling equipment associated with outgoing international R2 registers*

The multifrequency signalling equipment of the outgoing international R2 registers is assumed to be directly connected to the virtual switching point of the links in an international exchange. This equipment may be situated in a national switching centre of the country of origin on the national network side of the outgoing international exchange provided that the 4-wire extension links between this centre and the outgoing international exchange have the same upper limit for the standard deviation of transmission loss variations with time (1 dB) as the international links.

Should the national extension links not have a nominal transmission loss of 0.5 dB between the national exchange and the virtual switching point in the outgoing international exchange, there must be suitable compensation of the power level of the multifrequency combinations.

Recommendation Q.454

4.4.4 THE SENDING PART OF THE MULTIFREQUENCY SIGNALLING EQUIPMENT

4.4.4.1 *Signalling frequencies*

The composition of the multifrequency combinations is specified in Recommendation Q.441.

The frequencies in the forward direction are:

$$f_0 = 1380, f_1 = 1500, f_2 = 1620, f_3 = 1740, f_4 = 1860, f_5 = 1980 \text{ Hz.}$$

The frequencies in the backward direction are:

$$f_0 = 1140, f_1 = 1020, f_2 = 900, f_3 = 780, f_4 = 660, f_5 = 540 \text{ Hz.}$$

The frequency variation at the sending point must not exceed ± 4 Hz relative to the nominal value.

4.4.4.2 *Absolute power level transmitted*

a) Four-wire multifrequency signalling equipment for outgoing international R2 and incoming R2 registers assumed to be directly connected to the virtual switching point in an international exchange:

- i) The absolute power level of each non-modulated signalling frequency transmitted by the sending part of the multifrequency signalling equipment in the international exchange concerned will have a nominal value of $-3.5 - 8 = -11.5$ dBm with a tolerance of ± 1 dB.

- ii) The difference in level between the two signalling frequencies making up a multifrequency combination must be less than 1 dB.

The tolerances specified apply to the sending point itself, i.e. terminal B in Figure 16/Q.451.

- b) Four-wire multifrequency signalling equipment for outgoing international R2 registers situated in a national exchange further down in the network of the country of origin:

- i) The sending-level conditions mentioned above under a) are applicable in such national exchanges, provided that the national 4-wire extension links between the national exchange and the outgoing international exchange have the same nominal transmission loss (0.5 dB) and the same upper limit of standard deviation of transmission loss variations with time (1 dB) as the international links.
- ii) If these national links do not have a nominal transmission loss of 0.5 dB, the level of interregister frequencies must be compensated as required.

- c) *Multifrequency signalling equipment for incoming R2 registers in national exchanges:*

The nominal absolute power level N of a single signalling frequency transmitted by the sending part of the multifrequency signalling equipment (2-wire or 4-wire) in any national exchange must be chosen within the limits:

$$N \geq A_b + 0.5m + 2.3 \sqrt{(m + k) + (m + k + 1) 0.04} - 31 \text{ dBm} \quad (1)$$

and

$$N \leq A_b - 11.5 \text{ dBm} \quad (2)$$

or

$$N \leq A_b + 0.5m - 2.3 \sqrt{(m + k) + (m + k + 1) 0.04} - 9 \text{ dBm} \quad (3)$$

whichever of (2) or (3) yields the lower value.

In order to avoid marginal operation, it is recommended that levels higher than the minimum levels given by formula (1) be specified.

In these formulae:

- m = the number of 4-wire links switched in tandem between the outgoing international R2 register and the incoming international exchange. The number m thus includes the national 4-wire extension links in the country of origin (see Recommendation Q.457) and the international links. In formula (1) m should always be given the maximum value 4. In formula (3), m should be given all its values, from minimum to maximum, and the lowest value so obtained or derived from formula (2) is to be taken as the upper limit of N .
- k = the number of national 4-wire extension links switched in tandem between the incoming international terminal exchange and the national exchange. The maximum value of k will be 4.
- A_b = the nominal transmission loss at 800 Hz in the backward direction between the output terminals of the sending part of the multifrequency signalling equipment of the incoming R2 register in the exchange under consideration and the *send* side of the virtual switching point of the backward speech path in the incoming international exchange.

Formulae (1), (2) and (3) were derived as shown in Annex 1 to Section 4.

The variation in level relative to the nominal value N chosen for a given exchange must not exceed ± 1 dB.

However, the difference in level between the two signalling frequencies making up a multifrequency combination must not exceed 1 dB.

4.4.4.3 *Signalling frequency leak level*

The total power level of the leak current transmitted to line must be:

- a) at least 50 dB below the nominal level of one signalling frequency when no multifrequency combination is being sent;
- b) at least 30 dB below the level of either of the signalling frequencies when a multifrequency combination is being sent. Furthermore, any single leak current must be at least 34 dB below the level of either of the signalling frequencies when a multifrequency combination is being sent.

4.4.4.4 *Harmonic distortion and intermodulation*

The total power level of all frequencies due to harmonic distortion and intermodulation within the frequency band 300-3400 Hz must be at least 37 dB below the level of one signalling frequency.

4.4.4.5 *Time tolerance for multifrequency combinations*

The time interval between the start of sending of each of the two frequencies constituting a multifrequency combination must not exceed 1 ms.

The time interval between the cessation of sending of each of the two frequencies must not exceed 1 ms.

Recommendation Q.455

4.4.5 THE RECEIVING PART OF THE MULTIFREQUENCY EQUIPMENT

4.4.5.1 *Sensitivity range*

The power levels given below relate to the nominal impedance of the receiving part of the multifrequency signalling equipment.

The receiving part of the multifrequency signalling equipment shall have a sensitivity range of -35 dBm to -5 dBm.

4.4.5.2 *Operate and release time requirements*

The operating and release times of the receiving part of the multifrequency signalling equipment depend on the design and, for a given design, on:

- the time difference between the instants of reception of each of the two frequencies making up a multifrequency combination;
- the level of each of the two frequencies;
- the difference in level between the two frequencies;
- the level, spectrum and instant of onset of the noise.

The factors vary with transmission conditions. With certain types of switching equipment it may prove advisable to embody devices to counteract low-frequency disturbances in the multifrequency signalling equipment.

Time requirements have been specified for two types of *multifrequency test combinations*, A and B, applied to the input of the receiving part of the multifrequency signalling equipment in the presence of disturbing signals as specified below.

When test combinations and disturbing frequencies as specified under a) to c) below are applied to the terminals A (see Figure 17/Q.451) of 2-wire multifrequency signalling equipment or to the terminals C (see Figure 16/Q.451) of 4-wire multifrequency signalling equipment, the following time requirements must be met:

- for type A test combinations:

$$T_0 + T_R \leq 70 \text{ ms}$$

- for type B test combinations:

$$T_0 + T_R \leq 80 \text{ ms}$$

- for test combinations of types A and B:

$$(T_0 + T_R) \leq (T_0 + T_R) + 5 \text{ ms}$$

(For definitions of T_0 , T_0 , T_R , and T_R see Recommendation Q.451.)

For the third requirement, the only cases to be considered are those in which the frequency first appearing is also the first to disappear (transmission delay effect). The T_0 and T_R time requirements are specified to ensure proper functioning of the multifrequency signalling equipment when the received multifrequency combination is affected by group delay distortion, for example. The appropriate procedure for this test depends on the design of the equipment to be tested; in many cases it will be convenient to assume that a delay of one second or more for the second frequency constitutes the most unfavourable case.

When a multifrequency combination has caused the receiving part of the multifrequency signalling equipment to operate, the latter cannot release if the signal frequencies are interrupted for not more than 7 ms. A method of improving the system reliability in case of interrupted signals is described in Annex 2 of Section 4.

a) *Multifrequency test combinations type A*

- The multifrequency test combination consists of any 2-out-of- n combination of the n signalling frequencies;
- each frequency differs from the nominal frequency by not more than ± 5 Hz;
- the absolute power level of each of the two frequencies of the multifrequency combination lies between -5 dBm and -20 dBm;
- the difference in level between the two frequencies is not greater than 3 dB.

b) *Multifrequency test combinations type B*

- The multifrequency test combination consists of any 2-out-of- n combination of the n signalling frequencies;
- each frequency differs from the nominal frequency by not more than ± 10 Hz;
- the absolute power level of each of the two frequencies of the multifrequency combination lies between -5 dBm and -35 dBm;
- the difference in level between the two frequencies is not greater than 5 dB for adjacent frequencies and 7 dB for non-adjacent frequencies.

c) *Disturbing frequencies*

The disturbing frequencies to be applied are:

- in all cases one or more of the n frequencies for which the receiving part under test is designed, with a total power level of -55 dBm or less, when no multifrequency test combination is being applied;
- when a multifrequency test combination is applied, one or more of the $(n - 2)$ remaining frequencies with a total power level 20 dB below the highest test combination frequency level during application of the test combination;

- for testing the receiving part of 4-wire multifrequency signalling equipment in an outgoing international R2 register:

any multifrequency combination consisting of two frequencies out of the forward group of frequencies, each of these two frequencies having a level of 13.5 dB above the lowest test-combination frequency level in the backward direction; an upper limit of -12.5 dBm is nevertheless specified for the level of the disturbing signal.

System R2 interregister signalling may be used in the country of origin on the national links preceding the out-going international R2 register. In that case, the receiving part of 4-wire multifrequency signalling equipment connected to the forward speech path of the national 4-wire links may have to function in the presence of frequencies used in the backward direction. No general specification can be given for the level of these disturbing frequencies; it is recommended that Administrations formulate their own specifications.

- for testing the receiving part of 2-wire multifrequency signalling equipment:

any multifrequency combination at the highest level used in operational signalling (measured at point A, Figure 17/Q.451) by the sending part of the 2-wire multifrequency signalling equipment concerned.

4.4.5.3 *Non-operate and non-recognition requirements*

The receiving part of the multifrequency signalling equipment must remain in the *non-operate* state when the following disturbances, singly or together, are the only signals that are applied to the terminals A or C (see Figures 17/Q.451 and 16/Q.451):

- any single pure sine wave or any combination of two pure sine waves, each with a power level of -42 dBm within the 300-3400 Hz band;
- any combination of two pure sine waves, each with a power level of -5 dBm within the 1300-3400 Hz band for the set of frequency receivers used in the backward direction; and within the 330-1150 Hz and 2130-3400 Hz bands for the set of frequency receivers used in the forward direction.

Furthermore, when signalling tones have activated the receiving part of the multifrequency signalling equipment, this must assume the *non-operate* state when the signalling tones are removed in the presence of these same disturbances, singly or together, at the above-mentioned terminals.

The receiving part of the multifrequency signalling equipment must not recognize a combination consisting of two signalling frequencies out of the set of frequencies normally used in the transmission direction considered, each having a level not exceeding -5 dBm and a duration of less than 7 ms.

The receiving part of the multifrequency signalling equipment must not recognize a combination consisting of two signalling frequencies used in the transmission direction considered, having a difference in level of 20 dB or more.

4.4.5.4 *Influence of transient disturbances* (see also Recommendation Q.458)

The recognition of faulty signals due to short-lived transient conditions can largely be avoided if a multifrequency combination is recognized only after a specified minimum time, during which two, and only two, of the individual receivers are active and if the absence of multifrequency combinations is recognized only after a minimum time, during which all individual receivers are at rest. These times are included in the operating and release times T_0 and T_R .

Typical transient disturbances, such as clicks, change of polarity, etc., generated by the switching equipment, must not change signals transferred from the receiving part of the signalling equipment to the register.

It is recommended that Administrations formulate their own specification for a test method according to the type of disturbances encountered in their switching equipment.

4.5 RANGE, SPEED AND RELIABILITY OF INTERREGISTER SIGNALLING

Recommendation Q.457

4.5.1 RANGE OF INTERREGISTER SIGNALLING

4.5.1.1 *Number of international links*

The number of international links switched in tandem for establishing an international connection using System R2 must not exceed 4 (see Recommendation Q.440).

Assumptions for the transmission loss in 4-wire international links:

- i) nominal transmission loss at 800 Hz: 0.5 dB (Recommendation G.141, A.);
- ii) standard deviation of transmission loss variations with time must not exceed 1 dB [Recommendation G.151, C. a)];
- iii) the difference between the mean value and the nominal is assumed to be 0 [as in Recommendations G.122, A. b), and G.131, A.].

4.5.1.2 *Number of national links*

- a) *Outgoing international R2 register and number of national 4-wire extension links in the country of origin*

The outgoing international R2 register is always provided with 4-wire multifrequency signalling equipment and the 4-wire loop will be open during interregister signalling.

The outgoing international R2 register must be placed in an exchange from where the incoming international exchange in the country of destination is reached by not more than four 4-wire links switched in tandem (see Recommendation Q.440).

It is understood that the national 4-wire links in the country of origin shall have the same standard deviation of transmission loss variations with time (1 dB) as the international links and that, if these national links do not have the same nominal transmission loss as the international links (0.5 dB), appropriate compensation of the multifrequency combination levels will be made in both directions of transmission.

- b) *Number (k) of national 4-wire extension links in the country of destination*

Not more than four national 4-wire extension links may be used.

Forward transmission loss in the country of destination:

- i) The standard deviation of transmission loss variations with time in the national 4-wire extension links in the country of destination must not exceed 1 dB.
- ii) The nominal transmission loss at 800 Hz in the forward direction (A_f) between the virtual switching point in the incoming international exchange and any incoming R2 register in the country of destination must not exceed:

11.4 dB for a country using 3 national 4-wire extension links at the most

or

11.0 dB for a country using 4 national 4-wire extension links at the most,

and must never be less than:

$$A_{f \min.} = -2.5 - 0.5 m + 2.3 \sqrt{(m + k) + (m + k + 1) 0.04} \text{ dB.}$$

The values for the minimum forward transmission loss $A_{f \min.}$ resulting from this formula are shown in Table 6 (for the definitions of m and k see Recommendation Q.454). In practice the forward transmission loss must not fall below these values.

TABLE 6 – Minimum forward transmission loss
in the country of destination

$k \backslash m$	1	2	3	4
1	0.3	0.6	0.7	0.8
2	1.1	1.2	1.3	1.3
3	1.7	1.8	1.8	1.7
4	2.3	2.3	2.2	2.2

The formula has been determined as shown in Annex 3 to Section 4.

When System R2 end-to-end signalling is applied in a national network, the 4-wire links involved may not conform to the characteristics specified by the CCITT for international circuits. Also, national transmission plans may be based on principles different from those of the international transmission plan. Consequently, the range over which end-to-end signalling is possible must be established using calculations, e.g. as shown in Annex 3 to Section 4 (see also 4.5.1.3 and 4.5.1.4 below).

4.5.1.3 Total attenuation distortion

It has been assumed that at all frequencies within the 530-1990 Hz band the overall attenuation distortion relative to 800 Hz between the outgoing international R2 register and any incoming R2 register will not exceed ± 3 dB. Attention is drawn to the fact that on some national connections these assumptions might not be fulfilled.

As type B test signals (see Recommendation Q.455) allow for a 5 dB difference in level between two adjacent signalling frequencies, and a 7 dB difference between two non-adjacent signalling frequencies, a 4 dB attenuation distortion of the multi-link section can be allowed for two adjacent frequencies and a 6 dB distortion for two non-adjacent frequencies, provided that the level of the weakest signalling frequency is not lower than -35 dBm at the terminals of the receiving part of the multifrequency signalling equipment.

The values 4 dB and 6 dB were obtained by allowing for a 1 dB difference in sending level.

4.5.1.4 Intermodulation

A multifrequency signalling system in conformity with the above specifications will allow satisfactory working over a multi-link section introducing intermodulation products from two signalling frequencies and falling within the 520-1160 Hz and 1360-2000 Hz bands, the level of each of such products being at least 24 dB below the highest signal frequency level.

4.5.2 Build-up and time specification of a complete forward compelled signalling cycle

Figure 18/Q.457 shows in detail the build-up and time sequence of a compelled signalling cycle.

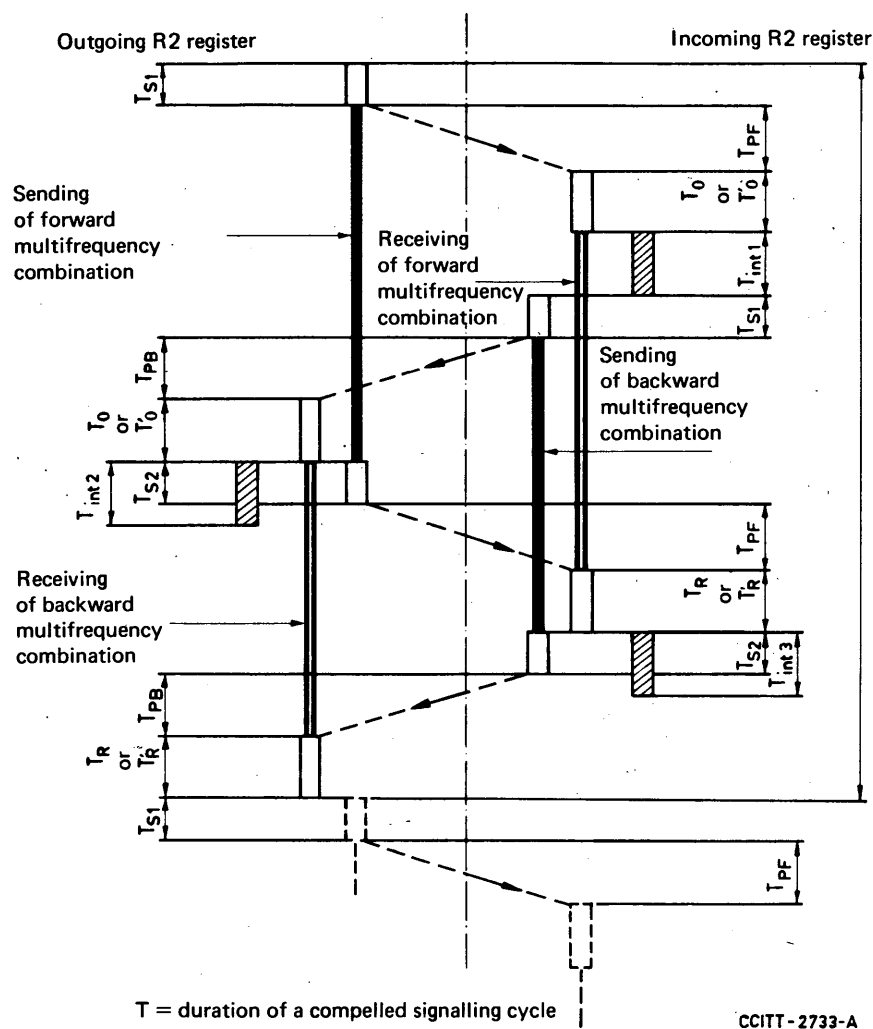


FIGURE 18/Q.457 – Sequence of a complete compelled signalling cycle

In this figure:

T_{PF} denotes the transmission delay of the slower of the two frequencies of a forward multifrequency combination;

T_{PB} denotes the transmission delay of the slower of the two frequencies of a backward multifrequency combination;

T_0 and T'_0 denote the operating times as defined in Recommendation Q.451;

T_R and T'_R denote the release times as defined in Recommendation Q.451;

T_{int1} , T_{int2} and T_{int3} denote the internal operation times as defined in Recommendation Q.451.

If the values of $T_{int\ 2}$ and $T_{int\ 3}$ lie within certain limits, they do not contribute to the total duration of the compelled signalling cycle, as can be seen from Figure 18/Q.457.

T_{S1} and T_{S2} denote respectively the time required for starting and stopping the sending of a multifrequency combination (switching-on or switching-off times, exclusive of logic operations).

It thus appears that the total duration T of a complete compelled signalling cycle is given by the formula:

$$T = 2(T_{PF} + T_{PB}) + \left\{ \begin{array}{c} (T_0 + T_R)_D + (T_0 + T_R)_A \\ \text{or} \\ (T'_0 + T'_R)_D + (T'_0 + T'_R)_A \end{array} \right\} + T_{int\ 1} + (T_{S1} + T_{S2})_D + (T_{S1} + T_{S2})_A$$

The subscripts D and A apply respectively to the outgoing and the incoming registers.

T_{PF} and T_{PB} depend on the propagation characteristics of the forward and backward speech paths respectively and therefore cannot be specified.

A value of 10 ms for T_{PF} and T_{PB} can be considered as typical, e.g. for average terrestrial regional connections.

The maximum value of $T_0 + T_R$ has been fixed at 70 ms. A value of 35 ms could be taken in a certain number of cases as representing the minimum duration of $T_0 + T_R$.

$T_{int\ 1}$, $T_{int\ 2}$ and $T_{int\ 3}$ are dependent on the type of exchange and therefore cannot be specified; but their contribution to the total duration of the compelled signalling cycle must be kept as small as possible.

If the influence of $T_{int\ 1}$, $T_{int\ 2}$ and $T_{int\ 3}$ is ignored, and if the extreme values of $T_0 + T_R$ and for $T_{S1} + T_{S2}$ are assumed to be identical for the outgoing and the incoming register, the extreme values of $T_{S1} + T_{S2}$ being taken as $5\text{ ms} \leq T_{S1} + T_{S2} \leq 10\text{ ms}$ and if the value of 10 ms indicated above as typical is adopted for T_{PF} and T_{PB} , the probable extreme values of the compelled signalling cycle T would be:

$$120\text{ ms} \leq T \leq 200\text{ ms}.$$

The signalling rates would be between approximately 8 and 5 signalling cycles per second. These values are not absolute limits; the signalling cycle could for example be longer on a complex connection or in the presence of noise or other conditions approaching those of type B test combinations (see Recommendation Q.455).

Recommendation Q.458

4.5.3 RELIABILITY OF INTERREGISTER SIGNALLING

4.5.3.1 General

In signal transmission, reliability and speed are to some extent conflict requirements: the slower the signalling, the more reliable it is likely to be. System R2 combines the two essential requirements of speed and reliability, since it is a compelled system, adapting its signalling speed to the working conditions with minimum loss of reliability.

System R2 is protected against the acceptance of faulty information (multifrequency combinations consisting either of one frequency only or of more than two frequencies) by means of the 2-out-of- n method of checking the number of frequencies received.

This protection is inoperative in the case of disturbances (noise, clicks, etc.) activating two, and only two, of the single frequency receivers; nor does it prevent the release of all the receivers (thus wrongly indicating the end of a multifrequency combination) in the event of an interruption caused by disturbances during transmission of a multifrequency combination.

Disturbances causing the operation of two single frequency receivers or the release of all the receivers are due mainly to short-lived, transient conditions. The recognition of faulty information due to such conditions can therefore largely be avoided by so designing the receiving part of the multifrequency signalling equipment that a multifrequency combination will be recognized only after a specified minimum time. During this time two, and only two, of the individual receivers are active and the absence of multifrequency combinations will be recognized only after a specified minimum time, during which all individual receivers are at rest. The degree of protection against faults due to the above-mentioned conditions is dependent on these times, which are included in the operating and release times defined for the receiving part of the multifrequency signalling equipment in Recommendation Q.451.

4.5.3.2 Error rate for compelled working

The test of the multifrequency signalling equipment as a whole consists in continuous, compelled transmission of multifrequency combinations.

It must be ensured that all possible combinations of the forward and backward multifrequency combinations have equal probability of occurrence during the test period.

The error rate is observed at the receiving part at both ends of the link and is defined, for each end, as the number of errors divided by the number of combinations sent by the corresponding sending parts at each end of the link.

It is for each Administration to define the sources of permanent and impulsive noise to be applied to the interface between the sending and receiving parts in the light of its experience and local conditions.

The compelled working may be tested, on the one hand, by using test combinations of Type A (see Recommendation Q.455) in the presence of noise at a power level of -40 dBm and a uniform power distribution in the 300-3400 Hz band (filtered white noise) and, on the other hand, by using Type B test combinations in the presence of noise at a power level of -45 dBm and a uniform power distribution in the 300-3400 Hz band.

The error rates in these conditions will be:

- for Type A test combinations and noise at -40 dBm $\leq 10^{-5}$;
- for Type B test combinations and noise at -45 dBm $\leq 10^{-4}$.

ANNEX 1

(to Section 4)

(see Recommendation Q.454)

Development of formulae for the power level of signalling frequencies

The formulae (1), (2), and (3) of Recommendation Q.454 describing the nominal absolute power level N of a transmitted single signalling frequency were derived as follows:

1. The nominal transmission loss in the backward direction between the incoming R2 register and the outgoing international R2 register is given by (see Recommendation Q.457):

$$A_b + 0.5m \text{ dB.}$$

2. On the assumption that the contribution of the national 2-wire links to transmission loss variations with time is negligible and with allowance for the standard deviation of transmission loss variations with time of the international and national 4-wire circuits and in the exchanges (see CCITT Recommendation Q.45: $\delta = 0.2$ dB), the total transmission loss variation for a 1% probability of it being exceeded is given by:

$$\pm 2.3 \sqrt{(m + k) + (m + k + 1) (0.2)^2} \text{ dB.}$$

3. Given a total attenuation distortion of ± 3 dB relative to 800 Hz (see Recommendation Q.457) and a tolerance of ± 1 dB on the nominal power level N , the lower and upper limits of the level received in the outgoing international R2 register will be:

$$N - A_b - 0.5m - 2.3 \sqrt{(m + k) + (m + k + 1) 0.04} - 3 - 1 \text{ dBm}$$

and

$$N - A_b - 0.5m + 2.3 \sqrt{(m + k) + (m + k + 1) 0.04} + 3 + 1 \text{ dBm}$$

respectively.

4. The receiving part of the multifrequency signalling equipment has a sensitivity range between

$$-35 \text{ dBm and } -5 \text{ dBm (see Recommendation Q.455).}$$

The minimum value of N is thus given by:

$$N - A_b - 0.5m - 2.3 \sqrt{(m + k) + (m + k + 1) 0.04} - 4 = -35 \text{ dBm;}$$

hence:

$$N \geq A_b + 0.5m + 2.3 \sqrt{(m + k) + (m + k + 1) 0.04} - 31 \text{ dBm} \quad (1)$$

The maximum value of N is given by:

$$N - A_b - 0.5m + 2.3 \sqrt{(m + k) + (m + k + 1) 0.04} + 4 = -5 \text{ dBm;}$$

hence:

$$N \leq A_b + 0.5m - 2.3 \sqrt{(m + k) + (m + k + 1) 0.04} - 9 \text{ dBm} \quad (3)$$

5. The nominal level of the backward signals at the virtual switching point of the incoming international exchange must not be higher than -11.5 dBm; thus

$$N - A_b \leq -11.5 \text{ dBm;}$$

hence:

$$N \leq A_b - 11.5 \text{ dBm.} \quad (2)$$

ANNEX 2

(to Section 4)

(see Recommendation Q.455)

Possible method of improving protection from interruptions

If the receivers are locked through an internal function of the registers until the times Q and S (see Figure 19) the intervals during which there is a risk that interruptions may cause their release are reduced by PQ and RS respectively.

To ensure that the duration of the compelled signalling cycle is not prolonged on links of short transmission delay $T_{PF} = T_{PB} \approx 0$, the time PQ must not exceed the expected value of $T_{int1} + T_{S1} + T_0 + T_{S2}$ and the time RS must not exceed the expected value of $T_{S2} + T_R + T_{S2}$.

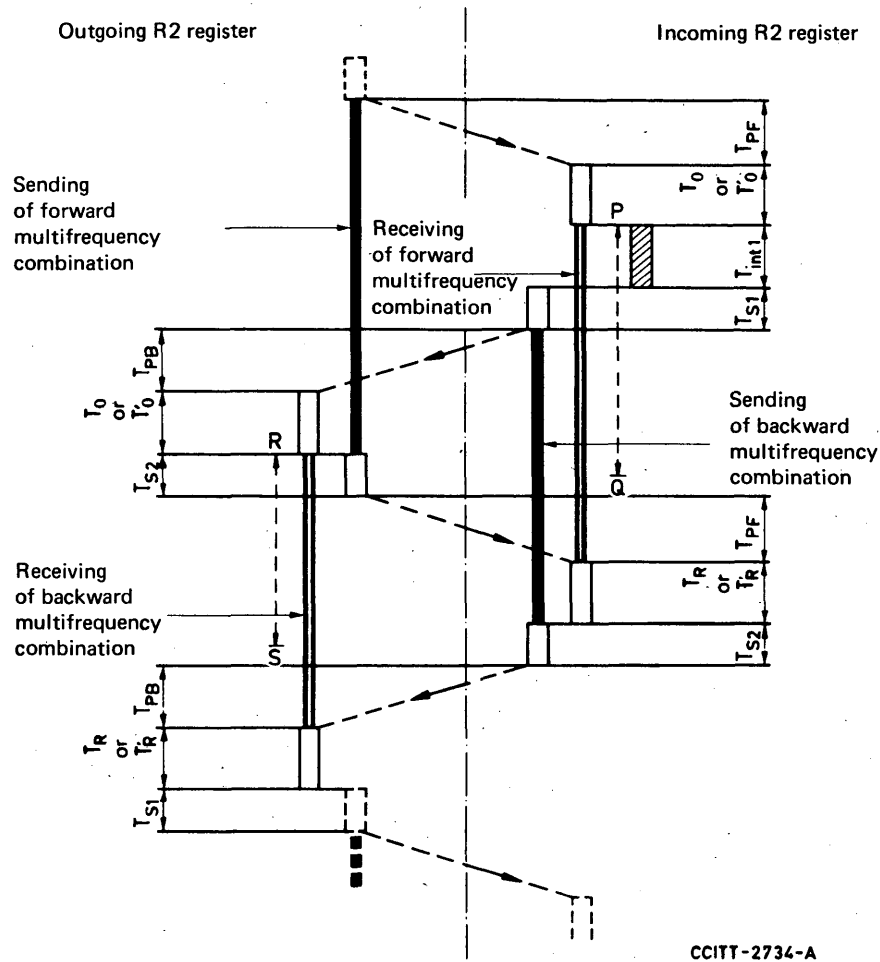


FIGURE 19

ANNEX 3

(to Section 4)

(see Recommendation Q.457)

**Development of a formula for the admissible forward
transmission loss in a country of destination**

The formula used in Recommendation Q.457 for the calculation of the minimum forward transmission loss $A_{f\min}$ in a country of destination was determined as follows:

1. According to Recommendation Q.454 the lowest and highest sending levels will be, respectively,

$$-11.5 - 1 = -12.5 \text{ dBm}$$

and

$$-11.5 + 1 = -10.5 \text{ dBm.}$$

2. Let A_f be the nominal transmission loss at 800 Hz in the forward direction, between the virtual switching point in the incoming international exchange and the incoming R2 register concerned.

The total nominal transmission loss between the outgoing international R2 register and the incoming R2 register will then be:

$$A_f + 0.5m \text{ dB.}$$

3. On the assumption that the contribution of the national 2-wire links to transmission loss variations with time is negligible, and that the standard deviation of transmission loss variation in the exchange is 0.2 dB (see Recommendation Q.45), the total transmission loss variation, calculated for a 1% probability of it being exceeded will be:

$$\pm 2.3 \sqrt{(m + k) + (m + k + 1) 0.2^2} \text{ dB.}$$

4. With allowance for a total attenuation distortion of ± 3 dB relative to 800 Hz (see Recommendation Q.457) the lower and upper limits of the level of each frequency at the input of the incoming R2 register will be respectively:

$$-12.5 - A_f - 0.5m - 2.3 \sqrt{(m + k) + (m + k + 1) 0.04} - 3 \text{ dBm}$$

and

$$-10.5 - A_f - 0.5m + 2.3 \sqrt{(m + k) + (m + k + 1) 0.04} + 3 \text{ dBm.}$$

5. The receiving part of the multifrequency signalling equipment has a sensitivity range of -35 dBm to -5 dBm.

6. The maximum value of A_f is thus given by:

$$-12.5 - A_{f \text{ max.}} - 0.5m - 2.3 \sqrt{(m + k) + (m + k + 1) 0.04} - 3 = -35 \text{ dBm}$$

hence:

$$A_{f \text{ max.}} = 19.5 - 0.5m - 2.3 \sqrt{(m + k) + (m + k + 1) 0.04} \text{ dB}$$

7. The minimum value for A_f is given by:

$$-10.5 - A_{f \text{ min.}} - 0.5m + 2.3 \sqrt{(m + k) + (m + k + 1) 0.04} + 3 = -5 \text{ dB}$$

hence:

$$A_{f \text{ min.}} = -2.5 - 0.5m + 2.3 \sqrt{(m + k) + (m + k + 1) 0.04} \text{ dB.}$$

According to Recommendation Q.457, the maximum number of 4-wire links with *international* characteristics is $m = 4$.

The maximum number of national 4-wire extension links is $k = 4$.

SECTION 5

SIGNALLING PROCEDURES

A major characteristic of System R2 is the inherent flexibility in the interregister signalling procedures which allow efficient signal information transfer, adapted to the particular requirements relating to different call types, traffic conditions and switching equipments. This flexibility is primarily achieved by the principle that the interregister signalling sequence is controlled by the incoming R2 register by means of backward signals.

In this context the function of an outgoing R2 register is basically to respond with the forward signal requested by the incoming R2 register. At the incoming R2 register the determination of the backward signal to be sent, thus controlling the signalling sequence, is closely related to the analysis necessary to determine the routing and handling of the call.

In this Section the signalling procedures are specified. Although System R2 in principle allows a high degree of freedom in the combination of these procedures within the signalling sequence for call set-up, the procedures to be used for normal international calls are described below. For national application of System R2 the signalling sequences to be applied have to be defined in accordance with the limitations of the present specifications by the Administration concerned.

Recommendation Q.460

5.1 NORMAL CALL SET-UP PROCEDURES FOR INTERNATIONAL WORKING

5.1.1 *General*

During call set-up an outgoing international R2 register is connected to an international link. This register signals to at least one incoming R2 register situated in an international exchange and possibly, depending upon the routing, to as many as 4 successive incoming R2 registers in international exchanges and 4 successive incoming R2 registers situated in national exchanges in the destination country where System R2 is employed.

The duration of the normal call set-up procedure can vary because different phases of the signalling sequence between the outgoing international R2 register and successive incoming R2 registers may be repeated.

Recommendation Q.462

5.1.2 SIGNALLING BETWEEN THE OUTGOING INTERNATIONAL R2 REGISTER AND AN INCOMING R2 REGISTER IN AN INTERNATIONAL EXCHANGE

The address signals from an operator or a subscriber must be stored in an outgoing international R2 register. When a sufficient number of digits is available an outgoing link is selected and a seizing (line) signal is sent. When the seizing signal is recognized an incoming R2 register is associated with the link.

Immediately the outgoing link is seized the outgoing international R2 register sends the first interregister signal.

5.1.2.1 *Signalling to an international transit exchange*

When the outgoing link is to an international exchange from which a transit routing is required to the destination country, the first interregister signal sent is a country code indicator. This is one of signals I-11, I-12, I-14 depending upon the requirement for echo-suppressors (see Recommendation Q.479).

On recognition of a country code indicator the incoming R2 register determines that the call is to be internationally transit switched. The incoming R2 register sends signal A-1 when it requests the first digit of the country code. The outgoing international R2 register sends this address digit (a signal I-1 to I-10). The incoming R2 register may send signal A-1 to request the next digit.

The incoming R2 register examines the address digit(s) and if a further digit (or digits) is required for routing, signal A-1 is sent to request the next digit.

When sufficient digits are stored at the incoming exchange to permit the call to be routed to the next exchange, the backward signal is determined by the nature of the signalling system employed on the outgoing link.

a) If the outgoing link employs System R2, one of two backward signals is sent immediately the outgoing link is seized.

- (i) If the outgoing link is to another international transit exchange from which a transit routing is required to the destination country, signal A-11 is sent to request repetition of the country code indicator.

On recognition of signal A-11 the outgoing international R2 register sends a country code indicator as the first signal to be received by the incoming R2 register in the next international transit exchange. This is one of signals I-12 or I-14. If signal I-11 was sent initially, signal I-14 is sent subsequently.

On recognition of a country code indicator the incoming R2 register determines that the call is to be internationally transit switched. The signalling procedure which follows is identical to that described above.

- (ii) If the outgoing link is to an incoming international exchange in the destination country, signal A-12 is sent to request a language or discriminating digit.

In both these cases after the backward signal is sent and the compelled signalling sequence is complete, the transit exchange releases the incoming R2 register and through-connects the speech-path between the outgoing exchange and the next exchange.

b) If the outgoing link employs a signalling system other than System R2, then the acting incoming R2 register is the last incoming R2 register. The exchange seizes an outgoing international link to a further international transit exchange or an incoming international exchange in the destination country. Signalling continues between the outgoing international R2 register and the last incoming R2 register and interworking takes place with the other signalling system.

If congestion is encountered signal A-15 is sent, if necessary in pulse form. After the compelled signalling sequence is complete or after the end of the pulse signal the transit exchange dismisses the register.

On recognition of signal A-15 the outgoing exchange may initiate a repeat attempt, a re-routing or cause the return of congestion information to the calling subscriber. In all cases the outgoing (multi-)link section is released.

5.1.2.2 *Signalling to an incoming international exchange in the destination country*

When the outgoing international link is a direct link to an incoming international exchange in the destination country the first interregister signal sent is a language or discriminating digit.

Alternately, if the outgoing multi-link section is routed via one, two or three international transit exchanges then on recognition of signal A-12 the outgoing international R2 register sends a language or discriminating digit as the first signal to be received by the incoming R2 register in the terminal international exchange in the destination country.

The first signal A-12 received from an international transit exchange by the outgoing international R2 register informs it that an international link terminating at an incoming international exchange has been added to the (multi-)link section.

In both cases, on recognition of a language or discriminating digit (a signal I-1 to I-10), the incoming R2 register determines that the call is to be routed to the national network, and selects the next backward signal.

- (i) The incoming R2 register may send signal A-14 to request information about the requirement for echo-suppression.
 - If an incoming-half-echo-suppressor is required the outgoing international R2 register sends signal I-14.
 In response to signal I-14 the incoming R2 register sends signal A-1 to request the first digit of the national (significant) number.
 In response to signal A-1 the outgoing international R2 register sends the first digit of the national (significant) number.
 - If no echo-suppressor is required the outgoing international R2 register sends the first digit of the national (significant) number.
- (ii) Alternatively, if it is known that no echo-suppressor is required to be inserted the incoming R2 register may send signal A-1 to request the first digit of the national (significant) number. In response to signal A-1 the outgoing international R2 register sends the first digit of the national (significant) number.

The incoming R2 register examines the first digit of the national (significant) number and if a further digit (or digits) is required for routing, signal A-1 is sent to request the next digit.

When sufficient digits are stored at the incoming exchange to permit the call to be routed to the next exchange the backward signal (if any) is determined by the nature of the signalling system employed on the outgoing link and the national routing principles.

- a) If the outgoing national link employs System R2 and international/national end-to-end signalling is used, a backward signal may be sent after the outgoing link is seized to request the address digit required as the first signal to be received by the incoming R2 register in the following national exchange.

The appropriate signal is one of signals A-1, A-2, A-7, A-8 or A-12. These signals may be sent after any digit, and can be repeated provided they do not conflict with the logic procedure.

However, if the address digit *on-line* is the digit required as the first signal to be received by the incoming R2 register in the next exchange, it is possible for the transit exchange to release the incoming R2 register and through-connect the speech-path after the outgoing link is seized without sending a backward signal.

Otherwise, after the appropriate backward signal is sent and the compelled signalling sequence is complete the transit exchange releases the register and through-connects the speech path.

- b) If the outgoing national link employs System R2 but end-to-end international/national signalling cannot be used, the register in the incoming international exchange relays the multifrequency signals: it acts as an outgoing R2 register. It requests the remainder of the address digits by repetitive use of signal A-1. The digits received by the outgoing R2 register are retransmitted over the outgoing national link at the request of the incoming R2 register in the following national exchange(s) (see Recommendation Q.478).

- c) If the outgoing link employs a signalling system other than System R2 then the acting incoming R2 register is the last incoming R2 register. The exchange seizes a national link. Signalling continues between the outgoing international R2 register and the last incoming R2 register and interworking takes place with the other signalling system.

If congestion is encountered, congestion signal A-4 or A-15 is transmitted (if necessary in pulse form) and the incoming R2 register is dismissed.

On recognition of the congestion signal A-4 the outgoing exchange releases the outgoing link or connection and causes the return of congestion information to the calling subscriber.

On recognition of the congestion signal A-15 the outgoing exchange may initiate a repeat attempt, re-routing or cause the return of congestion information to the calling subscriber. In all cases the outgoing link or connection is released.

It is desirable to use the congestion signal A-15 solely in the case of incoming international terminal traffic when repeat attempt or re-routing may be expected to be successful.

Recommendation Q.463

5.1.3 SIGNALLING BETWEEN THE OUTGOING INTERNATIONAL R2 REGISTER AND AN INCOMING R2 REGISTER IN A NATIONAL EXCHANGE IN THE DESTINATION COUNTRY

5.1.3.1 *Signalling to a national transit exchange*

The outgoing international R2 register sends the requested address digit as the first signal to be received by the incoming R2 register in the national transit exchange in the destination country.

The incoming R2 register examines the digit and if a further digit (or digits) is required for routing, signal A-1 is sent to request the next digit.

When sufficient digits are stored at the incoming exchange to permit the call to be routed to the next exchange the backward signal (if any) is determined by the nature of the signalling system employed on the outgoing link and the national routing principles.

a) If the outgoing national link employs System R2 a backward signal may be sent after the outgoing link is seized to request the address digit required as the first signal to be received by the incoming R2 register in the next exchange. The signalling procedure which occurs is similar to that described in 5.1.2.2 a) above.

b) If the outgoing link employs System R2 but end-to-end international/national signalling cannot be used, the register in the national exchange relays the interregister signals: it acts as an outgoing R2 register. The digits received by this outgoing R2 register are retransmitted over the outgoing link at the request of the incoming R2 register in the following exchange(s) (see Recommendation Q.478).

c) If the outgoing link employs a signalling system other than System R2 then the acting incoming R2 register is the last incoming R2 register. The exchange seizes an outgoing national link to the next national exchange. Signalling continues between the outgoing international R2 register and the last incoming R2 register and interworking takes place with the other signalling system.

If congestion is encountered signal A-4 is sent (if necessary in pulse form) and the incoming R2 register is released.

On recognition of congestion signal A-4 the outgoing exchange releases the outgoing multi-link section and causes the return of congestion information to the calling subscriber.

5.1.3.2 *Signalling to a national exchange to which the called subscriber is connected*

When the outgoing multi-link section is routed to the national exchange to which the called subscriber is connected the acting incoming R2 register is the last incoming R2 register: the outgoing international R2 register sends the requested address digit as the first signal to be received by the last incoming R2 register and signalling continues as described below.

Recommendation Q.464**5.1.4 SIGNALLING BETWEEN THE OUTGOING INTERNATIONAL R2 REGISTER AND THE LAST INCOMING R2 REGISTER****5.1.4.1 General**

The usual System R2 signalling procedure is to request in succession the remainder of the address digits stored in the outgoing international R2 register by the repetitive use of signal A-1 until it is determined at the incoming end that the complete address information has been received by the incoming exchange or that the call cannot be routed.

System R2 enables transmission of information concerning a large number of different conditions of called subscriber's line or reasons why call set-up has failed. But this can only be sent if the switching systems and other signalling systems employed on the remaining links of the connection offer the possibility of differentiating several line conditions. Group B-signals are provided for this purpose.

Transition from Group A to Group B meanings is indicated by means of address-complete signal A-3. However, if the incoming exchange is unable to send any signals concerning the condition of the called subscriber's line it is unnecessary to send signal A-3 followed by a Group B signal. In such cases the address-complete signal A-6, provided for the purpose is used.

If congestion is encountered after transmission of the address-complete signal A-3 the congestion signal B-4 is sent in place of signal A-4 or A-15.

5.1.4.2 When the last incoming R2 register is able to transmit the condition of the called subscriber's line

When the condition of the called subscriber's line can be determined the incoming R2 register can send signals conveying this information after receipt of the address digits.

As soon as the last address digit is received the last incoming R2 register sends the address-complete signal A-3 to announce changeover to the transmission of Group B signals. In response the outgoing international R2 register sends the appropriate calling party's category signal (II-7 to II-10). The last incoming R2 register acknowledges this with the relevant Group B signal indicating the condition of the called subscriber's line.

Immediately the compelled signalling sequence is complete the incoming R2 register is released and depending upon the Group B signal sent the speech-path may be through-connected.

When the condition of the called subscriber's line is determined by an electrical signal to the last incoming R2 register and if the called subscriber's line is free the address-complete signal A-6 can be sent instead of signal A-3, possibly in pulse form. This will be the last interregister signal. After signal A-6 is sent the incoming R2 register is released, the speech-path is through-connected and ringing tone returned to the calling subscriber. Outgoing international R2 registers must be able to interpret all Group B signals.

On recognition of the last backward signal the outgoing exchange releases the outgoing international R2 register and either through-connects the speech-path or releases the outgoing connection and causes the return of an appropriate tone or special announcement or both alternately to the calling subscriber.

5.1.4.3 When the last incoming R2 register is not able to transmit the condition of the called subscriber's line

In this case the last incoming R2 register sends the address-complete signal A-6, possibly in pulse form, as the last interregister signal. After this is sent, the last incoming R2 register is released and the speech-path is through-connected.

When the last incoming R2 register is in the exchange to which the called subscriber is connected, an appropriate tone is returned to the calling subscriber from this exchange.

On recognition of address-complete signal A-6, the outgoing exchange releases the outgoing international R2 register and through-connects the speech-path. The calling subscriber will then hear ringing tone, busy tone, special information tone or a recorded announcement alternately with special information tone sent by the incoming equipment.

Recommendation Q.465**5.1.5 PARTICULAR CASES****5.1.5.1 *Unallocated number***

When, after the reception of any digit, the incoming R2 register determines that the address information corresponds to an unallocated number, the address-complete signal A-3 is sent immediately without requesting all the address digits. In response the outgoing international R2 register sends the appropriate Group II signal. This is then acknowledged by signal B-5 *unallocated number*.

5.1.5.2 *Congestion in the national network*

If congestion is encountered in the national network the incoming R2 register sends congestion signal A-4, possibly in pulse form. However, if address-complete signal A-3 has already been sent, congestion signal B-4 is sent in acknowledgement of the Group II signal which commences the last compelled signalling sequence.

5.1.5.3 *Operator calls*

The procedures described in Recommendations Q.462-Q.464 are also valid for a semi-automatic call. However, in this case the address information is always terminated by the end-of-pulsing signal I-15.

For code 11 or code 12 calls only a limited number of backward signals can be employed as the last interregister signal (e.g. signal A-4, A-6 or B-6).

5.1.5.4 *Request of calling party's category*

At any time calling party's category information may be requested by the incoming R2 register interrupting the normal transmission of address information. The incoming R2 register sends signal A-5 in acknowledgement of a Group I signal and the outgoing international R2 register sends the appropriate Group II signal (a signal II-7 to II-10) in reply. If this Group II signal is acknowledged by a signal different from address-complete signal A-3 or signal A-5 the next forward signal sent will be one of the Group I.

5.1.5.5 *Identification procedure*

At any time the incoming R2 register can request the location of the outgoing international R2 register. Signal A-13 is sent in acknowledgement of a forward signal and the outgoing international R2 register sends its identity or rejects the request by signal I-12 (see Recommendation Q.480).

Recommendation Q.466**5.1.6 SUPERVISION AND RELEASE OF THE CALL**

An answer signal is sent when the called subscriber lifts his receiver. Each transit exchange in the connection relays this line signal. At the outgoing international exchange receipt of the answer signal normally causes call charging to take place and metering for international accounting purposes to start.

When the called subscriber replaces his receiver a clear-back signal is sent and relayed by each transit exchange.

When the calling subscriber replaces his receiver a clear-forward signal is relayed by the outgoing international exchange over the outgoing international link. On receipt of the clear-forward signal on an incoming link, release operations are initiated and the clear-forward signal is repeated forward on the outgoing link.

Immediately release operations at an exchange are complete (although the outgoing circuit may still be held) a release-guard sequence is initiated on the incoming link. After recognition of the end of the release-guard sequence at the outgoing exchange the link reverts to idle.

Supervision of a call must be in accordance with Recommendation Q.118.

Recommendation Q.468

5.2 ROUTING AND NUMBERING FOR INTERNATIONAL WORKING

System R2 as specified is suitable for international application and Recommendations Q.12 and Q.13 on routing are applicable.

Similarly, for international traffic the combinations of digits to be dialled by calling subscribers and operators must be in accordance with Recommendations Q.10, Q.11 and Q.101 to Q.107.

5.2.1 *Digit analysis at the outgoing international exchange*

The maximum number of digits which has to be analysed in the outgoing international exchange to determine the routing is 5, which number does not include the language or the discriminating digit.

In semi-automatic working in the case where the language digit is not sent by the operator and in automatic working it is necessary to determine in the outgoing international exchange the position where the language or discriminating digit should be automatically inserted (immediately after the country code). This position is determined by an analysis of the first one or the first two digits of the country code.

5.2.2 *Sequence of digits in the outgoing international R2 register*

Table 7 indicates the sequence of the digits to be sent by the outgoing international R2 register for the various types of calls. In relation to the backward signals A-1, A-2, A-7 and A-8 the latest address signal sent is assumed to have rank n within the sequence shown.

Table 8 indicates which signal is to be sent first on the international link.

5.2.3 *Maximum number of digits required for routing at an international transit exchange*

The maximum number of digits required to determine the routing at an international transit exchange is as follows:

$I_1 Z N_1 N_2 N_3$

or $I_1 I_2 Z N_1 N_2$

or $I_1 I_2 I_3 Z N_1 N_2$

where I_1, I_2, I_3 = digits of the country code

Z = characteristic digit, i.e. discriminating digit (D) or language digit (L), and

N_1, \dots, N_n = digits of the national (significant) number.

Accordingly, the maximum number of digits that has to be analysed at an international transit exchange is 6, which number includes the language or the discriminating digit.

TABLE 7 – Sequence of signals to be sent by the outgoing international R2 register

Call to:	Sequence of signals to be sent by the outgoing international R2 register	
	Automatic working	Semi-automatic working
A subscriber	1. Country code indicator ¹ 2. Country code ² 3. Discriminating digit ³ 4. National (significant) number	1. Country code indicator ¹ 2. Country code ² 3. Language digit ^{3,4} 4. National (significant) number 5. End-of-pulsing I-15 ⁵
Any operator's position		1. Country code indicator ¹ 2. Country code ² 3. Language digit ³ 4. Extra digit designating the incoming international exchange ⁵ 5. Signal I-11 or I-12 6. End-of-pulsing I-15
A particular delay operator, or one of those operating a particular group of delay operator's positions		1. Country code indicator ¹ 2. Country code ² 3. Language digit ³ 4. Extra digit designating the incoming international exchange ⁵ 5. Signal I-12 6. Number of a particular position or a group of positions 7. End-of-pulsing I-15

¹ This indicator, given by signal I-12 or I-14 or, in exceptional cases by signal I-11, is only necessary for calls that are set up via one or more international transit exchanges.

² The country code is only necessary for calls that are set up via one or more international transit exchanges.

³ This digit must be in accordance with Recommendation Q.104.

⁴ Unless the forward transfer facility is used, the discriminating digit may be used instead. Such a semi-automatic call would then be treated like a fully-automatic one.

⁵ This digit is only to be sent and analysed in special cases.

TABLE 8 – First signal to be sent on international links

International link		First signal sent on the international link
From	To	
Originating country	Destination country	Discriminating digit or language digit
Originating country	Transit country	Country code indicator
Transit country	Transit country	Country code indicator
Transit country	Destination country	Discriminating digit or language digit

5.2.4 General requirements for an international transit exchange

System R2 equipment for transit exchanges must be designed for the transfer of all information necessary for setting up the calls including information relating to access to operators' positions.

In an international transit exchange an analysis of some of the digits is required to determine routing to the desired international incoming exchange or to another international transit exchange. As a general rule the country code of the destination country is subject to this analysis. In some cases an analysis of more or fewer digits may be required. The transit exchange decides how many digits it needs for this analysis and asks for the sending of these digits from the outgoing international R2 register.

Possible cases for the digit transfer control by an international transit exchange are shown below (the letters given to the international exchanges correspond to Figure 20/Q.468 and the letters given to the digits correspond to 5.2.3 above).

5.2.4.1 Transit traffic via C in one country routed to two exchanges M or R in another country according to the first digit(s) of the national (significant) number

a) Automatic and semi-automatic calls with normal national numbers

Example: $I_1 I_2 Z N_1 N_2$

b) Semi-automatic calls to code 11 or code 12 operators

Examples: $I_1 I_2 L C_{11}$ or $I_1 I_2 L C_{12}$

In the case of countries with more than one incoming international exchange where code 11 or code 12 traffic requires for routing in the transit exchange a digit analysis beyond the country code, N_1 may be used as the extra digit designating the incoming international exchange ¹⁾

Examples: $\underbrace{I_1 I_2 L N_1 C_{11}}_{\text{analysed}}$ or $\underbrace{I_1 I_2 L N_1 C_{12}}_{\text{analysed}}$

5.2.4.2 Transit traffic via C in one country routed to G or S in another country with semi-automatic traffic to S and automatic traffic to G according to the presence of the language digit (L) or the presence of the discriminating digit (D)

Examples: $I_1 I_2 D$ or $I_1 I_2 L$

5.2.5 Example of digit analysis for incoming terminal traffic

Terminal traffic incoming to an international exchange C in a country and which is to be routed to code 11 or code 12 operators in another international exchange A in the same country according to the extra digit N_1 ¹⁾.

Examples: $\underbrace{L N_1 C_{11} C_{15}}_{\text{analysed}}$ or $\underbrace{L N_1 C_{12} X X C_{15}}_{\text{analysed}}$

5.2.6 Cross-border traffic between adjacent countries

If for cross-border traffic between adjacent countries access to operators' positions is not provided it may be decided by bilateral agreement to exclude the transfer of the language or the discriminating digit. In this case the first digit sent will be the first of the national (significant) number. In addition, one or more of the first digits of the national (significant) number may not be sent depending on the routing requirements at the incoming exchange.

¹⁾ It is recognized that existing design of some present-day equipments may not permit the reception of the extra digit N_1 . In this situation, agreement will be required between the relevant countries concerned that the insertion of N_1 would not be provided for at a particular outgoing international exchange as long as the equipment limitation applies.

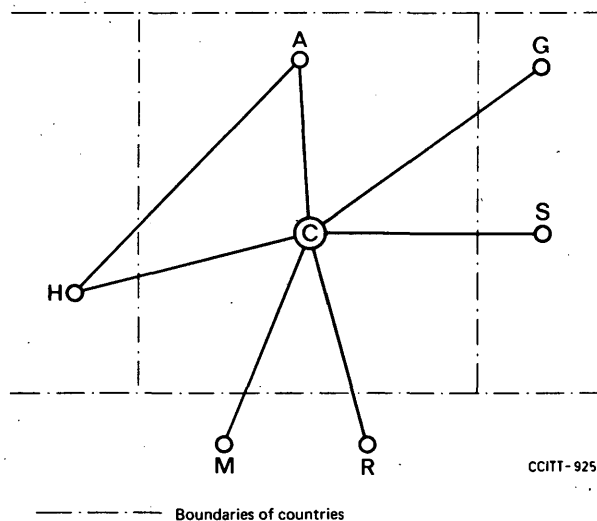


FIGURE 20/Q.468 – International transit exchange situation

5.3 TERMINATION OF INTERREGISTER SIGNALLING

Recommendation Q.470

5.3.1 AT AN INCOMING R2 REGISTER SITUATED IN A TRANSIT EXCHANGE

5.3.1.1 Successful routing

Normally, interregister signalling is terminated in one of the following ways:

- a) The last forward interregister signal received by the incoming R2 register at the transit exchange is not acknowledged from that register. After an outgoing link to the next exchange is seized, the register is dismissed and the speech-path is through-connected. The forward signal remains on-line and is the first signal received by the next incoming R2 register. Provision must be made for the switching operations to be completed so as to ensure that the signal will remain on-line and be received by the succeeding register.
- b) The last forward interregister signal received by the incoming R2 register at the transit exchange is acknowledged by a backward signal (A-1, A-2, A-7, A-8, A-11 or A-12) requesting transmission of a clearly specified signal as the first to be received by the next incoming R2 register. When the compelled signalling sequence is complete the register is dismissed and the speech-path is through-connected.

Because it is not possible to send signals A-2, A-7, A-8, A-11 or A-12 in pulse form, precautions are necessary to avoid acknowledging the last address digit (on automatic calls) until the signalling system employed on the outgoing link is known. If signal A-1 is sent in acknowledgement of the last address digit and if the outgoing link employs System R2 it may not then be possible to send one of these signals and therefore end-to-end signalling to the next exchange is no longer feasible (see also Recommendation Q.474).

In international working signals A-2, A-7 and A-8 may be used to acknowledge receipt of any forward signal.

Signal A-11 must be used to request a country code indicator.

Signal A-12 must generally be used to request the language or discriminating digit. However, in the case where an incoming R2 register is equipped with only 5 backward signalling frequencies only one of the signals A-2, A-7 or A-8 can be used for this purpose. Attention is drawn to the fact that in this case the language or discriminating digit may not be sent by all outgoing international R2 registers.

Although it is not normally necessary to request a repeat of a digit n because it remains on the line until acknowledged (but see Recommendation Q.476) such repetition may prove necessary after an interruption of digit transmission (e.g. to request information concerning the calling party's category) or if the completion of switching operations referred to in method *a*) above, cannot be guaranteed with a time compatible with the time-out of the outgoing (international) R2 register (see Recommendation Q.476). The procedure is then as follows:

Signal A-2 is sent, eliciting the digit $n-1$; this is immediately acknowledged by signal A-1 to elicit the required digit n . When the digit n in question is the first digit in the store of the outgoing R2 register this procedure is not applicable.

At an international transit exchange method *b*) above, must be used and only one of the signals A-11 or A-12 applies.

When the outgoing link connects to a further international transit exchange signal A-11 must be used to request a country code indicator. On recognition of signal A-11 the outgoing international R2 register must send a country code indicator (signal I-12 or I-14, see Recommendation Q.479) as the first forward signal to be received by the next incoming R2 register.

Signal I-12 or I-14 may be requested as many times as necessary by sending signal A-11.

When the outgoing link connects to an incoming international terminal exchange signal A-12 must be used to request the language or discriminating digit. On recognition of signal A-12 the outgoing international R2 register must send the language or discriminating digit (a signal I-1 to I-10) as the first forward signal to be received by the next incoming R2 register.

On recognition of signal A-12 (sent from an international transit exchange) an outgoing international R2 register is informed that an international link connected to an incoming international terminal exchange has been added to the (multi-)link section and that call set-up is now in progress in the national destination network. This is of importance when signal A-9 or A-10 are, in the originating country, amongst those used to set-up international calls.

5.3.1.2 Congestion

If it is impossible to set-up the desired connection in the transit exchange the incoming R2 register terminates interregister signalling by transmission of the congestion signal A-4 or A-15. The backward signal may serve as acknowledgement of the last forward signal received by the incoming R2 register at the transit exchange or is sent in pulse form.

The two congestion signals A-4 and A-15 are provided to enable an outgoing international R2 register to determine whether congestion is occurring in the international network or in that of the destination country so that provision for repeat attempt or re-routing can be made in the former case:

- Signal A-15 is sent from an international exchange.
- Signal A-4 is sent from a national exchange or possibly from a terminal international exchange. (See also Annex 2 to these specifications.)

Because receipt of congestion signal A-15 by an outgoing international R2 register may initiate repeat attempt or re-routing it is possible to transmit congestion signal A-4 from international exchanges where repeat attempt or re-routing may be expected useless.

Recommendation Q.471**5.3.2 AT THE LAST INCOMING R2 REGISTER SITUATED IN THE EXCHANGE
TO WHICH THE CALLED SUBSCRIBER IS CONNECTED****5.3.2.1 Successful routing**

When a call has been completely set up by means of System R2 interregister signalling, the incoming R2 register terminates interregister signalling immediately on receipt of the entire number.

The following criteria are used to determine whether the number received by the incoming R2 register is complete:

- a) analysis — to determine the last digit;
- b) electrical conditions given by the switching equipment succeeding the incoming R2 register;
- c) receipt of the end-of-pulsing signal (I-15);
- d) the assumption, after a specified time has elapsed, that no further digits will be sent (see Recommendation Q.476).

When criterion a) (analysis) is applied:

- if the incoming R2 register is equipped to send Group B signals to provide information about the condition of the called subscriber's line the address-complete signal A-3 is transmitted on receipt of the last digit. As soon as it is known whether the connection with the subscriber's line can be established, only the appropriate Group B signal needs to be sent. The use of the Group B signals is detailed in Recommendation Q.474;
- if the incoming R2 register is not equipped to receive information about the condition of the called subscriber's line the address-complete signal A-6 is sent immediately after reception of the last digit and no Group B signal will be transmitted.

In both cases the time interval between the end of a signal A-6 or a Group B signal and the start of the subsequent answer signal must not be less than 75 ms.

When criterion b) (electrical conditions) is applied:

It is recommended that, to avoid delay in sending the answer signal, no Group B signal should be sent when the called subscriber's line is free, and that the setting-up of speech conditions be ensured by sending address-complete signal A-6 immediately the electrical conditions are recognized. The time interval between the end of signal A-6 and the start of transmission of the subsequent answer signal must be not less than 75 ms (see also Recommendations Q.412 and Q.475).

Criterion c) (end-of-pulsing) can be applied only if the incoming R2 register is equipped to receive the 6 forward signalling frequencies (see also Recommendation Q.473). When signal I-15 is received and recognized the last incoming R2 register can perform in the way described under criterion a).

When criterion d) (time-out) is applied:

Address-complete signal A-6 must be sent in pulse form as soon as the specified time has elapsed. The time between the end of signal A-6 and the start of transmission of the subsequent answer signal must be, as indicated above for criterion b), not less than 75 ms (see also Recommendations Q.412 and Q.472).

It may happen, however, that the called subscriber answers before the specified time has elapsed. In such exceptional circumstances the pulse signal A-6 must be sent immediately the answer signal is recognized. In this case the time between the end of signal A-6 and the start of the transmission of the subsequent answer signal must be 75 ms or more but less than 150 ms. The calling subscriber will not hear the ringing tone.

This disadvantage can be avoided by not using a received digit to set up the call until after the following digit has been received or until a certain time has elapsed. This procedure, however, may give rise to difficulties if the time-out devices provided in the switching equipment succeeding the incoming R2 register are set for too short a delay [see also Recommendation Q.120, 1.5.5.2 b) iv)].

5.3.2.2 Congestion

An incoming R2 register should terminate interregister signalling immediately any conditions preventing complete setting-up of a call have been recognized.

If congestion is encountered congestion signal A-4 is sent, possibly in pulse form. However if address-complete signal A-3 has already been sent then congestion signal B-4 is sent in acknowledgement of the Group II signal which commences the last compelled signalling sequence.

Recommendation Q.472

5.3.3 AT THE LAST INCOMING R2 REGISTER SITUATED IN A TRANSIT EXCHANGE

5.3.3.1 Successful routing

Interregister signalling to such a register can be terminated after all the address digits are received. In order to determine that the number is complete the same criteria as described in Recommendation Q.471 are used.

When criterion *a*) (analysis) is applied:

- 1) if the signalling system employed on the outgoing link enables the condition of the called subscriber's line to be sent backwards within an acceptable period compared to the time-out of the outgoing international R2 register, the last incoming R2 register can react in accordance with one of the following methods:
 - i) address-complete signal A-3 is sent in acknowledgement of the last address digit followed by the relevant Group B signal depending upon the condition of the called subscriber's line;
 - ii) signal A-1 is sent in acknowledgement of the last address digit, and signal I-15 if received, to deliberately suspend compelled signalling and later,
 - when the condition of the called subscriber's line is known, address-complete signal A-3 is sent in pulse form followed by the relevant Group B signal. This makes it possible to avoid maintaining on-line the Group II signal sent after reception of signal A-3,
 - when the called subscriber's line is free, it is preferable to send the address-complete signal A-6 in pulse form,
- 2) if the signalling system employed on the outgoing link does not enable the condition of the called subscriber's line to be transmitted backwards or if such information is only available at the last incoming R2 register after a delay incompatible with the time-out of the outgoing international R2 register, then address-complete signal A-6 is sent in acknowledgement of the last address digit.

When criterion *b*) (electrical conditions) is applied:

Only signal A-1 can be used to acknowledge each address digit. Upon receipt of an electrical signal on the outgoing link, the last incoming R2 register acts in one of the following ways:

- if the condition of the called subscriber's line is not known or is known to be *free*, address-complete signal A-6 is sent in pulse form;
- if the condition of the called subscriber's line is known to be other than *free*, address-complete signal A-3 is sent in pulse form, followed by the relevant Group B signal.

Criterion *c*) (end-of-pulsing) is only applicable if the last incoming R2 register can receive 6 forward signalling frequencies (see also Recommendation Q.473). In this case, when end-of-pulsing signal I-15 is received and recognized, the last incoming R2 register can perform in the way described under criterion *a*).

When criterion *d*) (time-out) is applied:

Address-complete signal A-6 is sent in pulse form after the specified time has elapsed (see Recommendation Q.476).

5.3.3.2 Congestion

If congestion is encountered, the procedure described in Recommendation Q.470 is followed. However, if address-complete signal A-3 has already been sent then congestion signal B-4 is sent in acknowledgement of the Group II signal which commences the last compelled signalling cycle.

Recommendation Q.473

5.3.4 USE OF END-OF-PULSING SIGNAL I-15 IN INTERNATIONAL WORKING

In international working, the end-of-pulsing signal I-15 is used in accordance with Recommendation Q.468. Signal I-15 (end-of-pulsing) is sent immediately after the last digit (see Table 7).

In national working, signal I-15 may be used too.

In semi-automatic operation, calls to operators' positions are always terminated by transmission of signal I-15. This signal can only be interpreted if the incoming R2 register is equipped for reception of 6 forward frequencies. However, when an incoming R2 register is equipped for reception of only 5 forward signalling frequencies no provision can be made for recognition of signal I-15. Such an incoming R2 register will then act as though signal I-15 had not been sent. Consequently the next interregister signal is only one of the signals A-3, A-4 or A-6 sent in pulse form.

5.3.4.1 *Procedures to be followed after receipt of end-of-pulsing signal I-15 by the last incoming R2 register (situated in a transit exchange or in the exchange to which the called subscriber is connected)*

Incoming R2 registers equipped for the reception of all 6 forward signalling frequencies can acknowledge receipt of the end-of-pulsing signal I-15 by sending an appropriate backward signal to complete the compelled signalling cycle. Interregister signalling is terminated according to the procedures specified in Recommendations Q.471 or Q.472 when criterion a) (analysis) is applied.

In particular, if the last incoming R2 register acknowledges signal I-15 with signal A-1 the outgoing international R2 register will not send any signal and the incoming R2 register can only send one of signals A-3, A-4, A-6 or A-15 in pulse form.

Since there is no compulsion to equip incoming R2 registers in national exchanges with receivers for all 6 forward signalling frequencies, the signal I-15 sent by an outgoing international R2 register may not be recognized by the incoming R2 register. In such cases other criteria can be used to determine whether the number received by the incoming R2 register is complete.

When the incoming R2 register determines that the number received is complete using criteria other than c) (end-of-pulsing) it may be that the last digit of the subscriber number is acknowledged by signal A-3, A-4, A-6 or A-15. In this case interregister signalling is terminated without request for the signal I-15, in the normal way according to the procedures specified in Recommendations Q.471 or 472 (a compelled signalling cycle including signal I-15 is saved).

5.3.4.2 *Procedure to be followed after receipt of signal I-15 by an incoming R2 register situated in a transit exchange*

Signal A-1, A-2, A-7, A-8, A-11 or A-12 may be sent in acknowledgement of signal I-15 (end-of-pulsing). However, at a transit exchange precautions are necessary to avoid acknowledgement of signal I-15 before the signalling system employed on the outgoing link has been identified. If signal A-1 is sent in acknowledgement of signal I-15 and if the outgoing link employs System R2, it is not then possible to send backward signal A-2, A-7, A-8, A-11 or A-12 after the end of the compelled signalling cycle because these signals cannot be sent in pulse form. Therefore end-to-end signalling to the next exchange is no longer possible.

Recommendation Q.474

5.3.5 USE OF GROUP B SIGNALS

Group B signals are used to transmit information about the condition of switching equipment in the incoming exchange or the called subscriber's line, to the outgoing international R2 register, which can then take the necessary action.

The address-complete signal A-3 is sent by an incoming R2 register to announce changeover to sending Group B signals. In addition, signal A-3 indicates that the incoming R2 register has received all the Group I forward signals it requires from the outgoing international R2 register. On recognition of signal A-3 an outgoing R2 register sends a Group II signal. The incoming R2 register may interpret the Group II signal giving information about calling party's category, in order to control the switching operations accordingly (e.g. suppression of automatic ringing for operator initiated calls or to prevent subscriber access to data transmission terminals). Finally, a Group II forward signal is acknowledged by any Group B backward signal.

In cases where outgoing R2 registers are able to interpret all Group B signals there is generally no need to provide equipment at the incoming end able to send, in addition to Group B signals, the tones and/or announcements corresponding to those signals, except in the case of ringing tone.

In general, outgoing R2 registers must be equipped with devices permitting, after reception of signal A-3:

- the exchange of an additional cycle of interregister signals before the register is released;
- changeover from Group A to Group B meanings of backward signals.

Outgoing international R2 registers, however, must be able to interpret all Group B signals.

5.3.5.1 *Procedures to be followed by an outgoing international R2 register on receipt of Group B signals*

Signal B-1 is interpreted by an outgoing international R2 register as signal B-6: the register is released and the speech-path is through-connected. A subsequent answer signal initiates call charging.

Signal B-2 send special information tone is sent by the incoming R2 register:

- when the number of the called party has been changed,
- when the three following conditions are fulfilled together:
 - i) the called party's line condition does not fit with one of the meanings of the present Group B signals,
 - ii) it does not lead to setting up the speech path,
 - iii) it is not incompatible with return of special information tone to the calling party.

After recognizing signal B-2, the outgoing international R2 register clears forward and causes the transmission of only special information tone.

The subscriber's line busy signal B-3 is sent by the incoming register when the called subscriber's line is engaged. On recognition of this signal, the outgoing register releases the connection and causes transmission of the busy tone.

When the congestion condition is encountered following the changeover from Group A signals to Group B signals, the congestion signal B-4 shall be transmitted on the conditions specified for congestion signal A-4. In all cases recognition of the signal causes release of the call and transmission of congestion information.

After recognizing unallocated number signal B-5, the outgoing international R2 register clears the call and causes transmission of special information tone or a recorded announcement and special information tone, alternately, to the calling party.

After recognizing signal B-6, the outgoing international R2 register sets up speech conditions so that a caller may hear the ringing tone. In this case, a subsequent answer signal activates the call-charging mechanism.

After recognizing signal B-7 the outgoing international R2 register sets up speech conditions, so that a caller may hear the ringing tone. In this case, a subsequent answer signal does not activate the call-charging mechanism. However, in an outgoing international R2 register signal B-7 may be interpreted as B-6 if there is no international agreement on non-chargeable calls.

After recognizing signal B-8 subscriber's line out of order, the outgoing international R2 register clears forward and causes the transmission of a special information tone or recorded announcement and special information tone alternately to the calling party.

Receipt of signal B-9 or B-10 by an outgoing international R2 register causes release of the outgoing connection and return of special information tone to the calling subscriber, i.e. these signals should be interpreted as signal B-2.

If an outgoing international R2 register receives one of signals B-11 to B-15 the call should be released and indication of this returned to the calling subscriber or operator, i.e. this signal should be interpreted as signal B-4.

5.3.5.2 *Special procedures for national working*

Outgoing R2 registers in national exchanges may not be able to recognize and interpret Group B signals. In such networks it is essential that the equipment at the incoming end must transmit not only the Group B signals but also the corresponding tones and/or announcements, when the incoming R2 register does not know whether the outgoing R2 register is capable of interpreting Group B signals.

In the case where the incoming R2 register is able to make only two or three distinctions of conditions of the called subscriber's line the following procedure may be adopted: When the only distinction that can be made is between subscriber line free and subscriber line engaged,

- i) signal B-3 is sent if the line is engaged;
- ii) otherwise signal B-6, or signal A-6 alone is sent so the caller can hear the ringing tone sent by the incoming equipment.

In the case where outgoing R2 registers in national exchanges are only able to interpret a limited number of Group B signals or are indeed not able to interpret any, it is essential that such equipment be able to respond to signal A-3 in the specific manner and at least to recognize the next backward signal (which is a Group B signal) as indicating the end of interregister signalling.

5.3.5.3 *Possible application of signal B-1 in national working*

Signal B-1, for example, may be used to indicate that the call must remain under the control of the incoming equipment, insofar as this is possible (e.g. for maintenance reasons, to trace malicious calls, etc.). The incoming exchange sets up speech conditions, so that the calling subscriber can hear the ringing tone. At present such a use of signal B-1 in international working is not envisaged.

Recommendation Q.475

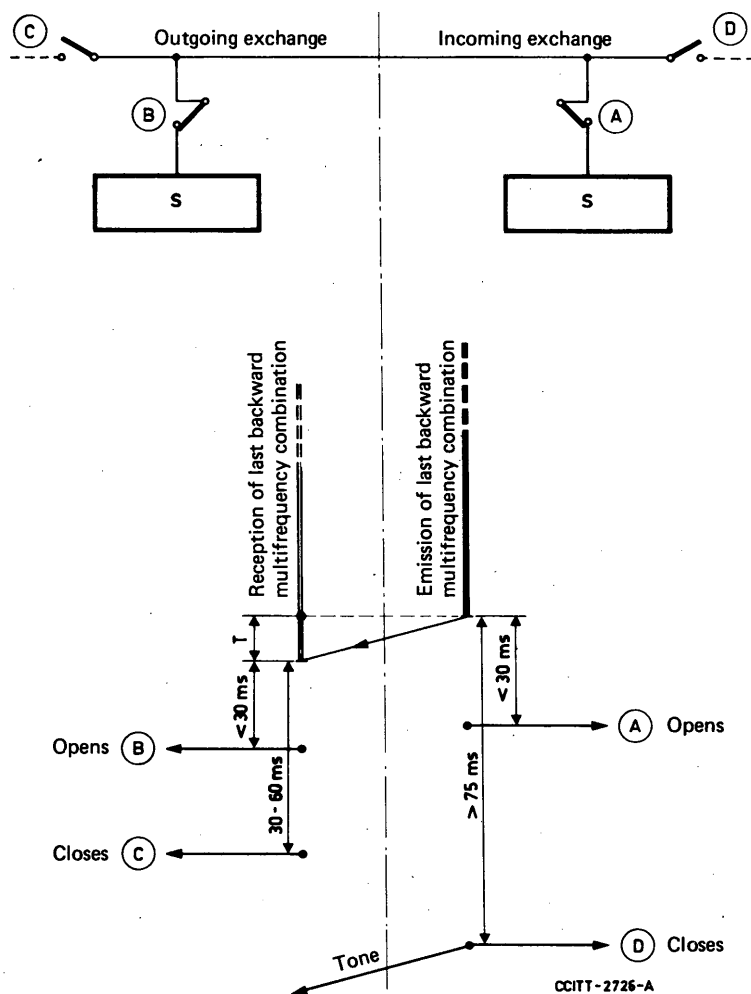
5.4 NORMAL RELEASE OF OUTGOING AND INCOMING R2 REGISTERS

An outgoing international R2 register must be released once it has received an appropriate backward interregister signal terminating the interregister signalling, or on receipt of a clear-forward (line) signal from the preceding link.

An incoming R2 register must be released once it has accomplished the necessary switching control and terminated the interregister signalling required, or on receipt of a clear-forward (line) signal from the preceding link.

The last recognized interregister signal preceding setting up of speech conditions will normally be a backward signal: e.g. address-complete signal A-6, subscriber's line free signals B-6 or B-7.

The multifrequency combination receivers at the two ends must be disconnected before the switching equipment passes to the speech condition; this procedure eliminates any possibility of their operating or being held under the influence of speech or line signals. The following conditions regarding the duration of the various phases should be observed (see Figure 21/Q.475).



T = transmission delay + recognition time for the disappearance of the last backward multifrequency combination
S = multifrequency signalling equipment (see Recommendation Q.451)

FIGURE 21/Q.475 – Disconnection of multifrequency signalling equipment and switching to the speech position

- the multifrequency signalling equipment of the incoming R2 register must be disconnected within 30 ms after recognition of the end of transmission of the last backward signal;
- the multifrequency signalling equipment of the outgoing R2 register must be disconnected within 30 ms after recognition of the end of the last backward signal;
- at the outgoing exchange speech conditions must be set up between 30 and 60 ms after recognition of the end of the last backward signal. However, at the exchange where the outgoing international R2 register is situated, the setting-up of speech conditions depends upon the signalling system employed on the preceding link;
- at the incoming exchange at least 75 ms must elapse between the end of transmission of the last backward signal and the setting up of speech conditions.

Recommendation Q.476

5.5 ABNORMAL RELEASE OF OUTGOING AND INCOMING R2 REGISTERS

To limit the holding time of R2 registers, when interregister signalling is interrupted either by a fault or by any other cause, all R2 registers must be equipped with devices for continuous supervision of the time taken by the various phases of interregister signalling. The time-out delay of these devices must be as short as possible, but long enough not to interrupt normal operation.

5.5.1 *Time-out of outgoing international R2 register*

In an outgoing international R2 register, the intervals during which a forward multifrequency combination is transmitted and the intervals during which no such combination is transmitted are supervised separately.

5.5.1.1 *Supervision during sending of forward multifrequency combinations*

The lower limit of the time-out delay is a function of the time required for the switching procedures in a transit exchange.

On this basis, the time-out delay is specified as 15 ± 3 seconds.

The supervision device will start functioning at the beginning of the transmission of a forward multifrequency combination and be reset with the deactivation of the senders involved. It will start again at the beginning of the transmission of the next forward multifrequency combination.

5.5.1.2 *Supervision during intervals when no forward multifrequency combination is being sent*

The lower limit of the time-out delay is a function of:

- a) the maximum permissible time interval between dialling of two successive digits by the subscriber;
- b) the time-out delay specified for incoming R2 registers (see 5.5.2 below).

On this basis, the time-out delay is specified to be longer than 24 seconds (a longer delay and an upper limit may be specified by each Administration).

If this specification is observed an incoming R2 register, which has acknowledged the last received digit with the signal A-1, is bound to be released before the supervision device of the outgoing international R2 register initiates the alarm condition.

5.5.1.3 *Procedure to be followed if time-out occurs*

If time-out occurs, the time supervision devices mentioned in 5.5.1.1 and 5.5.1.2 above will bring about operations producing:

- return of an appropriate signal and/or audible tone to inform the calling party,
- release of the outgoing international R2 register and of the connection as far as the latter is not necessary for the above-mentioned operation.

Fault recording equipment may start functioning and/or a delayed alarm may alert the technical staff.

5.5.1.4 *Time-out of outgoing R2 register*

It is recommended that the same principles outlined in 5.5.1.1 to 5.5.1.3 above be applied by analogy to outgoing R2 registers in the national network.

5.5.2 *Time-out of incoming R2 register*

The time-out device shall supervise the interval elapsing between seizure of the register and recognition of the first forward multifrequency combination as well as the interval elapsing between the recognition of two successive multifrequency combinations in the forward direction.

5.5.2.1 *Time-out delay*

The lower limit of the time-out delay is a function of:

- a) the maximum permissible time interval between the recognition of 2 successive forward multifrequency combinations; this time interval may in certain cases be influenced by the maximum permissible time interval between dialling of 2 successive digits by the subscriber;
- b) the maximum time required for setting-up the call under conditions which slow down the interregister signalling.

In view of the desirability expressed in 5.5.1.2 above that the incoming R2 register be released before expiry of the time-out delay specified for the outgoing international R2 register, an upper limit should be fixed as well.

On this basis the time-out delay should be specified within the range of 8-24 seconds. A minimum delay of 15 seconds corresponding to the time-out delays in other CCITT standardized systems is to be preferred.

For incoming R2 registers using the criterion *d*) (time-out) indicated in Recommendation Q.471 to determine completion of the number, the time referred to there as the *specified time* may exceptionally be shorter than 8 seconds, but never less than 4 seconds.

5.5.2.2 *Procedure to be followed if time-out occurs*

If time-out occurs, the time supervision device will bring about operations producing:

- sending of a congestion signal (A-4 or A-15) in pulse form;
- release of the incoming R2 register and other equipment in the incoming exchange;
- establishment of the blocked condition of the incoming circuit until the clear-forward signal is received (see Recommendation Q.412, abnormal conditions).

Fault recording equipment may start functioning and/or a delayed alarm may alert the technical staff.

Recommendation Q.478

5.6 RELAY AND REGENERATION OF R2 INTERREGISTER SIGNALS BY AN OUTGOING R2 REGISTER IN A TRANSIT EXCHANGE

When the overall multi-link connection is divided into end-to-end signalling sections, regeneration of R2 interregister signals is required by either an outgoing international R2 register or an outgoing R2 register (see Recommendation Q.440).

There are three possible procedures for relaying interregister signals by an outgoing R2 register:

- a) the outgoing R2 register acknowledges each signal received over the incoming link by transmitting the appropriate backward signal; this operation is independent of the operations entailed in retransmitting on the outgoing link.
- b) the forward address signal with rank $n + 1$ is acknowledged on the incoming link as soon as the forward address signal with rank n is acknowledged on the outgoing link.
- c) as soon as a forward signal is received on the incoming link, a signal is sent on the outgoing link; the acknowledgement signal is sent on the incoming link only when such a signal has been received on the outgoing link.

Methods *a)* and *b)* provide the most rapid transfer of information and are therefore the preferable methods of relaying the information necessary for setting up the call. It is essential, however, that the outgoing R2 register be provided with adequate storage capacity in the case of method *a)*.

Method *b)* can only be applied after method *a)*.

Method *c)* should be used for relaying information relating to the procedures for the termination of interregister signalling.

The changeover from method *a)* or *b)* to method *c)* may require transmission of an address-complete signal A-3 in pulse form as indicated in Recommendation Q.442 (see Figure 22/Q.478).

The procedure for disconnecting the multifrequency combination receivers and setting-up speech conditions for each link, incoming and outgoing, is given in Recommendation Q.475.

When method *a)* or *b)* is used the time-outs of the R2 registers associated with the first signalling section may expire if the signalling on the second signalling section is too slow. Relatively long time-outs are recommended (see Recommendation Q.476).

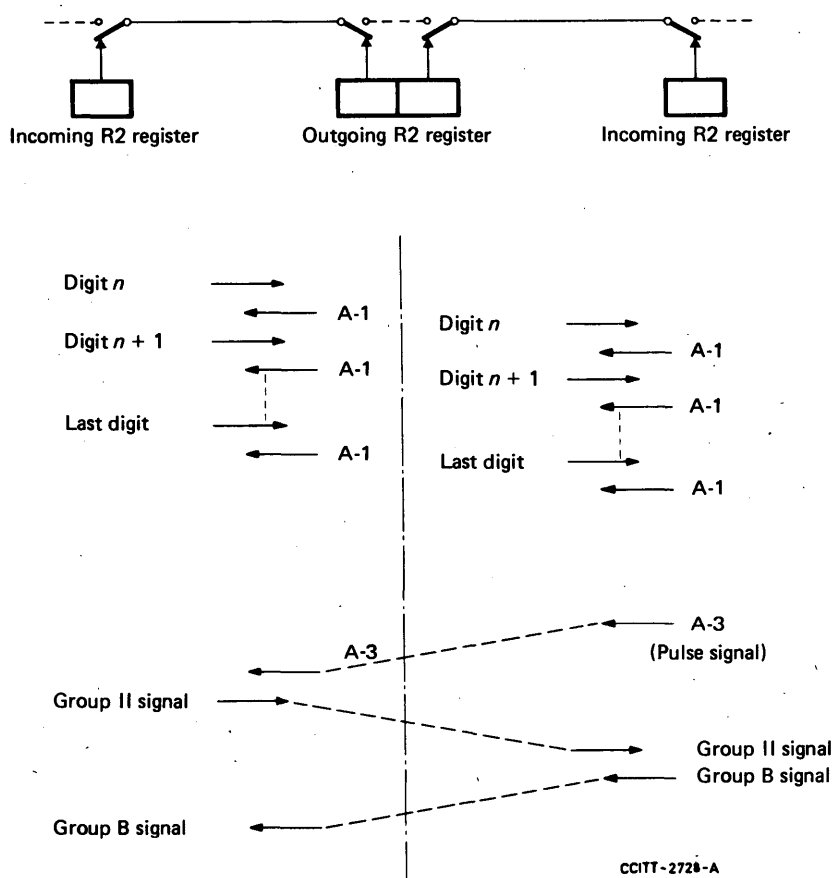


FIGURE 22/Q.478 – Sequence of interregister signals in an outgoing R2 register when the incoming link employs System R2

Recommendation Q.479**5.7 ECHO-SUPPRESSOR CONTROL – SIGNALLING REQUIREMENTS****5.7.1 Introduction**

Recommendations Q.42 and Q.115 give fundamental requirements that the insertion of echo-suppressors must comply with.

In System R2 (see Recommendation Q.441) two forward signals (I-12 and I-14) and one backward signal (A-14) are provided to indicate whether or not an incoming half-echo suppressor (IHES) is required.

A third forward signal (I-11) is also available for use by bilateral agreement to indicate that an outgoing half-echo suppressor (OHES) must be inserted.

The following principles must be taken into account:

5.7.2 Principles of echo-suppressor control

5.7.2.1 The outgoing international exchange can determine the need for echo-suppressors in the connection by analysing the received country code.

5.7.2.2 In direct traffic between 2 countries the insertion of echo-suppressors generally takes place according to fixed rules. Echo-suppressor control signalling is not, therefore, necessary in these cases, unless it is applied for the sake of uniformity.

5.7.2.3 In international transit traffic the outgoing half-echo suppressor (OHES) will be inserted by the outgoing international exchange, and the incoming half-echo suppressor (IHES) by the incoming international exchange, unless other arrangements are agreed upon with the Administration of the international transit exchange(s) (see 5.7.2.5 below).

5.7.2.4 An incoming international exchange, equipped for the insertion of IHES, must ask the outgoing international exchange whether or not an IHES must be inserted unless this is known from other criteria (e.g. line classification). It will do this by sending the backward signal A-14 as an acknowledgement of the discriminating or language digit (Z-digit).

5.7.2.5 It may be agreed upon bilaterally that in international transit traffic the OHES (IHES) will not be inserted in the outgoing (incoming) international exchange, but in the international transit exchange, e.g. in the case where most of the traffic on the circuit group between the outgoing exchange and the transit exchange (between the transit exchange and the incoming exchange) needs no echo-suppressor.

- a) When echo-suppressors are needed and the OHES must be inserted by the international transit exchange the outgoing international exchange sends the signal I-11 as a country code indicator.

If an international connection is routed via two or more transit exchanges, signal I-11 must not be sent beyond the first transit exchange. Therefore the outgoing exchange, after having sent the signal I-11 once, must send the signal I-14 if the country code indicator is requested again (signal A-11).

- b) When echo-suppressors are needed and the IHES must be inserted by the international transit exchange this is known by the international transit exchange. In this case the incoming international exchange will not send signal A-14.

5.7.2.6 After the echo-suppressors have been inserted, they will remain disabled until the answer signal is received. This condition is necessary in order to permit compelled interregister signalling to (e.g. national) exchanges further on in the connection.

5.7.3 Examples of echo-suppressor control signalling

In normal cases the following situations may arise:

5.7.3.1 Direct interregister signalling between two countries A and B

- a) No echo-suppressor control signalling is applied.

The signalling procedure is indicated in Table 9, column a. If echo-suppressors are necessary, the OHES is inserted in A and the IHES is inserted in B.

b) Echo-suppressor control signalling is applied.

There are two cases:

- (i) No echo-suppressors are required (see column b of Table 9).
- (ii) Echo-suppressors are required (see column c of Table 9). The OHES is inserted in A and the IHES is inserted in B.

5.7.3.2 Traffic between two countries A and D via two international transit exchanges B and C

There are two cases:

- a) No echo-suppressors are required (see column a of Table 10).

TABLE 9 – Signalling procedure on direct connections

A ————— B	a	b	c
Seizing —————>			
Z-digit —————>			
←—————	A-1	A-14	A-14
—————>	N1	N1	I-14
←—————	A-1	A-1	A-1
—————>	N2	N2	N1
Echo suppressor inserted	YES/NO	NO	YES

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TABLE 10 – Signalling procedure on international transit connections

A — B — C — D	a	b	c	d	e
Seizing —————>					
Country code indicator —————>	I-12	I-14	I-11	I-14	I-11
← A-1					
← I-1					
← A-1					
← I-2					
← A-11 —————> Seizing					
Country code indicator —————>	I-12	I-14	I-14	I-14	I-14
← A-1					
← I-1					
← A-1					
← I-2					
← A-12 —————> Seizing					
Z-digit —————>					
←—————	A-14	A-14	A-14	A-1	A-1
—————>	N1	I-14	I-14	N1	N1
←—————	A-1	A-1	A-1	A-1	A-1
—————>	N2	N1	N1	N2	N2
Echo suppressors in	—	A,D	B,D	A,C	B,C

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b) Echo suppressors are required (see columns b, c, d, e of Table 10).

The following examples may be mentioned:

- OHES in A; IHES in D (column b);
- OHES in B; IHES in D (column c).

The country code indicator I-11 is used by bilateral agreement and indicates that B must insert the OHES. When the country code indicator is to be sent to C, B asks A to do this by sending signal A-11. A now sends signal I-14 instead of Signal I-11, because B has inserted to the OHES. The signal A-14, which is sent from D as an acknowledgement of the Z-digit will, of course, also be answered by signal I-14.

- OHES in A; IHES in C (column d).

In accordance with item 5.7.2.5 b) above C knows that D cannot insert an IHES and C itself will therefore make the insertion. D will naturally not send signal A-14;

- OHES in B; IHES in C (column e).

Recommendation Q.480

5.8 MISCELLANEOUS PROCEDURES

5.8.1 *Identification procedures for international working*

An incoming R2 register in an international transit exchange or in the country of destination can elicit the location of an outgoing international R2 register as soon as at least one forward signal has been received from that register. Although it is desirable that the outgoing international R2 register be capable of responding with identification information the provision of this function is not mandatory. The identification procedure may be of value for traffic monitoring or other purposes.

The identification procedure is as follows (see Figure 23/Q.480):

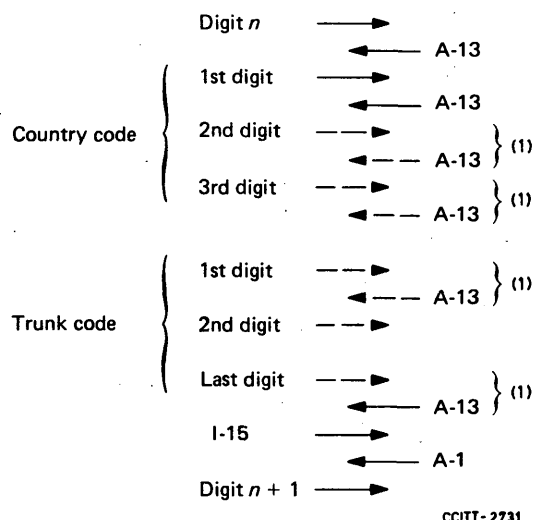
The incoming R2 register requests identification by sending the backward signal A-13. The outgoing international R2 register, if capable, sends the first digit of its country code in reply. A further digit of the country code is sent in reply to each subsequent repetition of signal A-13; further demands expressed through sending signal A-13 will elicit successive digits of the trunk code of the exchange where the outgoing international R2 register may be situated. When all digits required to indicate the location have been sent, the next signal A-13 must be acknowledged by the end-of-identification signal I-15.

The incoming R2 register may finish the identification sequence by sending a backward signal other than signal A-13. The outgoing international R2 register must recognize this signal and respond in accordance with its meaning. If the outgoing international R2 register again receives signal A-13 that signal must be interpreted as a new request and the identification procedure is recommenced.

If the outgoing international R2 register, having sent signal I-15 terminating the identification procedure, again receives signal A-13, that signal must be interpreted as a new request and the identification procedure is recommenced.

Signal A-13 can be sent after any forward signal (Groups I and II) and particularly after any address digit, but it can only be sent prior to any transmission of signal A-3. If, however, the identification procedure is started after the digit completing the called subscriber's number has been sent, it may happen that the called subscriber answers before the identification is complete. In that case all interregister signalling procedures must be terminated immediately and speech conditions must be set-up as specified in Recommendation Q.475.

If the outgoing international R2 register does not have the capability of providing the identification facility, signal I-12 (request not accepted) is sent in reply to signal A-13. The incoming R2 register will then ask for the following address digit by sending signal A-1, for example. If the outgoing international R2 register receives signal A-13 again it will send signal I-12 again.



Note (1). — This sequence may not be necessary.

FIGURE 23/Q.480 — Transmission of the digits identifying the location of an outgoing international R2 register

5.8.2 Identification procedure for national working

System R2 makes provision for the signalling necessary to identify the calling subscriber's number: for example, by repetition of signal A-5 or by using one of signals A-9 or A-10. For the time being this procedure is restricted to national working only; outgoing international R2 registers prevent its use over international links (see 5.8.4).

5.8.3 Processing of Group II signals reserved for national use

The Group II signals reserved for national use must be converted in the outgoing international R2 register to Group II signals used for international working.

The conversion must be carried out as follows:

- II-1 must be converted to II-7
- II-2 must be converted to II-7 or II-9
- II-3 must be converted to II-7
- II-4 must be converted to II-7
- II-5 must be converted to II-7 or II-10
- II-6 must be converted to II-8
- II-11 to II-15 must be converted to II-7.

Since there are no Recommendations yet regarding handling of priority calls in automatic international working, conversion of signal II-2 to signal II-9 must be the subject of bilateral agreement.

If an incoming R2 register is situated in a national exchange and because signals II-7 to II-10 are not used for national working, then analysis of Group II signals enables a distinction to be made between nationally and internationally originated calls.

If an incoming R2 register knows a call is of international origin and if a Group II signal reserved for national use is received, signal A-4 or B-4 (congestion on the national network) should be sent in acknowledgement. This procedure cannot be applied if an incoming R2 register in the destination country is employed for national and international working.

5.8.4 *Procedures to be followed by outgoing international R2 registers on receipt of particular backward signals*

An outgoing international R2 register must send the appropriate calling party's category signal (II-7 to II-10) in reply to signals A-3 and A-5.

On recognition of one of the signals A-9 or A-10 an outgoing international R2 register sends signal I-12 (request not accepted) in response. Therefore, national incoming R2 registers using these signals should be equipped to receive signal I-12.

The incoming national R2 register receiving I-12 has to determine the appropriate international standardized signal to be sent in response to signal I-12 and which substitutes for signals A-9 or A-10.

In reply to signal A-14 an outgoing international R2 register sends:

- signal I-14 when an incoming half-echo suppressor is required;
- the next address digit (a signal I-1 to I-10) when no incoming half-echo suppressor is required.

If an outgoing international R2 register receives a backward signal requesting an impossibility in the logical procedure (e.g. receipt of signal A-8 after sending the country code indicator), the call shall be released.

ANNEX 1

(to Signalling System R2 specifications)

(see Recommendations Q.400 and Q.441)

Provision of a forward-transfer signalling facility

1. *General*

The System R2 does not provide a forward-transfer line signal. However for certain relations it may be decided by bilateral or multilateral agreement to introduce the forward-transfer signalling facility into System R2.

One possible procedure that has been adopted for use within Europe, is to use the PYY in-band signal of System No. 4. This solution is only economical in regions where the facility is needed for a small proportion of the calls.

For international working the method as described below may be followed.

Note. — The method given in this Annex may also be adopted in national networks where the forward-transfer facility is considered necessary for trunk offering and recalling operators. However, care must be taken to see that the transmission limits applying to the forward-transfer signal specified are observed.

2. *Method recommended for introducing the forward-transfer signalling facility into System R2*

Forward-transfer signalling will be provided by means of special equipment which uses in-band signalling and which is switched only on to those connections which may require this facility. The amount of special equipment necessary can, accordingly, be reduced to a minimum and adapted, in a flexible manner, to actual needs. The in-band signal constituting the forward-transfer signal is sent end-to-end between the outgoing and incoming international exchanges. When the special equipment receives the forward-transfer signal, it performs the necessary operations at the incoming exchange.

2.1 *Access to the special equipment in an incoming international exchange*

In an incoming international exchange access to the special equipment for forward-transfer signalling can be determined by the use of the following indicators:

- 1) Special marking of incoming routes on which forward-transfer signalling is used.
- 2) Language digit indicating semi-automatic traffic.
- 3) Calls for code 11 or code 12 operator.
- 4) Special interregister signalling sequence in which the incoming exchange sends signal A-5, *send calling party's category*. If the forward-transfer signalling facility is required the outgoing R2 register will respond to this by sending the signal II-10. This signal indicates an operator – initiated call on which special equipment for forward-transfer signalling is needed.

The use of these indicators will depend on the amount of traffic for which forward-transfer signalling is employed. In some cases one or two of the indicators will be utilized. In others, combinations of all will be used to reduce to a minimum the amount of special equipment required.

2.2 *In-band forward-transfer signalling*

In System R2 the in-band forward-transfer signal is the same as that used in System No. 4. For the definition of this signal see Recommendation Q.120, 1.12. The signal is the signal PYY defined in Recommendation Q.121, 2.3. The forward-transfer signal is sent in accordance with Recommendations Q.122 and Q.124.

The signal receiver and the splitting arrangements to be incorporated in the special equipment at the incoming international exchange are in accordance with Recommendations Q.123 and Q.124.

Provided it creates no difficulty for incoming national network signalling, no splitting need be effected at the receiving end and the caller will then hear the entire signal PYY.

ANNEX 2

(to Signalling System R2 Specifications)

(see Recommendations Q.441 and Q.470)

A procedure for sending further information on conditions at the incoming end after the congestion signal A-4 has been transmitted

Information concerning the reason for transmission of signal A-4 may in certain cases be useful in the outgoing R2 register for rerouting, maintenance, or other purposes.

Administrations desiring to apply, in their national network, a procedure for sending such information to the outgoing R2 register are recommended to follow the specifications below.

When an outgoing R2 register, on recognizing signal A-4, desires extra information, the signal I-14 is sent in the forward direction as soon as the signal A-4 has ceased. If the incoming R2 register is able to supply the information required it will do so by sending a Group C signal in acknowledgement. This signal then terminates interregister signalling.

Group C represents the third meaning of the backward signals. Since the use of Group C signals is purely national, it is for each Administration to specify their significance.

The following meanings may be allocated to Group C signals:

- congestion of switching equipment at different centres of the hierarchic network;
- congestion of circuit groups;
- command to use another (specific) route;
- time-out in an incoming R2 register (see Recommendation Q.476);
- technical fault;
- other reasons for sending the signal A-4.

Because it is not obligatory for incoming R2 registers to act as described above it is recommended that the duration of the signal I-14 be limited to 150 ± 50 ms.

An incoming R2 register which is designed for the transmission of Group C signals must remain connected after the end of the signal acknowledged by A-4. If the signal I-14 is not received within 225 ± 75 ms after the end of signal A-4, it is assumed that the outgoing R2 register desires no further information and the incoming R2 register is dismissed.

The facility described above is not specified for international working. Therefore an outgoing international R2 register, on recognizing signal A-4, must not send signal I-14.

ANNEX 3

(to Signalling System R2 Specifications)

(see the introduction)

Use of Signalling System R2 on satellite links

1. *Model used for international application of System R2 on satellite links*

In order to evaluate the possible use of System R2 on satellite links, a generally applicable model for international working was elaborated. The model is based on the availability of System R2 in both national originating and destination networks.

The international section consists of a pre-assigned satellite link, with an extra outgoing R2 register — held during call set-up — at the incoming exchange B (see Figure 24). This avoids the repeated transmission of address digits via the satellite.

Figure 24 outlines the network model and shows the digits transferred for different situations.

The studies performed so far show that System R2 will work satisfactorily under the conditions given by this model. For different applications the relevant circumstances and parameters must be carefully considered and calculations should be performed for each case in order to determine whether or not System R2 is also suitable there.

2. *Line signalling for System R2-satellite links*

2.1 *General*

There are two possibilities specified of transmitting the line signals of signalling System R2, viz.:

- i) by means of the low level continuous tone-on-idle signalling method (-20 dBm0);
- ii) as far as PCM circuits are concerned a digital version has been specified which uses channel No. 16 of PCM multiplex equipment according to Recommendation G.732.

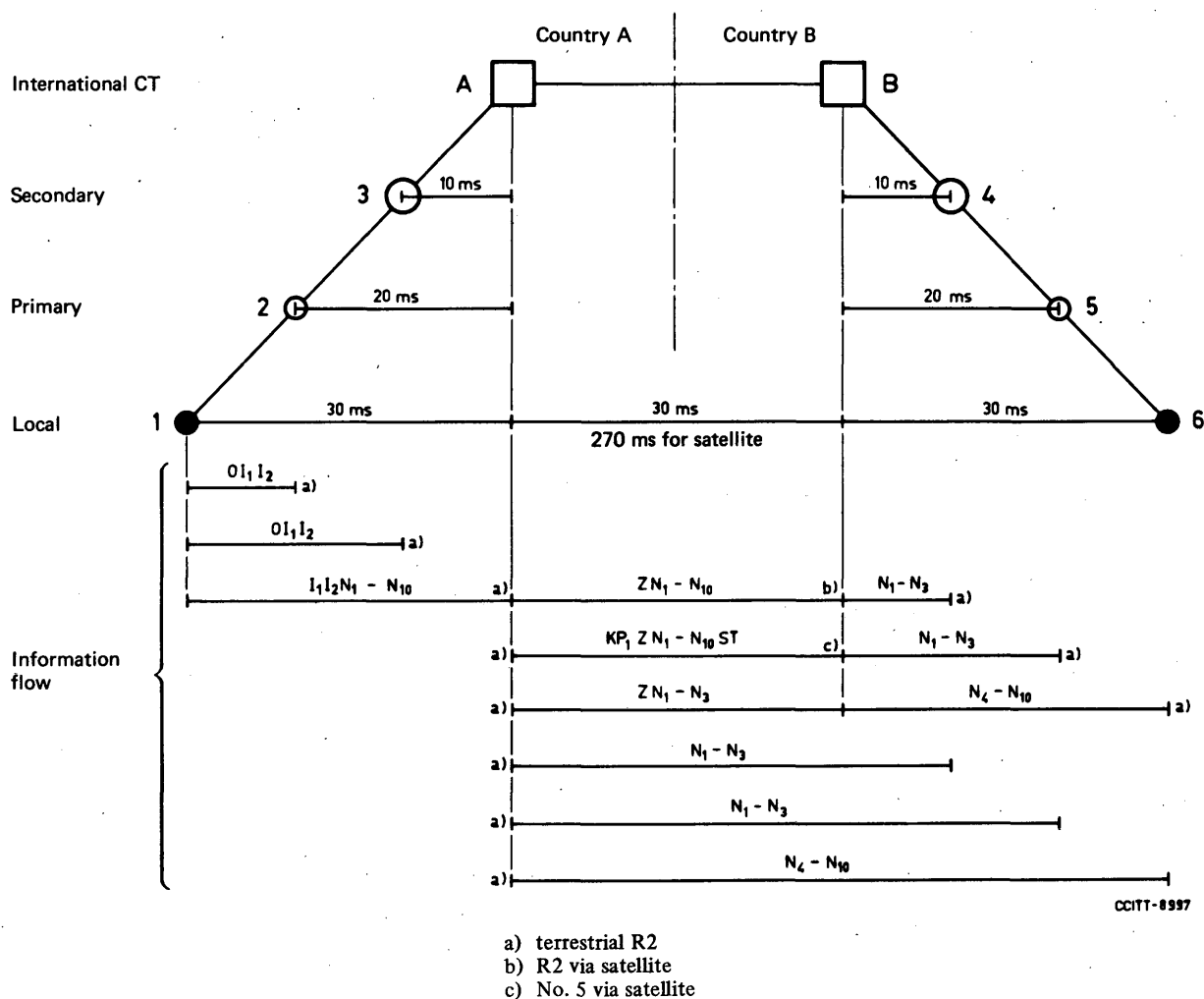


FIGURE 24 – Model for calculation of post dialling delay

The digital version does not need to be changed for satellite applications, because two signalling channels in each direction are available and thus the propagation delay t_p is of no consideration.

In 2.2 below the modifications necessary for the adaption of the existing analogue version of System R2-line signalling for long propagation delay are shown.

2.2 Modifications in the existing analogue version System R2-line signalling for satellite application (release and release-guard operating conditions)

Recommendation Q.412, 2.2.2.6 specifies intervals for the release and release-guard operating conditions:

- i) release prior to answered condition,
- ii) release in answered condition,
- iii) release in clear-back condition.

In Recommendation Q.412, 2.2.2.7 the intervals T_1 and T_2 are indicated for a transmission delay < 30 ms.

These intervals have to be determined anew for satellite circuits. It is assumed that the terminal equipment in the earth station does not require additional internal operating times.

The following is to be assumed for the satellite section:

$$t_{p1} = 270 \pm 20 \text{ ms}$$

and for the terrestrial section:

$$t_{p2} < 15 \text{ ms (outgoing terrestrial section)}$$

$$t_{p3} < 15 \text{ ms (incoming terrestrial section)}$$

Thus, the entire delay amounts to:

$$\begin{aligned} t_p &< t_{p1} \text{ max.} + t_{p2} + t_{p3} \\ &< (290 + 15 + 15) \text{ ms} \\ &< 320 \text{ ms.} \end{aligned}$$

With the formulae and values indicated in Recommendation Q.412, 2.2.2.7, one obtains:

$$\begin{aligned} T_1 &< 2 (t_p + t_0) \text{ max.} + T_r \text{ max.} + t_r \text{ max.} \\ &< (2 \times 350 + 27 + 20) \text{ ms} \\ &< 747 \text{ ms.} \end{aligned}$$

Allowing a safety margin of 53 ms and a tolerance of $\pm 20\%$ one obtains:

$$T_1 = 1000 \pm 200 \text{ ms}$$

$$800 \text{ ms} < T_1 < 1200 \text{ ms.}$$

The value hitherto specified with due regard to the transmission delay $t_p < 30 \text{ ms}$ is $T_1 = 250 \pm 50 \text{ ms}$.

The interval T_2 has been computed for two cases:

- i) $0 < t_p < 320 \text{ ms}$, i.e. the relay sets for System R2 can be used for terrestrial links and for links including a satellite circuit.

$$\begin{aligned} T_2 &< T_1 \text{ max.} + t_r \text{ max.} + t_i \text{ max.} - 2 (t_p + t_0) \text{ min.} - t_p \text{ min.} - t_i \text{ min.} \\ &< (1200 + 27 + 20 - 0 - 13 - 0) \text{ ms} \\ &< 1234 \text{ ms.} \end{aligned}$$

Allowing a safety margin of 36 ms and a tolerance of $\pm 20\%$ one obtains:

$$T_2 = 1600 \pm 320 \text{ ms}$$

$$1280 \text{ ms} < T_2 < 1920 \text{ ms.}$$

The value hitherto specified with due regard to the transmission delay $T_p < 30 \text{ ms}$ is $T_2 = 450 \pm 90 \text{ ms}$.

- ii) $250 \text{ ms} < t_p < 320 \text{ ms}$, i.e. the relays sets for System R2 are to be used for links including a satellite link.

$$\begin{aligned} T_2 &< T_1 \text{ max.} + t_r \text{ max.} + t_i \text{ max.} - 2 (t_p + t_0) \text{ min.} - t_r \text{ min.} - t_i \text{ min.} \\ &< (1200 + 27 + 20 - 2 \times 250 - 13 - 0) \text{ ms} \\ &< 734 \text{ ms.} \end{aligned}$$

Allowing a safety margin of 66 ms and a tolerance of $\pm 20\%$ one obtains:

$$T_2 = 1000 \pm 200 \text{ ms}$$

$$800 \text{ ms} < T_2 < 1200 \text{ ms.}$$

The value hitherto specified with due regard to the transmission delay $t_p < 30 \text{ ms}$ is $T_2 = 450 \pm 90 \text{ ms}$.

Summary

As far as intervals T_1 and T_2 are concerned, line signalling of System R2 can be adapted to the requirements of the satellite links.

2.3 Additional remarks

- a) In principle, System R2 is specified for one-way working. In the case of both-way working of circuits routed over a satellite system the time conditions of Recommendation Q.412, 2.2.5 "Both-way working" have to be amended accordingly.
- b) The analogue version of the line signalling for the System R2 provides means for the interruption control of the transmission bearer, using a group-pilot-supervision. As this feature is essential for the reliable making of the equipment, it has to be provided in any case, even if the number of circuits to be used in the given relation is smaller than the capacity of the concerned multiplex.

3. Interregister signalling

With the fully-compelled System R2 sequence, the digit transfer cycle on a satellite channel is of a duration of 1200 ms which is still within the same range as decadic pulsing. If only the necessary information is transferred at that speed over the satellite channel without the System R2 digit repetition, the impact of the reduced speed on the post-dialling delay is acceptable.

Avoiding the normal digit repetition on the satellite channel requires the incoming exchange serving the satellite link to provide the repetition feature itself. Thus an outgoing R2 register should be used in an incoming exchange to accommodate storage of the digits which can be subject to digit repetition requests. The register relays are the interregister signals as stated in the System R2 specifications with the exception of the backward signals A-2, A-7 and A-8.

In the case of satellite application the guard time for blocking at the recognition of forward signals when sending pulsed type backward interregister signals needs to be increased.

Assuming a maximum overall one-way propagation time of 320 ms the blocking time for signal recognition should be 900 ± 180 ms, including a safety margin of 60 ms and a tolerance of $\pm 20\%$.

The pulse transmission of signals A-4, A-6 and A-15 over signalling sections involving a satellite link do not present any problem because they finally terminate any interregister signalling.

The backward signal sequence A-3, B-n is not generally used at present because electric criteria corresponding to all specified Group B signals are not available in many of the existing national switching systems and recourse is made to signal A-6 instead.

PART IV

Series Q Recommendations (Q.488)

INTERWORKING OF SIGNALLING SYSTEM R2 WITH OTHER STANDARDIZED SYSTEMS

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INTERWORKING OF SIGNALLING SYSTEM R2 WITH OTHER STANDARDIZED SYSTEMS

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Recommendation Q.488

INTERWORKING OF SIGNALLING SYSTEM R2
WITH OTHER STANDARDIZED SYSTEMS

(The specifications of the interworking of Signalling System R2 with other standardized systems form Part XVII of the Series Q Recommendations.)

1. *Introduction*

Since System R2 will be used between international exchanges, it is necessary to specify the interworking of System R2 and other signalling systems standardized by the CCITT.

This is because:

- a) some CTs already equipped with CCITT Systems No. 4 and No. 5 may be equipped with System R2 while retaining and even extending the older systems. At these CTs it will be necessary to provide for interworking between these various systems in order to maintain the existing transit facilities and to establish new ones;
- b) System R2 is not designed for use on TASI or satellite links. These links, which are mainly provided for intercontinental traffic, will be equipped with Systems No. 5, No. 5 *bis* or No. 6. At the CTs where these circuits terminate, provision will have to be made for interworking with System R2.

2. *General*

It is possible to ensure satisfactory operation for both semi-automatic and automatic service when interworking takes place between signalling Systems No. 4, No. 5, No. 5 *bis* and No. 6 and the System R2. This interworking presents little difficulty because in all systems:

- the most important line signals in signalling Systems No. 4, No. 5, No. 5 *bis* and R2 and the corresponding signals in System No. 6 are comparable;
- the sequence of numerical (address) information is in all systems comparable;
- the language digits in the semi-automatic service are the same.

However, when the System R2 interworks with one of the other systems, certain precautions are necessary as some signals are lacking in one system or are used differently in the other. This applies to the following signals:

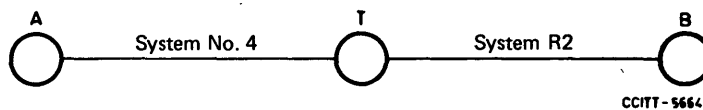
- a) Systems R2 and No. 5 *bis* have several backward interregister signals to indicate register release which also carry information regarding the condition of switching equipment, circuit groups or the called party's line. Systems No. 4 and No. 5 have no backward interregister signals. System No. 4 has only the number-received (line) signal to effect the release of the registers. Systems No. 4 and No. 5 use a line signal to indicate the busy condition.
- b) System No. 5 always sends a forward end-of-pulsing signal (ST), whereas the other systems do not always do so.
- c) The line signals of System R2 exclude the forward-transfer signal (see Recommendation Q.400) and the busy-flash signal.
- d) There are some cases where Systems R2 and No. 5 *bis* convey the same information in different ways. Moreover, these systems do not have the same optional features, e.g. identification of the location of the international outgoing R2 register.

Use of universal registers at the interworking point (T in the following) considerably facilitates interworking.

3. Interworking of System No. 4 with System R2

3.1 Calls from System No. 4 to System R2

3.1.1 Semi-automatic calls



3.1.1.1 Seizure of the link AT causes the seizing signal PY to be sent. T then returns the proceed-to-send signal Y, whereupon A sends numerical signals which T acknowledges by y. These include the end-of-pulsing signal (code 15) which is sent last.

3.1.1.2 After acknowledgement (y) of the end-of-pulsing signal, T sends the number-received signal P (see 3.1.1.5 below) and transmission of this signal must be accomplished under control of System R2 backward signalling before the through-connection of the speech path at T is achieved.

3.1.1.3 As soon as a sufficient number of digits is available in T, routing is effected there and the link TB is seized. T then transmits the address information to B in accordance with the compelled procedure. The end-of-pulsing signal is sent to the exchange B as signal I-15 unless the last digit of the national number has been acknowledged by A-3 or A-6.

3.1.1.4 At B, the forward signal I-15 or the last digit of the national number is acknowledged by one of the following signals:

- a) A-3. — Signal I-15 or the last digit of the national number is then followed by II-7 (or II-10 when the forward transfer signalling facility is provided, see Recommendation Q.400) in the forward direction, which is acknowledged by a Group B-signal in the backward direction. Signals B-3 and B-4 cause the sending of a busy-flash signal over link TA (initiating the release of this link and thereby the subsequent release of link TB); signals B-2, B-5, B-8 to B-10 cause the release of link TB and the return of the special information tone over link TA. Signals B-1, B-6 and B-7 effect the through-connection of the speech path at T. After the reception of signal B-7 a subsequent answer signal is not to be sent over the link TA.
- b) A-4 or A-15, if B is an international transit exchange. — These signals effect the sending of a busy-flash signal over link TA (initiating the release of this link and thereby the subsequent release of link TB).
- c) A-6. — This signal effects the through-connection of the speech path at T.
- d) A-1. — This signal is sent in order to hold the registers and must be followed afterwards by A-3, A-4, A-15 or A-6 in form of a pulse signal (see Recommendation Q.442).

3.1.1.5 In case of congestion in T, a busy-flash signal is sent over the link TA. In case of congestion in B, the appropriate backward signals are translated in T as described under 3.1.1.4 above. In both cases the number-received signal P should not be sent from T to A.

3.1.1.6 At A, the outgoing No. 4 register is released after the signal code 15 has been sent.

3.1.1.7 At T, the register is released after receipt of the last System R2 interregister signal (Group B signal, A-4, A-15, A-6).

3.1.1.8 At B, the register is released after it has transmitted forward, as appropriate, the address information, and after it has sent the last backward signal (B signal, A-4, A-15, A-6). When the succeeding link beyond B utilizes System R2 the register in B will already have been released after the through-connection in B. The clauses above are then applicable to the R2 register in the next exchange.

3.1.1.9 A forward-transfer signal arriving at T cannot be sent on to B, unless the method indicated in Recommendation Q.400 is used.

3.1.2 Automatic calls

3.1.2.1 In automatic operation A does not normally provide for a signal code 15. Transit exchange T sends the number-received signal P after receipt of the backward interregister signal A-6 or A-3. T acknowledges A-3 by II-7.

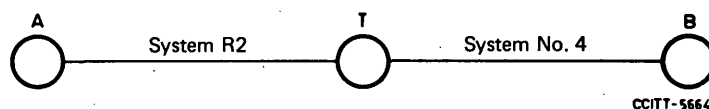
3.1.2.2 At A, the outgoing No. 4 register is released after receipt of signal P.

3.1.2.3 At T, the register is released after transmission of the number-received and completion of the exchange of System R2 interregister signals.

3.1.2.4 The above 3.1.1.1, 3.1.1.4, 3.1.1.5 and 3.1.1.8 are also applicable to automatic calls, as well as the first two sentences of 3.1.1.3.

3.2 Calls from System R2 to System No. 4

3.2.1 Semi-automatic calls



3.2.1.1 In semi-automatic operation A sends the seizing signal followed by the register signal I-11, I-12 or I-14 and the further address information. At T these signals are acknowledged in compelled cycles by A-1.

3.2.1.2 At T, the end-of-pulsing signal I-15 is acknowledged by A-1.

3.2.1.3 As soon as a sufficient number of digits is available in T, routing is effected there and the link TB is seized (terminal seizing: PX, proceed-to-send X; transit seizing: PY, proceed-to-send Y). Then the address information is transmitted from T to B according to signalling System No. 4. Signal I-15 is sent as signal code 15 to the terminal exchange. B acknowledges this signal and then sends the number-received signal P to T.

3.2.1.4 The transit exchange T translates the number-received signal P into an A-6 pulse signal.

3.2.1.5 In case of congestion in T, the signal A-15 is returned to A in accordance with Recommendation Q.462. This causes the release of the connection.

3.2.1.6 If after routing at T and during the transfer of digits from T to B a busy-flash signal PX is received, it will be translated into A-15, if a proceed-to-send signal Y was received previously (i.e. when B or the following exchanges are transit exchanges). If a proceed-to-send signal X was received previously in T, the busy-flash signal PX is translated into A-4 (i.e. when B is a terminal exchange). Signals A-15 or A-4 initiate the release of the link AT and thereby the subsequent release of the link TB. If a busy-flash signal PX arrives after the sending of A-6 by T, link TB is released, and a busy tone is applied in T in accordance with Recommendation Q.35.

3.2.1.7 At A, the outgoing R2 register is released after receipt of A-6, A-4 or A-15 (if no reattempt or re-routing is made).

3.2.1.8 At T, the register is released after the sending of code 15 and completion of the exchange of System R2 interregister signals.

3.2.1.9 At B the register is released after it has transmitted forward, as appropriate, the address information and after it has sent backward the number-received signal P or the busy-flash signal PX. When the succeeding link beyond B utilizes the System No. 4 the register in B will already have been released after the through connection in B. The clauses above are then applicable to the System No. 4 register in the next exchange.

3.2.2 Automatic calls

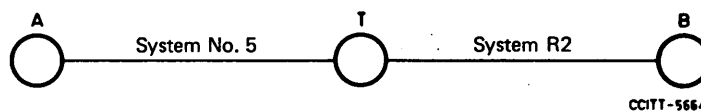
3.2.2.1 In automatic operation A does not normally send a signal I-15. The transit exchange T acknowledges by A-1 all R2 interregister signals arriving in the forward direction and waits for the arrival of the number-received signal P. This signal is passed on to A in the form of an A-6 pulse signal.

3.2.2.2 The above 3.2.1.1 and 3.2.1.3 to 3.2.1.9 are also applicable to automatic calls.

4. Interworking of System No. 5 with System R2

4.1 Calls from System No. 5 to System R2

4.1.1 Semi-automatic and automatic calls



4.1.1.1 After the initial compelled cycle (seizing, proceed-to-send) the address information including KP2 and ST is sent *en bloc* to T by the outgoing exchange A.

4.1.1.2 As soon as a sufficient number of digits is available in T, routing is effected and the link TB is seized. Then the address information is transmitted from T to B in accordance with the compelled System R2 signalling procedure. Signal ST is sent to the terminal exchange B as signal I-15 unless the last digit of the national number has been acknowledged by A-3 or A-6.

4.1.1.3 At B, the forward signal I-15 or the last digit of the national number is acknowledged in the same manner as indicated in 3.1.1.4 above.

4.1.1.4 In the case of congestion in T a busy-flash signal is sent over the link TA. In the case of congestion in B the appropriate backward signals are translated in T as described under 3.1.1.4 b) above.

4.1.1.5 At A, the outgoing No. 5 register is released after signal ST has been sent.

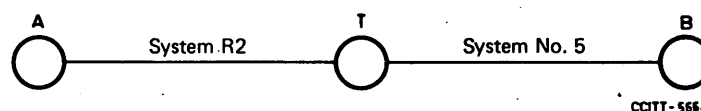
4.1.1.6 At T, the register is released after receipt of the last R2 interregister signal sent in the backward direction (Group B-signal, A-4, A-15, A-6).

4.1.1.7 At B, the register is released in accordance with 3.1.1.8 above.

4.1.1.8 A forward-transfer signal arriving in T cannot be passed on to B unless the method indicated in Recommendation Q.400 is applied on the link TB.

4.2 Calls from System R2 to System No. 5

4.2.1 Semi-automatic calls



4.2.1.1 In semi-automatic operation A sends the seizing signal followed by the register signal I-11, I-12 or I-14 and the further address information. At T these signals are acknowledged in compelled cycles by A-1.

4.2.1.2 At T, the receipt of the end-of-pulsing signal I-15 (acknowledged by A-1) establishes the ST condition.

4.2.1.3 As soon as there is ST condition at T, routing is effected and the next link TB is seized by the initial compelled cycle (seizing, proceed-to-send). The address information including KP1 (or KP2) and ST is then sent *en bloc* to B by the transit exchange T.

4.2.1.4 After seizure of the link TB and reception at T of the proceed-to-send signal, the transit exchange T sends an A-6 pulse signal to A.

4.2.1.5 In case of congestion in T or when no proceed-to-send signal is received from B, signal A-15 is returned to A in accordance with Recommendation Q.462. This causes the release of the connection. If a busy- flash signal arrives in T after transmission of A-6, the link TB is released and a busy tone is applied in T in accordance with Recommendation Q.35.

4.2.1.6 At A, the outgoing R2 register is released after receipt of A-6 or A-15.

4.2.1.7 AT T, the register is released after the sending of ST.

4.2.1.8 At B, the register is released after it has transmitted forward, as appropriate, the address information.

4.2.2 Automatic calls

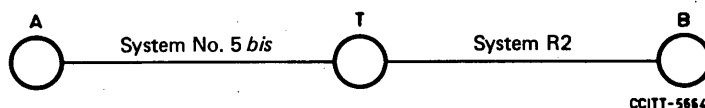
4.2.2.1 In automatic operation A does not normally send the signal I-15. The transit exchange T acknowledges by A-1 all R2 interregister signals arriving in the forward direction. It must determine the ST condition, according to 3.2.1 b) of Recommendation Q.152.

4.2.2.2 The above 4.2.1.3 to 4.2.1.8 are also applicable to automatic calls.

5. Interworking of System No.5 bis with System R2

5.1 Calls from System No. 5 bis to System R2

5.1.1 Semi-automatic calls



5.1.1.1 After an initial compelled cycle (seizing, proceed-to-send) the outgoing exchange A sends an initial address block consisting of not more than seven signals. Further signals and ST are transmitted as soon as they are available.

5.1.1.2 As soon as a sufficient number of digits is available in T, routing is effected and the link TB is seized. The address information is then transmitted from T to B in accordance with the compelled procedure. If B is acting as an international transit exchange the country code indicator I-12 or I-14 must be used, depending on the context of the X-digit. If B is acting as an international terminal exchange the language digit is transmitted first. The content of the X-digit concerning echo suppressors is conveyed to the international terminal exchange B by the appropriate answer to the backward signal A-14 which may be sent from B (see Recommendation Q.479). The Z-signals are translated as indicated below.

System No. 5 bis → Z	System R2 →	
	Language digit	Acknowledging A-3 or A-5
1 to 9	I-1 to I-9	II-7 or II-10

Signal ST is sent to the exchange B as signal I-15.

5.1.1.3 At B, the forward signal I-15 is acknowledged by one of the following signals:

- a) A-3. — Signal I-15 is then followed by II-7 (or II-10, when the forward transfer signalling facility is provided, see Recommendation Q.400) which is acknowledged by a B-signal.
- b) A-4 or A-15.
- c) A-6.
- d) A-1. — Signal A-1 does not dismiss the register and must be followed by A-3, A-4, A-15 or A-6 as pulse signals (see Recommendation Q.442).

5.1.1.4 The translation of the System R2 backward signals and the action required at T are listed below (see Table 4 in Recommendation Q.211):

← System No. 5 bis signal	← System R2 signal	Action required at T
No. 2	A-15	Await clear-forward signal from A
No. 3	A-4, B-4	Await clear-forward signal from A
No. 4	A-6	Through-connection of the speech path
No. 6	B-1, B-6	Through-connection of the speech path
No. 7	B-7	Through-connection of the speech path
No. 8	B-3	Await clear-forward signal from A
No. 9	B-5, B-8, B-9, B-10	Await clear-forward signal from A
No. 10	B-2	Await clear-forward signal from A

5.1.1.5 In case of congestion in T a congestion signal No. 1 or No. 2 (Table 4 in Recommendation Q.211) is sent over the link TA. In case of congestion in B the backward signals are translated at T as described in 5.1.1.4 above.

5.1.1.6 At A, the outgoing No.5 bis register is released after receipt of one of the signals listed in the Table in 5.1.1.4 above.

5.1.1.7 At T, the register is released after the end of the exchange of R2 interregister signals on link TB and after sending backwards one of the signals listed in the Table in 5.1.1.4 above.

5.1.1.8 At B, the register is released in accordance with 3.1.1.8 above.

5.1.1.9 A forward-transfer signal arriving in T cannot be passed on to B unless the method indicated in Recommendation Q.400 is applied on link TB.

5.1.2 Automatic calls

5.1.2.1 In automatic operation the Z-signals are translated as follows:

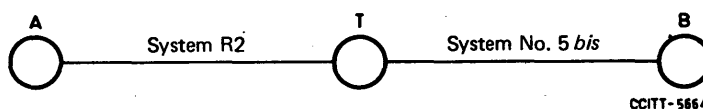
System No. 5 bis → Z	System R2 →	
	Discriminating digit	Acknowledging A-3 or A-5
0	I-10	II-7
11	I-10	II-9
12	I-10	II-8

5.1.2.2 The transit register in T awaits the receipt of one of the backward R2 register signals indicated under 5.1.1.4 above, which is then translated as described in that paragraph.

5.1.2.3 The other points under 5.1.1 above are also applicable to automatic calls.

5.2 Calls from System R2 to System No.5 bis

5.2.1 Semi-automatic and automatic calls



5.2.1.1 A sends to T the seizing signal followed by one of the register signals I-11, I-12 or I-14 and the further address information. At T these signals are acknowledged in compelled cycles by A-1.

5.2.1.2 At T, if the end-of-pulsing signal I-15 is received, it is acknowledged by A-1.

5.2.1.3 Normally the calling party's category signal is transferred over an R2 link with the sequence A-3 II-x B-x after transmission of the address information. However, as the initial address block on the No. 5 bis link must include information about the calling party's category, the No. 5 bis circuit cannot be seized unless this information has been received by T. Consequently, T must request transmission of a Group II signal from A by sending A-5 to A at an early stage of address signalling. This requirement could be fulfilled at T by sending A-5 to A in one of the following ways:

- after receipt of a certain number of address signals;
- after analysis indicating that the succeeding link uses No. 5 bis signalling;
- as a result of criteria considered suitable for that exchange.

A-5 shall only be sent as an acknowledgement signal to a forward signal.

5.2.1.4 After routing is effected at T the link is seized and the initial address block, which contains the following information, is sent to B:

- an X signal, which is selected according to the received country code indicator I-11, I-12 or I-14 and the nature of the link;
- the country code;
- the Z digit;
- address signals.

Any address signal which follows the initial address block is forwarded as received.

System R2 forward signals are translated as indicated below:

System R2 →	System No. 5 <i>bis</i> →
I-11 Country code indicator, outgoing half-echo suppressor required; or access to incoming operator (Code 11)	X = 2 or X = 3, echo suppressor required, with or without satellite link included
I-12 Country code indicator, no echo suppressor required	X = 1, no echo suppressor required and no satellite link included
I-14 Country code indicator, outgoing half-echo suppressor inserted; or incoming half-echo suppressor required	X = 2 or X = 3, echo suppressor required, with or without satellite link included
I-15 End-of-pulsing	ST end-of-pulsing
II-7 Discriminating digit = 0	Calling party's category Z = 0
II-8 Data transmission	Calling party's category Z = 12
II-9 Subscriber with priority	Calling party's category Z = 11
II-7 or II-10, Language digit = 1-8	Calling party's category Z = 1-8 (operator)

5.2.1.5 At B, the last digit of the national number or the forward signal ST are acknowledged by one of the signals listed in Table 4 of Recommendation Q.211.

5.2.1.6 The translation of the No. 5 *bis* backward signals and the actions required at T, are listed below:

← System R2	← System No. 5 <i>bis</i>	Action required at T
A-15	Nos. 1, 2	Await clear-forward signal from A
A-4 or B-4	No. 3	Await clear-forward signal from A
A-6	No. 5	Through-connection of the speech path
B-3	No. 8	Await clear-forward signal from A
B-6	No. 6	Through-connection of the speech path
B-7	No. 7	Through-connection of the speech path
B-5	No. 9	Await clear-forward signal from A
B-2	No. 10	Await clear-forward signal from A

5.2.1.7 In the case of congestion at T, signal A-15 is returned to A in accordance with Recommendation Q.462. This causes the release of the connection. If a busy-flash signal arrives after transmission of address-complete signal A-6 by T, link TB is released and a busy tone is applied in T in accordance with Recommendation Q.35.

In the case of congestion in B, the backward signals are translated in T as described in 5.2.1.6 above.

5.2.1.8 At A, the outgoing R2 register is released after receipt of a Group B signal, one of the signals A-6, A-4 or A-15 (if no re-attempt or re-routing is made).

5.2.1.9 At T, the register is released after completion of the exchange of R2 interregister signals following the receipt of one of the backward signals listed in 5.2.1.6 above (except A-3).

5.2.1.10 At B, the register is released after it has sent forward the address information signals and has sent backwards one of the signals listed in Table 4 of Recommendation Q.211.

6. *Interworking line-signalling conditions (channel associated signalling)*

6.1 *Intervals between consecutive signals*

At the transit exchange, where interworking between System R2 and Systems Nos. 4, 5, and 5 bis occurs, it is necessary to ensure that the minimum intervals between consecutive signals, specified for these signalling systems, are provided. A pair of consecutive signals may consist of two line-signals (e.g. answer signal and clear-back signal), or of a line signal and an interregister signal (e.g. register dismissal signal and answer signal).

6.2 *Answer and clear-back signals*

Transfer of these signals to the preceding signalling system must not occur before complete recognition of the signal at the interworking point T.

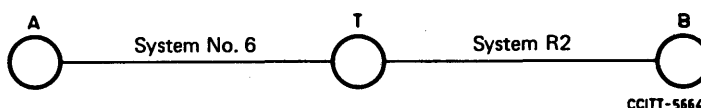
7. *Interworking of System R2 with national signalling systems*

International working of System R2 in the international and national network is dealt with in the specifications of System R2, Part III of this Volume.

Interworking between System R2 and national systems other than System R2 is not yet defined.

8. *Interworking of System No. 6 with System R2*

8.1 *Calls from System No.6 to System R2*



8.1.1 A sends to T in the forward direction an initial address message which contains the following signalling information:

- country-code indicator;
- nature-of-circuit indicator;
- echo-suppressor indicator;
- calling party's category indicator;
- address signals (at least all digits required for routing the call through the international network).

8.1.2 Routing is effected at T, the link TB is seized and address information is sent to B. If B is an international transit exchange, one of the country code indicators I-12 or I-14 is used depending on the content of the echo-suppressor indicator received from A. If B is an incoming international exchange the language or discriminating digit is the first digit sent depending on the content of the calling party's category indicator received from A (see Table 1). In semi-automatic operation the end-of-pulsing signal received from A is sent to B as signal I-15 in accordance with Recommendation Q.473. If required the calling-party's category signal (see Table 1) will be sent to B.

TABLE 1 – Conversion of calling party's category

System No. 6	System R2	
Calling party's category indicator	Language or discriminating digit	Calling party's category signal
Operator, language French	L = 1	II-7 ^a
Operator, language English	L = 2	
Operator, language German	L = 3	
Operator, language Russian	L = 4	
Operator, language Spanish	L = 5	
Ordinary calling subscriber	D = 0	II-7
Calling subscriber with priority	D = 0	II-9
Data call	D = 0	II-8

^a The calling party's category signal II-10, operator initiated call with forward-transfer facility, may be used as decided upon by bilateral agreement, see Recommendation Q.400.

8.1.3 On receipt of any System R2 backward signal except those listed in Table 2 below, no signal will be sent on link AT. The appropriate System R2 forward signal is sent to B in accordance with Recommendation Q.462.

8.1.4 On receipt of one of the signals A-6, B-1, B-6 or B-7 the corresponding address-complete signal (see Table 2) is sent to A after reception of the continuity signal and the speech path at T is through-connected. For the other System R2 backward signals listed in Table 2, the register and link TB is released and the corresponding System No. 6 signal (see Table 2) is sent to A.

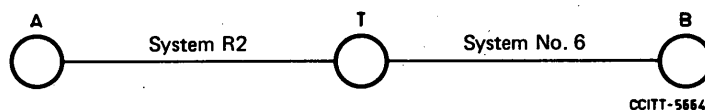
TABLE 2 – Conversion of backward R2 signals

System R2 signal	Meaning of System No. 6 signal
A-4	National-network-congestion
A-6	Address-complete, charge
A-15	Circuit-group-congestion
B-1	Address-complete, charge
B-2	Subscriber-transferred
B-3	Subscriber-busy (electrical)
B-4	National-network-congestion
B-5	Vacant-national-number
B-6	Address-complete, subscriber-free, charge
B-7	Address-complete, subscriber-free, no charge
B-8	Line-out-of-service
B-9	} Vacant-national-number
B-10	

8.1.5 Line signals received from either link will be repeated by T observing the requirements regarding signal sequence and minimum interval between consecutive signals as specified for Systems R2 and No. 6.

8.1.6 A forward-transfer signal received at T will be sent to B as described upon bilateral agreements (see Recommendation Q.400).

8.2 Calls from System R2 to System No. 6



8.2.1 A seizes link AT and starts address signalling to T. T cannot seize link TB until it has information about the calling party's category available for inclusion in the initial address message to be sent to B. T therefore has to request transmission of the calling party's category signal from A by sending signal A-5 (see note to 8.2.2). This request will be made upon any criteria considered suitable at T (e.g. after analysis indicating that link TB uses Signalling System No. 6). Signal A-5 may only be sent as an acknowledgement to a forward signal received from A.

8.2.2 The routing information in the initial address message sent to B will depend on the signals received from A as indicated in Table 3.

TABLE 3 – Coding of routing information

System R2	System No. 6
	<i>Echo-suppressor indicator</i>
	Outgoing half-echo suppressor
I-11	Included = 1
I-12	Not included = 0
I-14	Included = 1
L = 1 L = 2 L = 3 L = 4 L = 5 D = 0 and II-7 D = 0 and II-9 D = 0 and II-8	<i>Calling party's category indicator</i>
	Operator, language French Operator, language English Operator, language German Operator, language Russian Operator, language Spanish Ordinary calling subscriber Calling subscriber with priority Data call

Note. – Provided that it is known that the calling party's category data transmission call (signal II-8) or subscriber with priority (signal II-9) can never be received from A because of limitations in the outgoing national network, the initial address message may optionally be sent to B without requesting transmission of the calling party's category signal from A. If so, the calling party's category indicator of the initial address message sent to B will indicate ordinary calling subscriber in case the discriminating digit has been received from A.

8.2.3 On receipt from B of one of

- the address-complete signals, the corresponding System R2 signal (see Table 4) is sent to A and the speech path at T is through-connected;
- the other backward No. 6 signals listed in Table 4, unless a repeat attempt is made (see Recommendation Q.264), link TB is released and the corresponding System R2 signal (see Table 4) is sent to A.

TABLE 4 – Conversion of backward No. 6 signals

Meaning of System No. 6 signal	System R2 signal
Switching-equipment-congestion	A-15
Circuit-group-congestion	A-15
National-network-congestion	A-4
Call-failure	A-4
Message-refusal	A-4
Address-complete, subscriber-free, charge	B-6
Address-complete, subscriber-free, no charge	B-7
Address-complete, coin-box-free	B-6
Subscriber-busy (electrical)	B-3
Vacant-national-number	B-5
Line-out-of-service	B-8
Subscriber-transferred	B-2
Address-complete, no charge	B-7
Address-complete, coin-box	A-6
Address-complete, charge	A-6
Address-incomplete	A-4

8.2.4 If a congestion signal, the call-failure or the message-refusal signal is received at T after receipt of an address-complete signal (see Recommendation Q.261, 4.1.5) an appropriate audible tone or announcement has to be applied in T.

8.2.5 Line signals received from either link will be repeated by T observing the requirements regarding signal sequence and minimum interval between consecutive signals as specified for Systems R2 and No. 6.

