THE INTERNATIONAL TELEGRAPH AND TELEPHONE CONSULTATIVE COMMITTEE

(C.C.I.T.T.)

FIFTH PLENARY ASSEMBLY

GENEVA, 4-15 DECEMBER 1972

GREEN BOOK

VOLUME VI - 3

Telephone signalling and switching

SPECIFICATIONS OF SYSTEMS No. 6, R_1, R_2
(Recommendations Q.251 to Q.388)

Published by
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SIGNALLING SYSTEM C.C.I.T.T. No. 6

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SIGNALLING SYSTEM C.C.I.T.T. No. 6

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PART XIV

SIGNALLING SYSTEM No. 6

INTRODUCTION

General

Signalling system No. 6 can be used to control the switching of all types of international circuits to be used in a world-wide connection, including TASI-derived circuits and satellite circuits.

The system meets all requirements defined by the C.C.I.T.T. concerning the service features for world-wide international semi-automatic and automatic telephone traffic. It is designed for both-way operation of the speech circuits.

The system can also be used for regional and national applications, and a large part of the signal code capacity is reserved for this purpose.

Moreover, a large unused signal code capacity will allow the addition of new signals to cater for some unknown future requirements. This spare capacity may be used for increasing the number of telephone signals as well as for introducing other signals, e.g. network management signals and network maintenance signals.

The system features are obtained by entirely removing the signalling from the speech paths and introducing the concept of a separate common signalling link over which all signals for a number of speech circuits are transferred. A number of these common signalling links interconnected by a number of transit centres and signal transfer points will form a coherent signalling network which can transfer all signals for all speech circuit groups within that network area.

Modes of operation

The signalling system may be operated both in an associated and in a non-associated mode. In the associated mode of operation, the signals are transferred between the two exchanges which are the end points of a group of speech circuits over a common signalling link terminating at the same exchanges. In the non-associated mode of operation, the signals are transferred via two or more common signalling links in tandem associated with other groups of circuits, the signals being processed and forwarded through one or more intermediate exchanges acting only as signal transfer points.

The associated mode of operation is suited for use with large circuit groups, while a non-associated mode makes the signalling system economically suitable for use with small circuit groups by sharing the capacity of a signalling link among several groups.

A signalling link may be operated in the associated mode for one circuit group and in a non-associated mode for other circuit groups, either under normal or under breakdown conditions.

Common signalling link

The separate common signalling link is capable of operation over standard international voice bandwidth channels including the 3-kHz spaced telephone channels used for some intercontinental circuits. Signalling information is transmitted in the serial data mode on a link-by-link basis—i.e., the signals are transferred from one link to the next only after processing.

The stream of pulses, transmitted normally at a rate of 2400 bits per second using the four-phase modulation method, is divided into signal units of 28 bits each and into blocks of 12 signal units each.

The error control necessary for a common signalling link is based on error detection by coding and on error correction by retransmission. Error detection is based on decoding of checking bits included in each signal unit and on data carrier failure detection. This provides the desired system reliability. Error-free signal messages are used without delay. Provision is made for automatic transfer to an alternative link in the event of failure caused by breakdown or excessive error rate.

Signal messages

Signal messages carry information to identify the telephone circuit concerned. Since the circuit identity, i.e. the label, requires a large proportion of the bits (11 out of the 20 available information bits), provision is made for sending multi-unit messages consisting of several signal units under one label. A single digit or a random telephone signal will normally be transferred in a one-unit message while several or even all digits may be transferred in a multi-unit message.

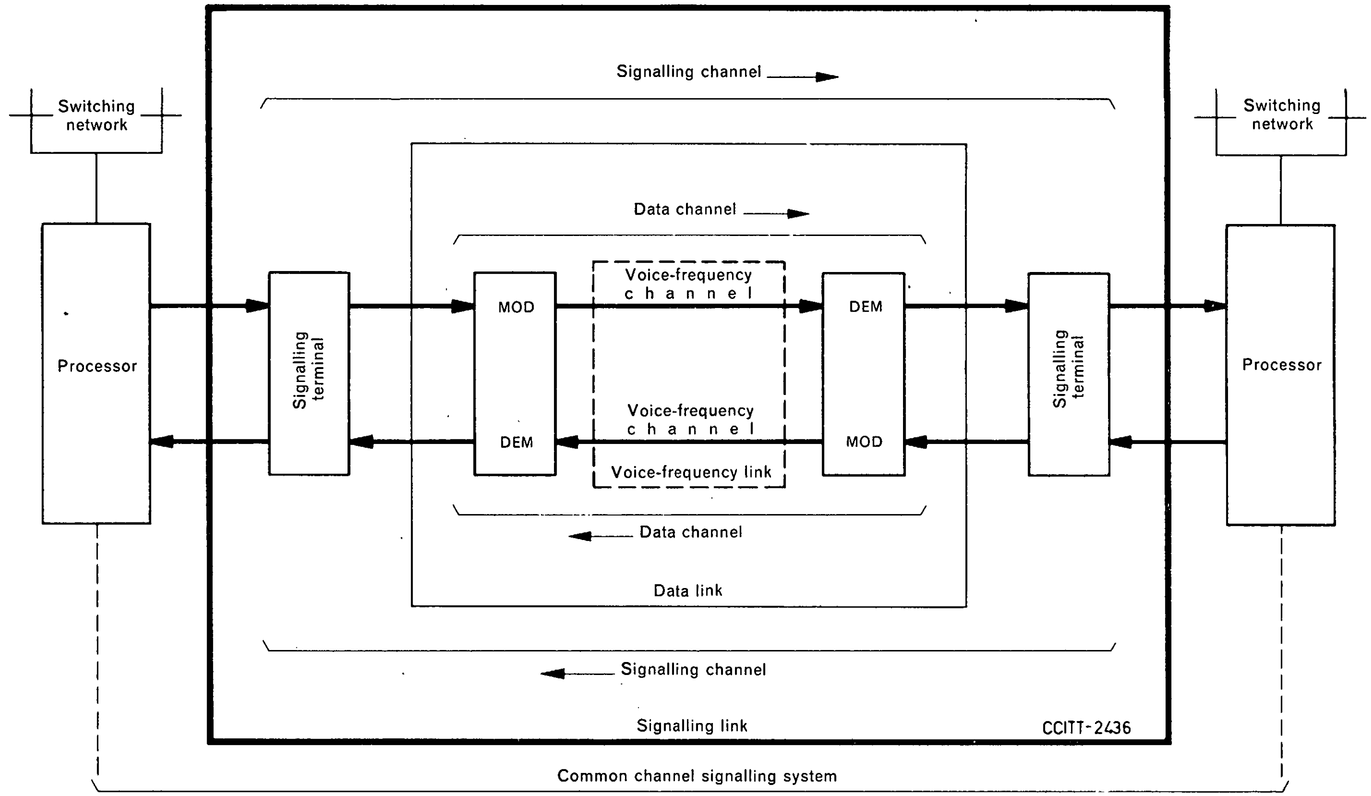
Signal processing

All signals are processed at each transit centre or signal transfer point which has to be passed.

The processing of messages at a signal transfer point is minimal and includes label translation, if necessary, and the sending of signal messages within the proper priority category. In addition to the processing required at a signal transfer point, a transit centre examines sufficient signal information to perform proper switching action.

Signalling equipment

Because of the new technique based on a separate common signalling link, on data type transmission and on central processing of the signalling information, signalling system No. 6 will be used in general between exchanges of the stored programme control type.



Voice-frequency channel:
a one-way voice-frequency transmission path from the output of a data modulator to the input of a data demodulator made up of one or more voice-frequency carrier channels in tandem

Voice-frequency link:
a two-way voice-frequency transmission path between two data modems made up of one voice-frequency channel in each direction

Data channel:
a one-way data transmission path between two points made up of a modulator, a voice-frequency channel and a demodulator

Data link:
a two-way data transmission path between two points, made up of one data channel in each direction

Signalling channel:
a one-way signalling path from the processor of one switching machine to the processor of another switching machine

Signalling link:
a two-way signalling path from processor to processor made up of one signalling channel in each direction

Figure 1/Q.251. — **Basic diagram of the common channel signalling system.**

CHAPTER I

Functional description of the signalling system

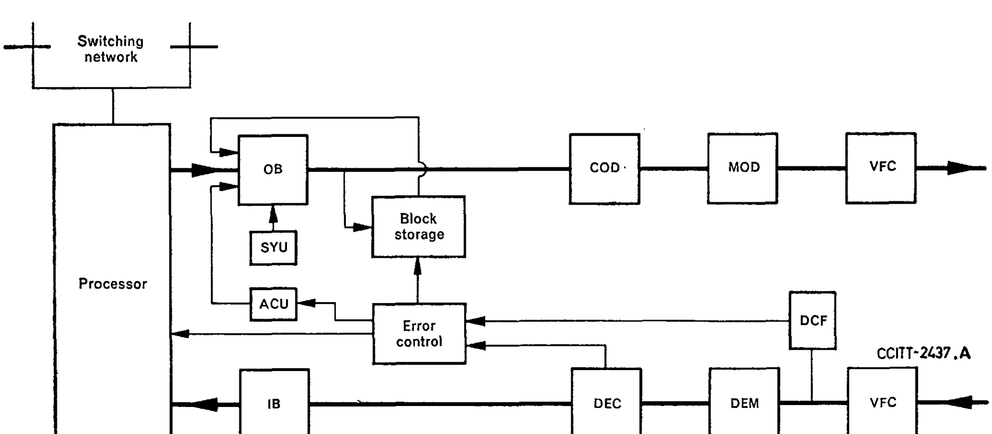
Recommendation Q.251

1.1 GENERAL

1.1.1 Block diagrams

Because common channel signalling, used in conjunction with exchanges having stored programme control, allows a wide latitude in distribution of signalling functions between the processor and peripheral equipment, and because common channel signalling is not limited to exchanges of this type, it is not practicable to specify well-defined equipment interfaces.

The major signal transfer functions are shown in Figures 1 and 2/Q.251. The blocks indicated in Figure 2/Q.251 are functional blocks and should not be construed as depicting equipment arrangements.



OB — Output buffer
IB — Input buffer
SYU — Synchonization signal unit generator
ACU — Acknowledgement signal unit generator
DEC — Decoder
COD — Coder
MOD — Data modulator
DEM — Data demodulator
DCF — Data carrier failure detector
VFC — Voice-frequency channel

FIGURE 2/Q.251. — **Functional block diagram of a system No. 6 terminal.**

1.1.2 Signal unit and block structure

Each signalling channel of the system (shown in Figure 1) is operated synchronously; that is, a continuous stream of data flows in both directions. The data stream is divided into signal units of 28 bits each, of which the last 8 are check bits, and these signal units in turn are grouped into *blocks* of 12 signal units. The 12th and last signal unit of each block is an acknowledgement signal unit coded to indicate the number of the block being transmitted, the number of the block being acknowledged and whether or not each of the 11 signal units of the block being acknowledged was received without detected errors.

In normal operation, the first 11 signal units within a block will consist of signal units carrying either telephone signals or management signals, or of synchronization signal units. Synchronization signal units, which are transmitted only in the absence of other signalling traffic, are coded to indicate the number of the position they occupy within the block to facilitate locating the acknowledgement signal unit. Their format has been chosen to produce a large number of dibit transitions to facilitate achieving or maintaining bit synchronism.

During system-synchronizing procedures, only synchronization and acknowledgement signal units are transmitted until bit, signal unit, and block synchronism has been achieved at both ends of the system.

1.1.3 Transmitting terminal

The transmission of a signal in system No. 6 starts in the processor as shown in Figure 2. Signals corresponding to the information to be transmitted are formed in accordance with the format specified and delivered to the output buffer. These signals, which may be one-unit messages or multi-unit messages, are stored in this buffer according to their priority level. The output buffer delivers the highest priority signal awaiting transmission to the coder in serial form in the next available time slot. In the coder, each signal unit is encoded by the addition of check bit in accordance with the check bit polynomial. The signal is then modulated and delivered to the outgoing voice-frequency channel for transmission to the distant receiving equipment.

1.1.4 Receiving terminal

The receiving function, as indicated in Figure 2, starts with acceptance of modulated serial data from the voice-frequency channel. After demodulation, serial data are delivered to the decoder, where each signal unit is checked for error on the basis of the associated check bits. Signal units received with detected errors are discarded. Signal units carrying telephone signals or management signals which are error-free are transferred to the input buffer after deletion of the check bits. The input buffer delivers the signal units to the processor where the processor analyzes the signals and takes appropriate action.

1.1.5 Error control

Error control is based on error detection by redundant coding and on error correction by retransmission of those signal messages found to be in error. This procedure requires that each transmitted signal message be stored until acknowledged as being received correctly. In the case of multi-unit messages, each signal unit of the message must be stored until all units of the message are acknowledged as being received correctly. When an acknowledgement signal unit is received, it is analyzed in the box marked error control in Figure 2. If an acknowledgement bit indicates that a signal unit being acknowledged was received in error, the retransmission process is started. Request for retransmission of a synchronization signal unit is ignored. If any unit of a multi-unit message is in error, the entire multi-unit message must be retransmitted in its initial order.

The data carrier failure detector complements the decoder for longer error bursts. When activated by a data carrier failure, it gives an indication to the box marked error control in Figure 2. An error indication from either the decoder or the data carrier failure detector is associated with the position of the erroneous signal unit(s) within the block. This information is used by the acknowledgement signal unit generator to control the marking of the acknowledgement bits.

As shown in Figure 2, the processor may also be notified whenever an error is detected in a signal unit. This information may be used by the processor to erase the memory of any signal unit(s) of a multi-unit message received which is associated with the one found in error, since this entire message will be retransmitted.

Recommenbation Q.252

1.2 SIGNAL TRANSFER TIME DEFINITIONS

1.2.1 Functional reference points

The major functional reference points are as indicated in Figure 3/Q.252: Points A, B, C and D, which are defined below:

Point A. — That point in a switching centre where the signal as a signal unit, before being coded (check bits added), is delivered from the processor to an output buffer store.

Point B. — That point where the modulated signal unit (check bits included) in serial form will be delivered to the outgoing voice-frequency channel.

Point C. — That point where the modulated signal unit (check bits included) in serial form will be delivered to the data demodulator.

Point D. — That point in a switching centre where the signal unit, after being decoded (check bits deleted), will be presented from an input buffer store to the processor.

The functional reference points B and C are typically those points which define the voice-frequency channel used for common channel signalling.

1.2.2 Signal transfer time components

The various components of signal transfer time between two switching centres are defined as follows:

T_c = cross-office transfer time

T_e = emission time of a signal unit (included in T_s)

T_h = processing (handling) time

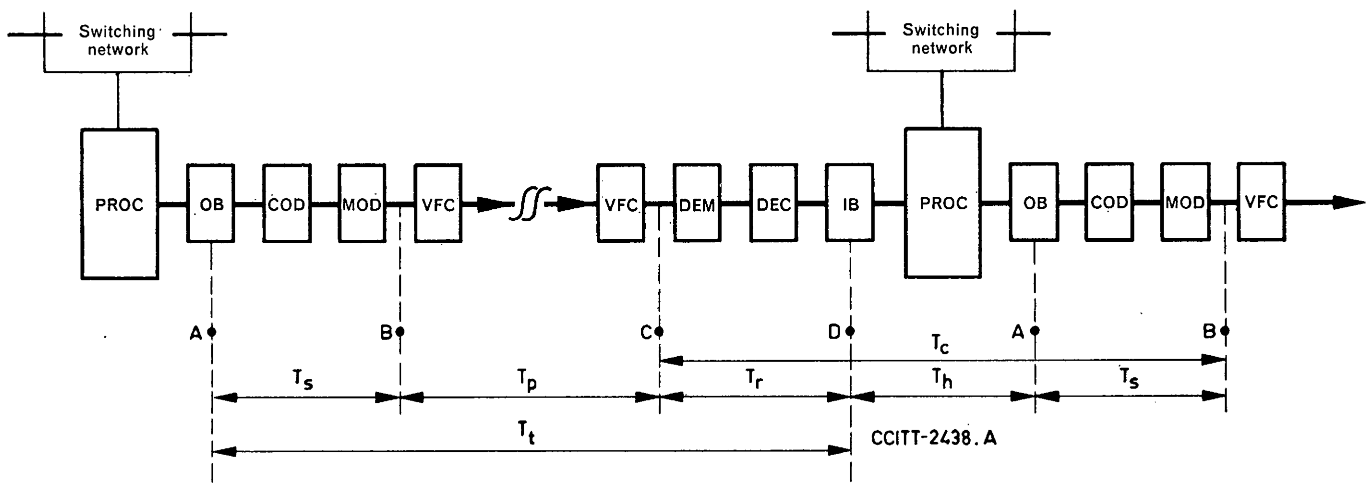
T_p = voice-frequency channel propagation time

T_q = queueing delay in the output buffer store (included in T_s)

T_r = receiver transfer time

T_s = sender transfer time

T_t = total signal transfer time



VFC	— Voice-frequency channel		T_c	— Cross-office transfer time
MOD	— Data modulator		T_h	— Processing (handling) time
DEM	— Data demodulator		T_p	— Voice-frequency channel propagation time
COD	— Coder		T_r	— Receiver transfer time
DEC	— Decoder		T_s	— Sender transfer time
PROC	— Processor		T	— Total signal transfer time
OB	— Output buffer			
IB	— Input buffer			

FIGURE 3/Q.252. — **Functional signal transfer time diagram.**

T_h is that period from the moment the signal is available for acceptance by the processor to the moment the signal is placed in the output buffer and is available for transmission.

T_r is that period of time from the moment when the last bit of the signal unit leaves the voice-frequency channel to that time when the signal is completely in the input buffer and is available for acceptance by the processor. T_r thus includes the following actions: demodulation, decoding (error detection) and, where present, serial to parallel conversion.

T_s is that period of time from the moment when the signal enters the output buffer store to that time when the last bit of the signal unit passes into the voice-frequency channel. T_s thus includes the following times and actions: emission time of signal unit(s) (one-unit or multi-unit message), queueing delay in the output buffer store, encoding (adding check bits), modulation and, where present, parallel to serial conversion.

The definitions of signal transfer times give rise to the following time relationships:

$$T_c = T_r + T_h + T_s$$
$$T_t = T_s + T_p + T_r$$

In case when an error is detected, retransmission will occur and the above time relationships are not valid. Rather, the time involved in retransmission and the extra queueing delays, which may occur on a retransmitted signal, must be taken into consideration.

Recommendation Q.253

1.3 ASSOCIATION BETWEEN SIGNALLING AND SPEECH NETWORKS

1.3.1 Definitions

The signals pertaining to a given group of speech circuits between two exchanges utilizing a common channel signalling system can be transferred in the following ways:

1.3.1.1 *Associated mode of operation*

In the associated mode of operation, the signals are transferred between the two exchanges over a common signalling link which terminates at the same exchanges as the group of speech circuits to which the signalling link has been assigned.

1.3.1.2 *Non-associated mode of operation*

In a non-associated mode of operation, the signals are transferred between the two exchanges over two or more common signalling links in tandem, the signals being processed and forwarded through one or more intermediate *signal transfer points* (see section 1.3.3). Following this definition, there may be a range of non-associated modes of operation which vary in the degree of rigidity imposed on the choice of the path utilized by the signals pertaining to the speech circuit. The ends of this range can be described as fully dissociated mode and quasi-associated mode of operation.

a) *Fully dissociated mode of operation*

The fully dissociated mode of operation is the extreme case of the non-associated mode. It is assumed that there is an established network of common signalling links and signal transfer points which may have its own routing principles.

In the fully dissociated mode of operation, the signals are transferred between the two exchanges via any available path in the signalling network according to the rules of that network.

b) *Quasi-associated mode of operation*

The quasi-associated mode of operation is the limited form of the non-associated mode. The common signalling links to be used are generally each operating in the associated mode with a group of circuits.

In the quasi-associated mode of operation the signals are transferred between the two exchanges over two or more common signalling links in tandem, but only over certain predetermined paths and through predetermined signal transfer points.

1.3.2 Association methods provided by the system No. 6

Signalling system No. 6 is designed to provide associated and quasi-associated modes of operation as defined in sections 1.3.1.1 and 1.3.1.2 b, e.g. as shown in Figure 4/Q.253.

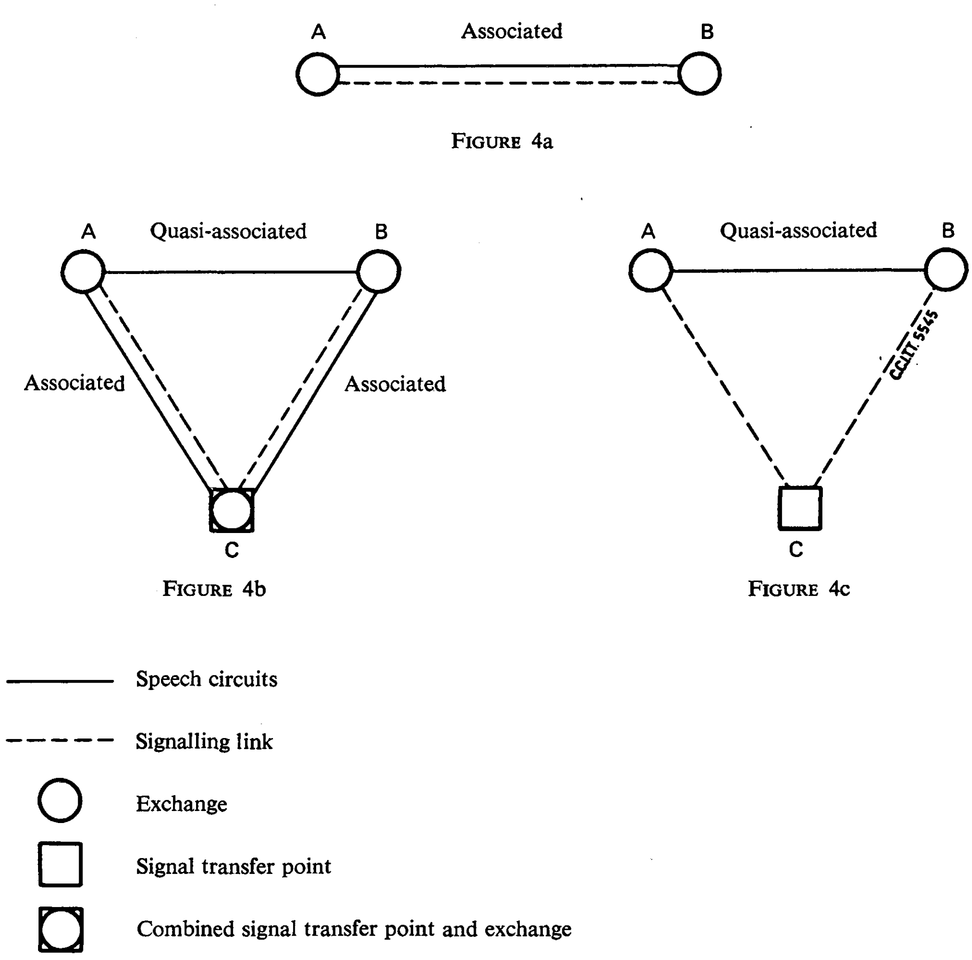


FIGURE 4/Q.253. — **Examples of associated and quasi-associated modes of operation**

As far as quasi-associated structures are concerned, the number of signal transfer points in the signalling path for a group of speech circuits between the two No. 6 exchanges should be kept as low as practicable. Normally, one such signal transfer point should suffice. However, there may be groups of circuits without associated common signalling links which will need more than one signal transfer point to handle the signalling traffic.

Attention is drawn to the fact that the addition of a signal transfer point involves the handling time at that point and one additional signal transfer time. Extensive use of signal transfer points will reduce some of the advantages of the signalling speed of system No. 6.

Note. — It should be noted that where a speech circuit group has an associated signalling link, dependability requirements may be met with economically, by using quasi-associated operation under breakdown condition when the associated signalling link is non-operative.

1.3.3 Signal transfer point

1.3.3.1 *Definition*

A signal transfer point is a signal relay centre handling and forwarding telephone signals from one signalling link to another in case of signalling in a non-associated mode of operation as defined in section 1.3.1.2.

Note. — Following this definition there is no need for a signal transfer point to have any connection with or relation to a switching centre.

However, in case of a quasi-associated mode of operation as defined in section 1.3.1.2 b, it is obvious that a signal transfer point may coincide with the No. 6 exchange where the signalling links terminate and that the equipment may be incorporated into the signalling equipment of that No. 6 exchange.

1.3.3.2 *Functions of a signal transfer point*

a) The equipment at a signal transfer point has to analyze the label and telephone signal information of every telephone signal message received in order to offer the message to the proper outgoing signalling channel, taking account of its priority, if any.

b) In doing so, it may be necessary to change the label of the received telephone signal message according to some present rules. However, the telephone signal information included in the message will never be changed by the equipment of a signal transfer point.

c) If for some reason a signal transfer point is unable to transfer signal messages, a procedure is provided to notify the preceding exchange(s) so that signal messages may be sent via reserve routes if available.

Note. — The fact mentioned under b above and the fact that the analysis of the received message will never be accompanied by the switching of speech circuits provide a distinction between a signal transfer point and a transit exchange. In general, a transit exchange will be designed to perform both the normal transit exchange functions and the signal transfer point functions.

CHAPTER II

Definition and function of signals

Recommendation Q. 254 [1]

2.1 TELEPHONE SIGNALS

Signals concerning a particular call or a particular speech circuit.

2.1.1 Address signal

A call set-up signal sent in the forward direction containing one element of information (digit 1, 2, . . . 9 or 0, code 11 or code 12) about the called party's number or the end-of-pulsing (ST) signal.

For each call, a succession of address signals is sent.

2.1.2 Country-code indicator

Information sent in the forward direction indicating whether or not the country code is included in the address information.

2.1.3 Nature-of-circuit indicator

Information sent in the forward direction about the nature of the circuit or any preceding circuit(s) already engaged in the connection:

— *satellite circuit*, or

— *no satellite circuit.*

An international exchange receiving this information will use it (in combination with the appropriate part of the address information) to determine the nature of the outgoing circuit to be chosen.

2.1.4 Echo suppressor indicator

Information sent in the forward direction indicating whether or not an outgoing half-echo suppressor is included in the connection.

[1] Some section numbers have been reserved for future use.

2.1.5 Calling-party's-category indicator

Information sent in the forward direction about the *category of the calling party* and, in case of semi-automatic calls about the *service language* to be spoken by the incoming, delay and assistance operators.

The following categories are provided:

— operator,

— ordinary calling subscriber,

— calling subscriber with priority,

— data call,

— test call.

2.1.6 End-of-pulsing (ST) signal

An address signal sent in the forward direction indicating that there are no more address signals to follow.

2.1.10 Continuity signal

A signal sent in the forward direction indicating continuity of the preceding No. 6 speech circuit(s) as well as of the selected speech circuit to the following international exchange, including verification of the speech path across the exchange with the specified degree of reliability.

2.1.12 Switching-equipment-congestion signal

A signal sent in the backward direction indicating the failure of the call set-up attempts due to congestion encountered at international switching equipment.

2.1.13 Circuit-group-congestion signal

A signal sent in the backward direction indicating the failure of the call set-up attempt due to congestion encountered on an international circuit group.

2.1.14 National-network-congestion signal

A signal sent in the backward direction indicating the failure of the call set-up attempt due to congestion encountered in the national destination network (excluding the busy condition of the called party's line(s)).

2.1.15 Address-incomplete signal

A signal sent in the backward direction indicating that the number of address signals received is not sufficient for setting up the call. This condition may be determined in the incoming international exchange (or in the national destination network):

— immediately after the reception of an ST signal or

— on time-out after the latest digit received.

2.1.16 Address-complete signal, charge

A signal sent in the backward direction indicating that all the address signals required for routing the call to the called party have been received, that no called-party's-line-condition signals (electrical) will be sent, and that the call should be charged on answer.

2.1.17 Address-complete signal, no charge

A signal sent in the backward direction indicating that all the address signals required for routing the call to the called party have been received, that no called-party's-line-condition signals (electrical) will be sent, and that the call should be charged on answer.

2.1.18 Address-complete signal, coin-box

A signal sent in the backward direction indicating that all the address signals required for routing the call to the called party have been received, that no called-party's-line-condition signals (electrical) will be sent, that the call should be charged on answer, and that the called number is a coin (box) station.

2.1.19 Address-complete, subscriber-free signal, charge

A signal sent in the backward direction as an alternative to the address-complete, charge signal indicating that the called party's line is free, and that the call should be charged on answer.

2.1.20 Address-complete, subscriber-free signal, no charge

A signal sent in the backward direction as an alternative to the address-complete, no charge signal indicating that the called party's line is free, and that the call should not be charged on answer.

2.1.21 Address-complete, subscriber-free signal, coin-box

A signal sent in the backward direction as an alternative to the address-complete, coin-box signal indicating that the called party's line is free, that the call should be charged on answer, and that the called number is a coin (box) station.

2.1.23 Vacant-national-number signal

A signal sent in the backward direction indicating that the received national number is not in use (for example spare level, spare code, vacant subscriber's number).

2.1.24 Subscriber-busy signal (electrical)

A signal sent in the backward direction indicating that the line(s) connecting the called party with the exchange is (are) engaged. The subscriber-busy signal will also be sent in case of complete uncertainty about the place where the busy or congestion conditions are encountered and in the case where a discrimination between subscriber busy and national-network congestion is not possible.

2.1.25 Line-out-of-service signal

A signal sent in the backward direction indicating that the called party's line is out-of-service or faulty.

2.1.26 Subscriber-transferred signal (changed number)

A signal sent in the backward direction indicating 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.

2.1.27 Confusion signal

A signal sent in the backward direction indicating that an exchange is unable to act upon a message received from the preceding exchange because the message is considered unreasonable.

2.1.28 Call-failure signal

A signal sent in the backward direction indicating the failure of a call set-up attempt due to the lapse of a time-out or a fault not covered by specific signals.

2.1.29 Message-refusal signal

A signal sent by a signal transfer point in response to the reception of a telephone signal which it is unable to deal with as a consequence of the transfer-prohibited situation.

2.1.31 Forward-transfer signal

A signal sent in the forward direction on semi-automatic calls when the outgoing international exchange operator wants the help of an operator at the incoming international exchange. The signal will normally serve to bring an assistance operator (see Recommendation Q.101) into the circuit if the call is automatically set up at that exchange. When a call is completed via an operator (incoming or delay operator) at the incoming international exchange, the signal should preferably cause this operator to be recalled.

2.1.32 Answer signal, charge

A signal sent in the backward direction indicating that the call is answered and subject to charge.

In semi-automatic working, this signal has a supervisory function. In automatic working, the signal is used:

— to start metering the charge to the calling subscriber (Recommendation Q.28) and

— to start the measurement of call duration for international accounting purposes (Recommendation Q.50).

2.1.33 Answer signal, no charge

A signal sent in the backward direction indicating that the call is answered but is not subject to charge. It is used for calls to particular destinations only.

In semi-automatic working, this signal has a supervisory function. In automatic working, the reception of this signal shall not start the metering to the calling subscriber.

2.1.34 Clear-back signals

Signals sent in the backward direction, the first of which indicates that the called party has cleared. Subsequent clear-back signals indicate that the called party has cleared following a reanswer, e.g. switchhook flashing.

In semi-automatic working, they perform a supervisory function. In automatic working, the arrangements specified in Recommendation Q.118 apply.

2.1.35 Reanswer signals

Signals sent in the backward direction indicating that the called party, after having cleared, again lifts his receiver or in some other way reproduces the answer condition, e.g. switchhook flashing.

2.1.36 Clear-forward signal

A signal sent in the forward direction to terminate the call or call attempt and release the circuit concerned. This signal is normally sent when the calling party clears.

2.1.37 Release-guard signal

A signal sent in the backward direction in response to the clear-forward signal when the speech circuit concerned has been brought into the idle condition.

2.1.41 Blocking signal

A signal sent for maintenance purposes to the exchange at the other end of a circuit to cause engaged conditions of that circuit for subsequent calls outgoing from that exchange. An exchange receiving the blocking signal must be capable of accepting incoming calls on that circuit unless it also has sent a blocking signal.

2.1.42 Unblocking signal

A signal sent to the exchange at the other end of a circuit to cancel in that exchange the engaged conditions of that circuit caused by an earlier blocking signal.

2.1.43 Blocking-acknowledgement signal

A signal sent in response to a blocking signal indicating that the speech circuit has been blocked.

2.1.44 Unblocking-acknowledgement signal

A signal sent in response to an unblocking signal indicating that the speech circuit has been unblocked.

Recommendation Q.255

2.2 SIGNALLING-SYSTEM-CONTROL SIGNALS

Signals used for the proper functioning of the signalling system via the common signalling link.

2.2.1 Acknowledgement indicator

Information indicating whether or not an error has been detected in a received signal unit.

2.2.2 Synchronization signal

A signal sent in order to establish and maintain synchronization between the two ends of a signalling channel.

2.2.3 System-control signals

2.2.3.1 *Changeover signal*

A signal sent to indicate a failure on a synchronized signalling link. If this signal is sent on a link carrying signalling information, it also indicates that a changeover to the next reserve signalling link is required.

2.2.3.2 *Manual-changeover signal*

A signal sent to initiate a changeover to a reserve signalling link because of need for rearrangements, changes, maintenance, etc.

2.2.3.3 *Manual-changeover-acknowledgement signal*

A signal sent in response to a manual-changeover signal to indicate that manual changeover can take place.

2.2.3.4 *Standby-ready signal*

A signal sent on a standby reserve link to indicate that the error rate on that link has met the requirements of the *one-minute proving period.*

2.2.3.5 *Standby-ready-acknowledgement signal*

A signal sent on the standby reserve link in response to a standby-ready signal and indicating that the error rate on that link has met the requirements of the *one-minute proving period.*

2.2.3.6 *Load-transfer signal*

A signal sent on a link to indicate that the error rate on that link has met the requirements of the *one-minute proving period* and that signalling traffic should be transferred to that particular link.

2.2.3.7 *Emergency-load-transfer signal*

A signal sent on as many links as possible to indicate that the error rate on those links has met the requirements of the *emergency proving period*, and that emergency transfer can take place to one of these links.

2.2.3.8 *Load-transfer-acknowledgement signal*

A signal sent on a link in response to a load-transfer signal or to an emergency-load-transfer signal to indicate that the load-transfer will take place to that particular link.

Recommendation Q.256

2.3 MANAGEMENT SIGNALS

Signals concerning the management of the speech circuit network and the signalling network. The three following categories of signals are distinguished:

2.3.1 Network-management signals

Information regarding the conditions of circuit groups or equipment sent from one point in the network to one or more other points. This excludes information relevant to individual calls or individual speech circuits.

The nature and use of network-management signals are still under consideration by the C.C.I.T.T.

2.3.2 Network-maintenance signals

Management signals used for maintenance purposes.

The nature and use of network-maintenance signals are still under consideration by the C.C.I.T.T.

2.3.3 Signalling-network-management signals

Information regarding the conditions of signalling links which may be required to modify signal routings. This excludes information relevant to the signals concerned with individual calls or speech circuits.

2.3.3.1 *Transfer-prohibited signal*

A signal sent by a signal transfer point when it is unable to transfer signals for a particular group of circuits.

2.3.3.2 *Transfer-allowed signal*

A signal sent by a signal transfer point when it is once again ready to transfer signals for the particular group of circuits.

2.3.3.3 *Transfer-allowed-acknowledgement signal*

A signal sent in response to the reception of a transfer-allowed signal.

CHAPTER III

Signal unit formats and codes

Recommendation Q.257

3.1 GENERAL

3.1.1 Types of message and signal unit (SU)

Signalling and other information carried by the common signalling link is transferred by means of messages consisting of one or more signal units.

A signal unit (SU) is the smallest defined group of bits on the signalling channel and contains 28 bits.

Dependent upon the number of signal units necessary to transmit one message, the message is called a one-unit message or a multi-unit message.

3.1.1.1 *One-unit message, lone signal unit (LSU)*

A one-unit message is a message which is transmitted entirely within one signal unit. Such a signal unit is called a lone signal unit (LSU). It is designed to transmit either:

a) a single telephone signal, or

b) signalling-system-control signal(s), or

c) management signals(s).

3.1.1.2 *Multi-unit message (MUM)*

A multi-unit message (MUM) consists of 2, 3, 4, 5 or 6 signal units in tandem. It is designed to transmit a number of related signals (e.g. address signals) in an efficient way. A special case of the multi-unit messages is the initial address message, which is the only one which can have six signal units in tandem and has a minimum of three signal units.

3.1.1.3 *Initial signal unit (ISU)*

The first signal unit of a multi-unit message is called the initial signal unit (ISU).

3.1.1.4 *Subsequent signal unit (SSU)*

The second and any following signal unit of a multi-unit message are called subsequent signal units (SSU).

3.1.2 Basic formats

3.1.2.1 *Basic format of a lone signal unit*

The basic format of a lone signal unit is shown in Figure 5/Q.257.

The basic format of a lone signal unit is not used in all cases. Where a different format is used it is shown in the sections relating to individual signal units.

```
X X X X X / X X X X / X X X X X X X / X X X X / X X X X X X X X
   1-5        6-9          10-16          17-20        21-28
 heading     signal        band          circuit       check
          information     number         number
                      \_______________________/
                                label
```

FIGURE 5/Q.257. — **Basic format of: — a lone signal unit**
— an initial signal unit of a multi-unit message

3.1.2.2 *Basic format of a multi-unit message*

The format of the initial signal unit of a multi-unit message is shown in Figure 5/Q.257. The use of a special code in the signal information field (bits 6-9) distinguishes an initial signal unit from a lone signal unit. See section 3.1.2.1.

The format of a subsequent signal unit of a multi-unit message is shown in Figure 6/Q.257.

```
0 0 / X X / X X X X X X X X X X X X X X X X / X X X X X X X X
1-2   3-4               5-20                      21-28
 *     **         signal information              check

         *  = subsequent signal unit heading code
         ** = length indicator
```

FIGURE 6/Q.257. — **Format of a subsequent signal unit of a multi-unit message**

For some messages, the signal information field of a subsequent signal unit (bits 5-20) can be sub-divided, notably in address messages where the field is divided into four 4-bit parts.

3.1.3 Codes for the general parts of signal units

The interpretation of a message depends upon a system of codes in various parts of the message.

3.1.3.1 *Heading*

The heading is used to identify the type of:

a) group of signals, or

b) message, or

c) signal.

The heading generally consists of the first five bits of the signal units (bits 1-5). There are two exceptions to this rule, viz.:

— all subsequent signal units are identified by the same 2-bit heading code 0 0 (bits 1-2);

— the acknowledgement signal unit is identified by a 3-bit heading code 0 1 1 (bits 1-3).

The heading codes are allocated as follows:

0 0	Subsequent signal unit
0 1 0 0 0 0 1 0 0 1 0 1 0 1 0 0 1 0 1 1	Spare (reserved for regional and/or national use)
0 1 1	Acknowledgement signal unit
1 0 0 0 0	Initial signal unit of an initial address message (or of a multi-unit message)
1 0 0 0 1 1 0 0 1 0 1 0 0 1 1 1 0 1 0 0 1 0 1 0 1 1 0 1 1 0 1 0 1 1 1	Subsequent address message (one-unit message or multi-unit message)
1 1 0 0 0 1 1 0 0 1 1 1 0 1 0 1 1 0 1 1	International telephone signals
1 1 1 0 0	Spare (reserved for regional and/or national use)
1 1 1 0 1	Signalling-system-control signals (except acknowledgement signal unit) and management signals
1 1 1 1 0 1 1 1 1 1	Spare (reserved for regional and/or national use)

The heading code allocation is also shown in Table 1 at the end of this chapter.

3.1.3.2 *Signal information*

Signal units with a 5-bit heading code have a signal information field of four bits (bits 6-9). The signal information field is used:

a) to define a particular signal within a group of signals, the group of signals being defined by the heading code, or

b) to define a sub-group within a group of signals, or

c) to indicate that the signal unit is an initial signal unit and that the subsequent signal unit(s) contain(s) a number of signals belonging to the group of signals defined by the heading code.

For case c, the signal information code 0 0 0 0 is used except with heading code 1 0 0 0 0 which alone is sufficient to identify the signal unit as an initial signal unit.

The allocation of signal information codes is shown in Table 1 at the end of this chapter.

3.1.3.3 *Label*

Messages which relate to a speech circuit (or a group or sub-group of speech circuits) must carry a label to identify that circuit (or group of circuits). Only one label per message is used.

To identify a group of up to sixteen speech circuits, a 7-bit *band number* is used (bits 10-16).

To identify a circuit within a group of up to sixteen speech circuits, an additional 4-bit code (circuit number) is used (bits 17-20). See Figure 5.

This provides a total of 11 bits which can be used to identify 2048 speech circuits.

Label codes will be assigned by the Administration concerned.

The label field position is in bits 10-20 of either a lone signal unit or an initial signal unit of a multi-unit message. Subsequent signal units of multi-unit messages do not require a label. Where a 7-bit band number alone is sufficient to identify the destination of a signal (e.g. some management signals), bits 17-20 can contain some further signalling information.

3.1.3.4 *Length indicator*

Subsequent signal units have a length indicator field of two bits (bits 3-4) to indicate the number of subsequent signal units contained in a multi-unit message. Each subsequent signal unit of a multi-unit message carries the same length indicator. The codes used are shown below.

Number of subsequent signal units	Length indicator	
	Initial address message	Other multi-unit messages
1	—	00
2	01	01
3	10	10
4	11	11
5	00	—

The length indicator 0 0 has a different, but unambiguous meaning in the initial address message because the initial address message has a minimum requirement of two subsequent signal units.

3.1.3.5 *Check*

Every signal unit has a check field of eight bits (bits 21-28) for error detection purposes (see Recommendation Q.277).

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3.2 TELEPHONE SIGNALS

3.2.1 Initial address message (IAM)

The initial address message (IAM) is the first message of a call. It is a special case of the multi-unit message as it consists of a minimum of three signal units and a maximum of six signal units. It can contain different types of information—address signals (including ST), other routing information, and the filler code—under the same heading code.

3.2.1.1 *Format of the initial address message*

The format of the initial signal unit is shown in Figure 5.

The format of the subsequent signal units is shown in Figure 6 except for the subsequent signal units numbers 2-5 in which the signal information field (bits 5-20) is sub-divided into four 4-bit parts so that four address signals can be carried in each of these subsequent signal units.

The subsequent signal units of an initial address message do not require the 5-bit heading or 11-bit label as this information is already contained in the initial signal unit.

The number of address signals available for transmission determines the length of the initial address message.

3.2.1.2 *Codes used in the initial address message*

a) *Initial signal unit*

— The 5-bit heading code 1 0 0 0 0 is used.

— The signal information code 0 0 0 0 is used.

— The assigned label code is used.

b) *Subsequent signal unit (number 1)*

— The heading code 0 0 is used.

— The length indicator is coded as appropriate (see Recommendation Q.257, section 3.1.3.4).

— Bit 5: country code indicator:

0 country code not included

1 country code included

— Bit 6: nature of circuit indicator:

0 no satellite circuit in the connection

1 one satellite circuit in the connection

— Bit 7: echo-suppressor indicator:

0 outgoing half-echo suppressor not included

1 outgoing half-echo suppressor included

— Bit 8: spare (reserved for international use) [1]

— Bits 9-12: spare (reserved for regional and/or national use) [1]

[1] *Note.* — These bits are coded as 0 at present.

— Bits 13-16: calling-party's-category indicator:

0 0 0 0	spare
0 0 0 1	operator, language French
0 0 1 0	operator, " English
0 0 1 1	operator, " German
0 1 0 0	operator, " Russian
0 1 0 1	operator, " Spanish
0 1 1 0 0 1 1 1 1 0 0 0	available to Administrations for selecting a particular language provided by mutual agreement
1 0 0 1	reserved (see Recommendation Q.104)
1 0 1 0	ordinary calling subscriber
1 0 1 1	calling subscriber with priority
1 1 0 0	data call
1 1 0 1	test call
1 1 1 0	spare
1 1 1 1	spare (reserved for regional and/or national use)

— Bits 17-20: spare (reserved for regional and/or national use) [1]

c) *Subsequent signal units (numbers 2-5) — telephone call*

— The heading code 0 0 is used.

— The length indicator is coded as appropriate (see Recommendation Q.257, section 3.1.3.4).

— The four 4-bits parts of the signal information field contain address signals in sequence, bit 5-8, bit 9-12, etc., and coded as follows:

0 0 0 0	filler (no information)
0 0 0 1	digit 1
0 0 1 0	" 2
0 0 1 1	" 3
0 1 0 0	" 4
0 1 0 1	" 5
0 1 1 0	" 6
0 1 1 1	" 7
1 0 0 0	" 8
1 0 0 1	" 9
1 0 1 0	" 0
1 0 1 1	code 11
1 1 0 0	code 12
1 1 0 1	spare
1 1 1 0	spare
1 1 1 1	ST

The filler code 0 0 0 0 is used where needed to complete the signal information field of the last subsequent signal unit of the initial address message.

d) *Subsequent signal unit (number 2)—test call*

— The heading code 0 0 is used.

— The length indicator is coded as appropriate (see Recommendation Q.257, section 3.1.3.4).

[1] *Note.* — These bits are coded as 0 at present.

— The first 4-bit part (bits 5-8) of the signal information field contains an address signal coded as follows:

0 0 0 0	System No. 6 continuity check
0 0 0 1	ATME 2 — signalling check and transmission test
0 0 1 0	ATME 2 — signalling check only
0 0 1 1	spare
0 1 0 0	spare
0 1 0 1	spare
0 1 1 0	spare
0 1 1 1	spare
1 0 0 0	spare
1 0 0 1	spare
1 0 1 0	spare
1 0 1 1	spare
1 1 0 0	spare
1 1 0 1	spare
1 1 1 0	spare
1 1 1 1	spare

The codes used to complete the signal information field of the subsequent signal unit (number 2)—test call are the end-of-pulsing (ST) and fillers.

3.2.1.3 *Example of an initial address message*

An example of a three-unit initial address message is shown in Figure 7/Q.258.

ISU	**1 0 0 0 0 / 0 0 0 0 / X X X X X X X X X X X / X X X X X X X X**
	heading code / signal information code / label / check
1st SSU	**0 0 / 0 1 / X X X 0 0 0 0 0 X X X X 0 0 0 0 / X X X X X X X X**
	* / ** / other routing information / check
2nd SSU	**0 0 / 0 1 / X X X X X X X X X X X X X X X X / X X X X X X X X**
	* / ** / 1st, 2nd, 3rd, 4th address signals / check

* = subsequent signal unit heading code
** = length indicator

FIGURE 7/Q.258. — **Example of a three-unit initial address message**

3.2.2 Subsequent address message (SAM)

A subsequent address message (SAM) is used to transmit additional address signals not available when the initial address message is formed.

A subsequent address message may be either a one-unit message or a multi-unit message.

3.2.2.1 *Formats of subsequent address messages*

a) *Lone signal unit*

The format of the lone signal unit is shown in Figure 5/Q.257.

b) *Multi-unit message*

The format of the initial signal unit is shown in Figure 5.

The format of the subsequent signal units is shown in Figure 6/Q.257. In this case, however, the signal information fields of every subsequent signal unit are sub-divided into four 4-bit parts.

3.2.2.2 *Codes used in subsequent address messages*

a) *Heading*

Heading codes in the range **1 0 0 0 1 - 1 0 1 1 1** are used in the lone signal unit or initial signal unit depending on the sequence number of the subsequent address message concerned. The first subsequent address message of a call uses heading **1 0 0 0 1**, the second **1 0 0 1 1**, the third **1 0 0 1 0**, etc. While it is preferred to limit the number of subsequent address messages, if more than seven are sent, the sequence is recycled so that the eighth uses heading code **1 0 0 0 1**.

Subsequent signal units of subsequent address messages use the heading code **0 0**.

b) *Signal information*

— *Lone signal unit*

In the case of a one-unit subsequent address message, the signal information field (bits 6-9) contains one of the address signals which are coded as follows:

0 0 0 1	digit 1
0 0 1 0	" 2
0 0 1 1	" 3
0 1 0 0	" 4
0 1 0 1	" 5
0 1 1 0	" 6
0 1 1 1	" 7
1 0 0 0	" 8
1 0 0 1	" 9
1 0 1 0	" 0
1 1 1 1	ST

Codes **1 0 1 1**, **1 1 0 0**, **1 1 0 1**, **1 1 1 0** and **0 0 0 0** are not used in the signal information field of a one-unit subsequent address message.

— *Multi-unit message*

The signal information field of the initial signal unit is coded as **0 0 0 0**.

The signal information field of the subsequent signal units contains the address signals which are coded as follows:

0 0 0 0	filler (no information)
0 0 0 1	digit 1
0 0 1 0	" 2
0 0 1 1	" 3
0 1 0 0	" 4
0 1 0 1	" 5
0 1 1 0	" 6
0 1 1 1	" 7
1 0 0 0	" 8
1 0 0 1	" 9
1 0 1 0	" 0
1 1 1 1	ST

Signal information codes **1 0 1 1**, **1 1 0 0**, **1 1 0 1** and **1 1 1 0** are not used in multi-unit subsequent address messages.

The filler code 0 0 0 0 is used, where needed, to complete the signal information field of the last subsequent signal unit of the subsequent address message.

c) *Label*

The assigned label code is used.

3.2.3 Other telephone signals

3.2.3.1 *Telephone signals with heading code* 1 0 0 0 0.

The following signal information codes, in conjunction with heading code 1 0 0 0 0, are allocated:

0 0 0 0	initial signal unit of an initial address message (see Recommendation Q.258, section 3.2.1.2)	
0 0 0 1	spare (reserved for international use)	
0 0 1 0	spare	(reserved for regional and/or national use)
0 0 1 1	spare	
0 1 0 0	spare	
0 1 0 1	spare	
0 1 1 0	spare	
0 1 1 1	spare	
1 0 0 0	spare	
1 0 0 1	spare	
1 0 1 0	spare	
1 0 1 1	spare	
1 1 0 0	spare	
1 1 0 1	spare	
1 1 1 0	spare	
1 1 1 1	spare	

The formats for messages using signal information code 0 0 0 1 have not yet been decided. The formats for messages using signal information codes in the range 0 0 1 0 -1 1 1 1 will be determined by regional organizations and/or national Administrations.

3.2.3.2 *Telephone signals with heading code* 1 1 0 0 0

The format of one-unit telephone signals using heading code 1 1 0 0 0 is shown in Figure 5/Q.257.

Signals, sent in the backward direction, in lone signal units using heading code 1 1 0 0 0, are allocated signal information codes as follows:

0 0 0 1	release-guard
0 0 1 0	answer, charge (priority)
0 0 1 1	answer, no charge (priority)
0 1 0 0	clear-back No. 1
0 1 0 1	reanswer No. 1
0 1 1 0	clear-back No. 2
0 1 1 1	reanswer No. 2
1 0 0 0	clear-back No. 3
1 0 0 1	reanswer No. 3
1 0 1 0	spare
1 0 1 1	spare
1 1 0 0	spare
1 1 0 1	spare
1 1 1 0	spare
1 1 1 1	spare

Signal information code 0 0 0 0 indicates that the signal unit is the initial signal unit of a multi-unit message. This facility is reserved for possible future expansion.

3.2.3.3 *Telephone signals with heading code* 1 1 0 0 1

The format of one-unit telephone signals using heading code 1 1 0 0 1 is shown in Figure 5/Q.257.

Signals, sent in the backward direction, in lone signal units using heading code 1 1 0 0 1, are allocated signal information codes as follows:

0 0 0 1	spare
0 0 1 0	spare
0 0 1 1	switching-equipment-congestion
0 1 0 0	circuit-group-congestion
0 1 0 1	national-network-congestion
0 1 1 0	spare
0 1 1 1	spare
1 0 0 0	call-failure
1 0 0 1	spare
1 0 1 0	spare
1 0 1 1	spare
1 1 0 0	spare
1 1 0 1	spare
1 1 1 0	confusion
1 1 1 1	spare

Signal information code 0 0 0 0 indicates that the signal unit is the initial signal unit of a multi-unit message. This facility is reserved for possible future expansion.

3.2.3.4 *Telephone signals with heading code* 1 1 0 1 0

The format of one-unit telephone signals using heading code 1 1 0 1 0 is shown in Figure 5/Q.257.

Signals, in lone signal units using heading code 1 1 0 1 0, are allocated signal information codes as follows:

0 0 0 1	continuity	sent in the forward direction
0 0 1 0	clear-forward	sent in the forward direction
0 0 1 1	forward-transfer	sent in the forward direction
0 1 0 0	spare	
0 1 0 1	spare	
0 1 1 0	spare	
0 1 1 1	spare	
1 0 0 0	spare	
1 0 0 1	spare	
1 0 1 0	spare	
1 0 1 1	blocking	sent in either direction
1 1 0 0	unblocking	sent in either direction
1 1 0 1	blocking-acknowledgement	sent in either direction
1 1 1 0	unblocking-acknowledgement	sent in either direction
1 1 1 1	message-refusal	sent in either direction

Signal information code 0 0 0 0 indicates that the signal unit is the initial signal unit of a multi-unit message. This facility is reserved for possible future expansion.

3.2.3.5 *Telephone signals with heading code* 1 1 0 1 1

The format of one-unit telephone signals using heading code 1 1 0 1 1 is shown in Figure 5/Q.257.

Signals, sent in the backward direction, in lone signal units using heading code 1 1 0 1 1, are allocated signal information codes as follows:

0 0 0 1 address-complete, subscriber-free, charge
0 0 1 0 address-complete, subscriber-free, no charge
0 0 1 1 address-complete, subscriber-free, coin-box
0 1 0 0 subscriber-busy (electrical)
0 1 0 1 vacant-national number
0 1 1 0 line-out-of-service
0 1 1 1 subscriber-transferred (changed number)
1 0 0 0 spare
1 0 0 1 spare
1 0 1 0 address-complete, charge
1 0 1 1 address-complete, no charge
1 1 0 0 address-complete, coin-box
1 1 0 1 address-incomplete
1 1 1 0 spare
1 1 1 1 spare

Signal information code 0 0 0 0 indicates that the signal unit is the initial signal unit of a multi-unit message. This facility is reserved for possible future expansion.

3.2.3.6 *Reserved heading codes*

The signal information codes under the heading codes 0 1 0 0 0, 0 1 0 0 1, 0 1 0 1 0, 0 1 0 1 1, 1 1 1 0 0, 1 1 1 1 0 and 1 1 1 1 1 are reserved for regional and/or national use.

Signal information code 0 0 0 0 indicates that the signal unit is the initial signal unit of a multi-unit message. This facility is reserved for possible future expansion.

3.2.4 Examples of address messages

Examples of address messages are given below to elucidate the formats and codes adopted for address messages. As there is no telephone signal information contained in the check fields of the signal units, these fields are not shown in the examples.

3.2.4.1 *Transit call* from U.S.A. (international exchange New York) to the Netherlands (international exchange Amsterdam) via the United Kingdom (transit exchange London).

Assumptions:
- Semi-automatic traffic, English language.
- The signalling links New York-London and London-Amsterdam are both associated with their respective speech circuit groups.
- Speech path New York-London is a satellite circuit equipped with echo suppressors, speech path London-Amsterdam is a cable circuit not equipped with echo suppressors (due to bilateral agreement between the Administrations concerned).
- Dialled information: 31 2150 43551.
- " En bloc " operation.

a) *Address message New York-London*

```
10000/0000/ 000 0101/0011
00/11/1110 0000 0010 0000
00/11/0011/0001/0010/0001
00/11/0101/1010/0100/0011
00/11/0101/0101/0001/1111
```

b) *Address message London-Amsterdam*

```
10000/0000/ 000 0000/1010
00/11/0100 0000 0010 0000
00/11/0010/0001/0101/1010
00/11/0100/0011/0101/0101
00/11/0001/1111/0000/0000
```

The intermediate CT London serves as a transit exchange.

3.2.4.2 *Direct call* from the Netherlands (international exchange Amsterdam) to U.S.A. (international exchange New York).

Assumptions:
- Automatic traffic, ordinary subscriber.
- Speech path Amsterdam-New York is a cable circuit equipped with echo suppressors.
- Speech circuit group Amsterdam-New York has no associated signalling link. Signal information will be transferred via the two signalling links Amsterdam-London and London-New York in tandem, thus using a quasi-associated mode of operation.
- Dialled information: 1 201 949 5813.
- " Overlap with subscribers' dialling " operation.

a) *Address messages Amsterdam-London*

```
10000/0000/ 001 0000/1001 )
00/10/0010 0000 1010 0000 } Initial address message
00/10/0010/1010/0001/1001 }
00/10/0100/1001/0000/0000 )
10001/0101/ 001 0000/1001  —First subsequent address message
10010/1000/ 001 0000/1001  —Second subsequent address message
10011/0001/ 001 0000/1001  —Third subsequent address message
10100/0011/ 001 0000/1001  —Fourth subsequent address message
10101/1111/ 001 0000/1001* —Fifth subsequent address message
```

* ST-signal, sent if the end of the address has been recognized.

b) *Address messages London-New York*

Exactly the same messages are sent as under a.

The London exchange serves as signal transfer point only. It is assumed that by agreement between the Administrations concerned there is no need for a change of label at this signal transfer point.

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3.3 SIGNALLING-SYSTEM-CONTROL SIGNALS

3.3.1 General

The signalling-system-control signals are not related to telephone signal information. They are necessary for the proper functioning of the signalling system.

All signalling-system-control signals specified (see Recommendation Q.255) are transferred by means of lone signal units:

Acknowledgement signal unit,
Synchronization signal unit and
System-control signal unit.

3.3.2 Acknowledgement signal unit (ACU)

The function of the acknowledgement signal unit (ACU) is described in Recommendation Q.251.

3.3.2.1 *Format of the ACU*

The format of the ACU is given in Figure 8/Q.259.

0 1 1 /	X X X X X X X X X X X /	X X X /	X X X /	X X X X X X X X
1-3	4-14	15-17	18-20	21-28
heading code	acknowledgement indicators	*	**	check

* sequence number of block being acknowledged
** sequence number of block completed by this ACU

FIGURE 8/Q.259. — **Format of the acknowledgement signal unit**

3.3.2.2 *Codes for the ACU parts*

a) *Heading*

The heading code 0 1 1 is used.

b) *Acknowledgement indicators*

The ACU contains eleven acknowledgement indicators to acknowledge sequentially the corresponding eleven signal units of a block received. That is, bit 4 refers to the first signal unit in the block being acknowledged, bit 5 refers to the second, etc. Each indicator will be coded in the following way:

0 no error detected
1 error detected

The " error detected " condition includes signals rejected by the terminal as covered in Recommendations Q.277, Q.278 and Q.293, section 8.6.1.

c) *Sequence numbers*

Both the block being acknowledged and the block completed by the ACU are indicated by cyclic sequence numbers from the series 0 0 0, 0 0 1, 0 1 0, 0 1 1, 1 0 0, 1 0 1, 1 1 0, 1 1 1, 0 0 0...

3.3.3 Synchronization signal unit (SYU)

The function of the synchronization signal unit (SYU) is described in Recommendation Q.251.

3.3.3.1 *Format of the SYU*

The format of the SYU is given in Figure 9/Q.259.

1 1 1 0 1 / 1 1 0 1 / 1 1 0 0 0 1 1	X X X X	X X X X X X X X
1-16	17-20	21-28
synchronization pattern	*	check

* sequence number of signal unit in the block

FIGURE 9/Q.259. — **Format of the synchronization signal unit**

3.3.3.2 *Codes for the SYU parts*

a) *Synchronization pattern*

This pattern is coded as: 1 1 1 0 1 1 1 0 1 1 1 0 0 0 1 1

The first nine bits of the synchronization pattern may be considered to contain the heading and signal information fields which are coded 1 1 1 0 1 and 1 1 0 1 respectively.

The heading code 1 1 1 0 1 is used for signalling-system-control signals (except ACU) as well as for management signals. The spare signal information codes can be allocated either to system-control signals or to management signals.

b) *Signal unit sequence number*

The sequence number may have any code of the 4-bit binary code 0 0 0 0, 0 0 0 1, 0 0 1 0 up to 1 0 1 0 inclusive. The number chosen for a synchronization signal unit is determined by the position of that synchronization signal unit in the block of signal units.

The remaining codes 1 0 1 1 to 1 1 1 1 are not assigned.

3.3.4 System-control signal units (SCU)

3.3.4.1 *Format of an SCU*

The format of an SCU is given in Figure 10/Q.259.

1 1 1 0 1	1 1 0 0	X X X	X X X X	X X X X	X X X X X X X X
1-5	6-9	10-12	13-16	17-20	21-28
heading code	signal information code	control information			check

FIGURE 10/Q.259. — **Format of a system-control signal unit**

3.3.4.2 *Codes for the SCU parts*

a) *Heading*

The heading code 1 1 1 0 1 is used.

The heading code 1 1 1 0 1 is used for signalling-system-control signals (except ACU) as well as management signals. The spare signal information codes can be allocated either to system-control signals or to management signals.

b) *Signal information*

The signal information code 1 1 0 0 is used.

c) *Control information*

— bits 10-12 are coded as 0 0 1. The other codes are spare.

— bits 13-16 are coded as 0 0 0 1. The other codes are spare.

— bits 17-20 system-control signals, defined in Recommendation Q.255, are coded as follows:

0 0 0 0	spare
0 0 0 1	changeover
0 0 1 0	manual-changeover
0 0 1 1	spare
0 1 0 0	standby-ready
0 1 0 1	spare
0 1 1 0	load-transfer
0 1 1 1	emergency-load-transfer
1 0 0 0	spare
1 0 0 1	spare
1 0 1 0	manual-changeover-acknowledgement
1 0 1 1	spare
1 1 0 0	standby-ready-acknowledgement
1 1 0 1	spare
1 1 1 0	load-transfer-acknowledgement
1 1 1 1	spare

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3.4 MANAGEMENT SIGNALS

3.4.1 General

Management signals may include:

— network-management signals,

— network-maintenance signals,

— signalling-network-management signals,

i.e. signals concerned with the management of the signalling network and of the speech circuit network.

These signals may be transferred by means of one-unit messages or multi-unit messages.

3.4.1.1 *Basic format of management signals*

The basic format of a one-unit management message is shown in Figure 11/Q.259.

1 1 1 0 1 /	X X X X /	X X X X X X X X X X X /	X X X X X X X X
1-5	6-9	10-20	21-28
heading code	signal information	management information	check

FIGURE 11/Q.260. — **Basic format of a one-unit management message**

The management information field, bits 10-20, may be subdivided as required. When a band number is included in the management signal unit, it is placed in bits 10-16.

The format of multi-unit management signals has not yet been decided.

3.4.1.2 *Codes for management signals*

a) *Heading*

The heading code 1 1 1 0 1 is used. This code is also assigned to signalling-system-control signals (except ACU). See Recommendation Q.259.

b) *Signal information*

Signal information codes are assigned as follows:

0 0 0 1	network-management and network-maintenance signal units
0 0 1 0	spare
0 0 1 1	spare
0 1 0 0	spare
0 1 0 1	signalling-network-management signal unit
0 1 1 0	spare (reserved for regional and/or national use)
0 1 1 1	spare (reserved for regional and/or national use)
1 0 0 0	spare
1 0 0 1	spare
1 0 1 0	spare
1 0 1 1	spare
1 1 0 0	SCU (see Recommendation Q.259)
1 1 0 1	SYU (see Recommendation Q.259)
1 1 1 0	spare (reserved for regional and/or national use)
1 1 1 1	spare (reserved for regional and/or national use)

Signal information code 0 0 0 0 indicates that the signal unit is the initial signal unit of a multi-unit message. This facility is reserved for possible future expansion.

The spare international signal information codes may be assigned to either management signals or signalling-system-control signals.

c) *Management information*

The codes used in the management information field are shown later in this Recommendation.

3.4.2 Network-management signals

As network-management signals have not yet been defined, no detailed format can be given, except for the heading and signal information fields, which are coded as 1 1 1 0 1 and 0 0 0 1 respectively.

3.4.3 Network-maintenance signals

As network-maintenance signals have not yet been defined, no detailed format can be given, except for the heading and signal information fields, which are coded as 1 1 1 0 1 and 0 0 0 1 respectively.

3.4.4 Signalling-network-management signals

3.4.4.1 *Format of a signalling-network-management signal*

The format of a one-unit signalling-network-management message is given in Figure 12/Q.260.

1 1 1 0 1	0 1 0 1	X X X X X X X	X X X X	X X X X X X X X
1-5	6-9	10-16	17-20	21-28
heading code	signal information code	band number	management information	check

FIGURE 12/Q.260. — **Format of a one-unit signalling-network-management message**

3.4.4.2 *Codes for the signalling-network-management signal unit parts*

a) *Heading*

The heading code 1 1 1 0 1 is used.

b) *Signal information*

The signal information code 0 1 0 1 is used.

c) *Band number*

The band number (bits 10-16) indicates the group or sub-group of circuits to which the signal refers (see Recommendation Q.257).

d) *Management information*

The codes used in the management information field are allocated as follows:

0 0 0 0 spare
0 0 0 1 spare
0 0 1 0 spare
0 0 1 1 spare
0 1 0 0 spare
0 1 0 1 transfer-prohibited
0 1 1 0 transfer-allowed
0 1 1 1 spare
1 0 0 0 transfer-allowed-acknowledgement
1 0 0 1 spare
1 0 1 0 spare
1 0 1 1 spare
1 1 0 0 spare
1 1 0 1 spare
1 1 1 0 spare
1 1 1 1 spare

TABLE 1

ALLOCATION OF HEADING AND SIGNAL INFORMATION CODES

Bits 6-9 \ Bits 1-5	0000 x	0001X	0010 X	0011 X	01000	01001	01010	01011	011XX	10000	10001	10010	10011	10100	10101	10110	10111	11000	11001	11010	11011	11100	11101	11110	11111	Bits 1-5 / Bits 6-9
0000	SSU				ISU of MUM	ISU of MUM	ISU of MUM	ISU of MUM		ISU of IAM	ISU of SAM 1	ISU of SAM 2	ISU of SAM 3	ISU of SAM 4	ISU of SAM 5	ISU of SAM 6	ISU of SAM 7	ISU of MUM	ISU of MUM	ISU of MUM	ISU of MUM	ISU of MUM	ISU of MUM	ISU of MUM	ISU of MUM	0000
NOT 0000					LSU	LSU	LSU	LSU		ISU of MUM	Lone SAM 1	Lone SAM 2	Lone SAM 3	Lone SAM 4	Lone SAM 5	Lone SAM 6	Lone SAM 7	LSU	LSU	LSU	LSU	LSU	LSU	LSU	LSU	NOT 0000
0000	ONE SSU or FIVE SSUs (IAM only)	TWO SSUs	THREE SSUs	FOUR SSUs	RESERVED FOR REGIONAL and/or NATIONAL USE	RESERVED FOR REGIONAL and/or NATIONAL USE	RESERVED FOR REGIONAL and/or NATIONAL USE	RESERVED FOR REGIONAL and/or NATIONAL USE	ACU													RESERVED FOR REGIONAL and/or NATIONAL USE		RESERVED FOR REGIONAL and/or NATIONAL USE	RESERVED FOR REGIONAL and/or NATIONAL USE	0000
0001											Digit 1	Digit 1	Digit 1	Digit 1	Digit 1	Digit 1	Digit 1	RLG		COT	AFC		NMM			0001
0010										RESERVED FOR REGIONAL and/or NATIONAL USE	2	2	2	2	2	2	2	ANC		CLF	AFN					0010
0011											3	3	3	3	3	3	3	ANN	SEC	FOT	AFX					0011
0100											4	4	4	4	4	4	4	CB 1	CGC		SSB					0100
0101											5	5	5	5	5	5	5	RA 1	NNO		VNN		SNM			0101
0110											6	6	6	6	6	6	6	CB 2			LOS		REGIONAL and/or NATIONAL			0110
0111											7	7	7	7	7	7	7	RA 2			SST					0111
1000											8	8	8	8	8	8	8	CB 3	CFL							1000
1001											9	9	9	9	9	9	9	RA 3								1001
1010											0	0	0	0	0	0	0				ADC					1010
1011																				BLO	ADN					1011
1100																				UBL	ADX		SCU			1100
1101																				BLA	ADI		SYU			1101
1110																			COF	UBA			REGIONAL and/or NATIONAL			1110
1111											ST	ST	ST	ST	ST	ST	ST			MRF						1111

CCITT-5441A.

Note. — All unassigned codes are reserved for international use.

The interpretation of the abbreviations for signals is given in the List of abbreviations on the inside of the flap of the cover at the end of the volume.

CHAPTER IV

Signalling procedures

(Including interworking with systems No. 4 and No. 5)

Recommendation Q.261

4.1 NORMAL CALL SET-UP

4.1.1 Initial address message

An initial address message which is sent as the first message of a call set-up generally includes all of the information required by the next international exchange to route the call. The seizing function is implicit in the reception of this initial address message. The format of the initial address message is given in Recommendation Q.258.

The initial address message (IAM) will contain the following signalling information:

a) country-code indicator,

b) nature-of-circuit indicator,

c) echo-suppressor indicator,

d) calling-party's category,

e) address signals.

The *country code indicator* provides information as to whether or not a country code is included in the address signals. It is necessary in system No. 6 as the country code is not sent to the incoming international exchange.

This indicator must be translated to the appropriate signal for transmission over succeeding circuits using other signalling systems.

Interworking with other systems is specified in the parts of the *Green Book* covering those systems.

The *nature-of-circuit indicator* provides information as to whether or not this circuit or any preceding circuit in the connection has traversed a high-altitude satellite, and makes it possible for an international transit exchange to ensure that a second high-altitude circuit is included only in known exceptional circumstances.

The *echo-suppressor indicator* provides information as to whether or not a standard outgoing half-echo suppressor (Recommendation G.161) has been included in the forward direction at a preceding international exchange. Receipt of this signal marked "1" indicates that a standard incoming half-echo suppressor should be included in the backward direction at the last four-wire exchange in the connection. Exceptionally, it is possible for the echo suppressors to be inserted at a point other than the last four-wire exchange on the basis of this signal.

The use of an echo suppressor at an international transit exchange must be by agreement and only in those connections which have been analyzed and where it has been found that the transmission requirements are fulfilled.

Recommendation Q.115 covers the arrangements for control of echo suppressors.

The *calling-party's-category indicator* is used to indicate the type of caller originating the call, e.g. ordinary caller, operator or data caller and may indicate that a special routing is required. The *language and discriminating information* is included in the calling-party's category. It will be necessary to translate the language digit received from an operator in semi-automatic working or a discriminating digit received from a preceding link to the appropriate calling-party's-category code. The language or discriminating information must be translated from the calling-party's-category indicator to the appropriate digit for transmission over a circuit using system No. 4 or system No. 5 in a succeeding link.

The *sending sequence of address information* will be the country code (not sent to an incoming international exchange) followed by the national (significant) number. For calls to code 11 and code 12, refer to Recommendation Q.107.

All digits required for routing the call through the international network will be sent in the *initial address message*. On calls with a country code in the address (except in the case of calls to special operators), the initial address message will contain a minimum of four digits and should contain as many as are available. All digits of the address may be included. In a terminal link, the initial address may contain one digit. Thus, the initial address message could consist of as few as three signal units (one digit) or as many as six signal units. Although 15 digits and ST could be included in a six-unit message, the international numbering plan allows only 12 digits.

Selection of the outgoing national circuit normally can start at the incoming international exchange on receipt of the initial address message and signalling can proceed on the first national link.

Note. — When interworking towards another signalling system with fewer facilities, it will be necessary to discard some of the signals, e. g. nature-of-circuit indicator and echo-suppressor indicator.

When no echo suppressor or nature-of-circuit indication is received from a preceding circuit using a signalling system with fewer facilities, the indicators will be considered as received "*no*" unless positive knowledge is available.

4.1.2 Subsequent address messages

The remaining digits, if any, of the address may be sent individually in one-unit messages or in groups in multi-unit messages. Efficiency can be gained by grouping together as many digits as possible. However, to prevent an increase in post-dialling delay in those cases where overlap operation with subscribers' dialling is used, it may be desirable to send the last few digits individually. The number of signal units used in a subsequent address message may be from one to four. If the outgoing circuit from an international transit exchange is equipped with system No. 5, any digits received in overlap must be grouped for " en bloc " sending.

Subsequent address messages can be sent on to the national network as they are received. Appropriate measures (e.g. by withholding the last digit(s) of the national number) must be taken at the last common channel exchange, to prevent ringing the called subscriber or alerting the operator until the continuity of the speech circuits served by the common channels has been verified.

The *sequence of address messages* may be disturbed in the event that one or more messages have been retransmitted because of an error. To prevent the assembly of digits in an incorrect sequence, the last No. 6 or common channel exchange must examine the sequence number included in each address message and reassemble the digits if necessary. In some instances, intermediate common channel exchanges must also resequence address messages; refer to Recommendation Q.262, section 4.2.1.

4.1.3 End-of-pulsing (ST) signal

The ST signal is always sent in the following situations:

a) semi-automatic calls,

b) test calls, and

c) when tbe ST is received from a preceding circuit.

In automatic working, this signal will be sent whenever the outgoing international exchange is in a position to know, by digit analysis, that the final digit has been sent. Digit analysis may consist of an examination of the country code and counting of the maximum (or fixed) number of digits of the national number. In other cases, the ST signal is not sent and the end-of-address information is determined by the receipt of one of the address-complete signals from the incoming international exchange.

4.1.4 Continuity check of the speech path

The continuity check is described in Chapter V. The use of the loop method of continuity checking requires that any echo suppressors in the check loop be disabled. Each No. 6 exchange must disable any echo suppressor in that exchange, which is required to be active for the speech connection, for the period of attachment of tbe *continuity-check loop* or *transceiver*.

Each No. 6 exchange will connect the transceiver to the outgoing speech circuit when the initial address message is sent (see Recommendation Q.271, section 5.7.2 a).

The first No. 6 exchange will send forward the *continuity signal* after completion of the following conditions:

— the continuity check performed on the outgoing circuit is completed,

— the speech path across the exchange has been checked and found correct (Recommendation Q.271 section 5.2), and

— if the preceding link is a common channel link, receipt of a continuity signal from the preceding exchange.

Succeeding intermediate No. 6 exchanges will send forward the continuity signal after the completion of the three following conditions:

— a continuity signal is received from the preceding link,

— the speech path across the exchange has been checked and found correct (Recommendation Q.271 section 5.2), and

— the continuity check performed on the outgoing circuit is completed.

The speech path may be switched through at an international exchange and the transceiver disconnected after the continuity check of the circuit has been successfully completed. However, the switching through of the speech path should be delayed until the residual check tone has propagated through the return path of the speech circuit. This determination may be made by timing, or by using the check-tone receiver to test for the removal of the check-tone or other appropriate means.

On receipt of the continuity signal in the following international exchange, the continuity-check loop will be removed. Also, any digits of the national number which were withheld may be released (see section 4.1.2).

At the No. 6 exchange, on failure of the outgoing circuit to satisfy the continuity check:

— the continuity-check transceiver will be removed and an automatic repeat attempt will be made on another circuit,

— the outgoing terminal of the faulty circuit will be removed from service,

— a blocking signal will be sent to the following exchange, and

— after receipt of the blocking-acknowledgement signal, a clear-forward release-guard sequence will take place.

A *repeat of the continuity check* of the speech path will be made on the failed outgoing circuit within 1 to 10 seconds of receipt of the release-guard signal.

The second continuity check will be initiated by the No. 6 exchange detecting the failure, using the test call procedure specified in Recommendation Q.295, section 9.1.1. The address information shall contain the code 0 0 0 0 to notify the incoming exchange that the test call is not to be switched through.

If the repeated check passes on this test call, the speech circuit will be unblocked and returned to service. If the check fails, the maintenance staff will be alerted that a failure has occurred and the circuit has been blocked.

In either case the test call is terminated using the clear-forward release-guard sequence.

According to transmission maintenance requirements, system No. 6 should provide for:

a) a print-out each time a second continuity check is started. In such cases, the circuit involved should be identified;

b) a print-out each time a continuity check results in a warning being given to maintenance personnel.

Continuity check by means of the test call procedure may be performed at any time as required under the control of the maintenance staff. In these circumstances, although the test call is always terminated by the clear-forward signal, the blocking and unblocking signals are sent only at the discretion of the maintenance staff.

The second continuity check is not performed in the case of check failure in test calls (see Recommendation Q.295, section 9.1.1).

Since a continuity check failure can be caused by a faulty transceiver, precautions should be taken to ensure a low probability of selecting a faulty one for both the initial continuity check and the second check, e.g. by ensuring the selection of a different transceiver for each of the checks.

4.1.5 Address-complete signals

The address-complete signals should be originated either in or as close as possible to the called-party's-exchange since they imply that no further electrical called-party's-line condition signals or congestion signals (see, however, 4.1.7) will be sent. An address-complete signal will not be sent until the continuity signal has been received and the cross-office check made, if applicable.

If the succeeding network does not provide electrical called-party's-line-condition signals, the last No. 6 exchange shall originate and send an address-complete signal when the end of address signalling has been determined:

a) by receipt of an end-of-pulsing (ST) signal,

b) by receipt of the maximum number of digits used in the national numbering plan,

c) by analysis of the national (significant) number to indicate that a sufficient number of digits has been received to route the call to the called party,

d) by receipt of an end-of-selection signal from the succeeding network (e.g. number received signal in system No. 4), or

e) exceptionally, if the succeeding network uses overlap pulsing and number analysis is not possible, by observing that 4 to 10 (for new equipment 4 to 6) seconds have elapsed since the last digit was received, and that no fresh information has been received; in such circumstances, transmission to the national network of the last digit received must be prevented until the end of the waiting period which causes an address-complete signal to be sent over the international circuit. In this way, it is ensured that no national answer signal can arrive before an address-complete signal has been sent.

If the succeeding circuit in a connection utilizes system No. 5, the last No. 6 exchange shall originate and send an address-complete signal whenever the conditions for sending the end-of-pulsing (ST) signal over the No. 5 circuit have been met as specified in Recommendation Q.152.

When the last No. 6 (common channel) exchange receives an address-complete or equivalent signal, it will release routing and address information from memory and transmit the address-complete signal over the preceding link after receipt of the continuity signal.

If in normal operation delay in the receipt of an address-complete or equivalent signal from the succeeding network is expected, the last common channel exchange will originate and send an address-complete signal 15 to 20 seconds after receiving the latest address message. See Recommendation Q.268, section 4.8.4.1 a.

An intermediate No. 6 exchange which receives an address-complete signal will release routing and address information from memory and transmit the signal over the preceding link.

On receipt of an address-complete signal, the first No. 6 exchange will release registers and through-connect the speech path of the interconnected circuit, release address and routing information from memory and transmit the same or an equivalent signal over the preceding link.

When interworking from system No. 4 to system No. 6, the number-received signal will be sent over the system No. 4 link on receipt of the end-of-pulsing signal (ST) from the system No. 4 link or an address-complete signal from the system No. 6 link. However, the number-received signal will also be sent on failure to receive one of those signals within 4 to 6 seconds after reception of the latest digit.

Unless the exchange originating an address-complete signal has the ability to determine that a called number is a coin-box or a no charge number, the address-complete charge signal will be sent.

After an address-complete signal, only the following signals relating to the call may be sent:

a) in normal operation, one of the answer signals, clear-back or release-guard signals,

b) call-failure signal (section 4.8.3), message-refusal signal (section 4.6.2.3), or

c) when interworking with systems No. 4 and No. 5, one of the congestion signals derived from busy-flash signals (section 4.1.7).

Any further information about the called-party's line condition or congestion will be transmitted to the calling subscriber or operator as audible tones or announcements.

The appropriate address-complete, subscriber-free signal is sent as an alternative to the address-complete signals given above when it is known that the called subscriber's line is free (not busy). It must be originated in the called subscriber's exchange, and therefore cannot be followed by the busy-flash signal. The procedures for handling the address-complete, subscriber-free signals are the same as for the other address-complete signals when generated in the called subscriber's exchange.

4.1.6 Address-incomplete signal

The address-incomplete signal is sent whenever it can be determined that the proper number of digits has not been received. This determination can be made at once if the end-of-pulsing (ST) signal is received or by receipt of an address-incomplete signal (or equivalent) from the national network. When overlap working is used, and the end-of-pulsing (ST) signal has not been received, the address-incomplete signal will be sent by the last common channel exchange 15 to 20 seconds after receipt of the latest digit.

If the incoming international exchange has already generated and sent an address-complete signal as described in section 4.1.5, an address-incomplete signal received from the succeeding network will be suppressed and the suitable tone or announcement sent.

Each No. 6 exchange on receipt of the address-incomplete signal will send the signal to the preceding No. 6 (common channel) exchange, if any, clear forward the connection, and remove the record of the call from memory. The first common channel exchange will send the appropriate tone or announcement, if any, for the national network concerned to the calling party.

4.1.7 Congestion signals

The three types of congestion signals are defined in sections 2.1.12 to 2.1.14 of Recommendation Q.254. The congestion signals may be sent without waiting for the completion of the continuity-check sequence. Reception of a congestion signal at any No. 6 exchange will cause the clear-forward signal to be sent and either cause:

a) an automatic repeat attempt to be made (section 4.4), or

b) the appropriate signal or the appropriate audible tone or announcement to be sent to the preceding international exchange or to the national network.

If a busy-flash signal is received from a succeeding international link which uses another signalling system, it shall be coded as a circuit-group-congestion signal on system No. 6. Any of the congestion signals from system No. 6—i.e. switching equipment, circuit group, national network—will be converted to a busy-flash signal for transmission over a preceding link using system No. 4 or system No. 5.

If a signal equivalent to a busy-flash signal is received by an incoming international exchange from a national network, it should be coded as a national-network-congestion signal to be transmitted on system No. 6.

4.1.8 Called-party's-line-condition signals

The following signals will be sent when the appropriate electrical signals are received at the incoming international exchange from the national networks:

Subscriber-busy signal (electrical),

Line-out-of-service signal,

Vacant-national-number signal, or

Subscriber-transferred signal.

These signals will be sent without waiting for the completion of the continuity check.

On receipt of one of these signals, the first common channel exchange (or the outgoing international exchange) will clear forward the connection and cause an appropriate indication to be given to the originating subscriber or operator.

Each No. 6 exchange on receipt of a subscriber-busy, line-out-of-service, vacant-national-number or subscriber-transferred signal can clear forward the connection. Preceding links using system No. 4 or system No. 5 will be able to transmit only the busy-flash signal; these conditions must be indicated by appropriate audible tones or announcements.

4.1.9 Answer signals

The signals answer, charge and answer, no charge are sent as received from the national network or from the succeeding international link.

The answer, no charge signal shall be used when:

a) an answer, no charge signal is received from a succeeding link, or

b) an answer signal is received and an address-complete, no charge or equivalent signal has been sent to a preceding link.

The answer, no charge signal will be suppressed when the preceding signalling system does not include a no-charge signal, either address-complete, no charge, answer, no charge or equivalent.

The signals answer, charge and answer, no charge are used only as a result of the first off-hook signal from the called party and are priority signals.

4.1.10 Clear-back signals

A clear-back signal is sent when the called party clears before a clear-forward signal has been received. A clear-back signal must not disconnect the speech path at a No. 6 international exchange. The requirements for the release of a connection in the event that a clear-forward signal is not received are given in Recommendation Q.118.

4.1.11 Reanswer and clear-back signal sequences

Subsequent off-hook, on-hook signals from the called party, such as will result from switch-hook flashing, will cause the following sequence of signals to be sent:

Clear-back No. 1
Reanswer No. 1
Clear-back No. 2
Reanswer No. 2
Clear-back No. 3
Reanswer No. 3
Clear-back No. 1
etc.

Following the suppression of an answer signal (section 4.1.9), all subsequent clear-back and reanswer signals must be suppressed.

In contrast to the answer signal, the reanswer signal has no special priority. The sequence numbering of the clear-back and reanswer signals makes it possible for the first system No. 6 exchange to reassemble the sequence in proper order in the event that the original sequence is disturbed as a result of retransmission of one or more of the signals. It is necessary, however, that a flashing sequence be retransmitted to the operator (or the preceding link) and that the final condition of the circuit represents the final position of the called party's switch hook. A reanswer signal is transmitted as an answer signal over a preceding link using system No. 4 or system No. 5.

4.1.12 Forward-transfer signal

The forward-transfer signal may be sent in semi-automatic working in either of the following two cases:

a) following a call switched automatically to a subscriber, or following a call established via a special operator, the controlling operator wishes to call in an assistance operator. On receipt of the forward-transfer signal at the incoming international exchange, an assistance operator is called in;

b) following a call via code 11 or code 12, the controlling operator wishes to recall the incoming operator at the incoming international exchange. Receipt of the forward-transfer signal at the incoming international exchange recalls the incoming operator on calls completed via the operator positions at the exchange.

4.1.13 Clear-forward and release-guard signal sequence

The clear-forward signal is overriding and all international exchanges must be in a position to respond by releasing the circuit and sending a release-guard signal at any time during the progress of a call and even if the circuit is in the idle condition. The clear-forward signal is sent only after all equipment has been released, information concerning the call has been released from memory and the circuit is available for a new incoming call. Receipt of a clear-forward signal will cause all associated equipment to be returned to the idle condition and all information concerning the call to be released from memory. If sent while a circuit is blocked, however, it will *not* result in unblocking the circuit concerned (see section 4.6.1).

The release-guard signal is sent in response to the clear-forward signal, but not until the circuit is available for a new call. The fact that the circuit is blocked will not delay the transmission of the release-guard signal.

4.1.14 Diagrams showing signal sequence

The normal call set-up sequences are shown diagrammatically in Annex 1.

Recommendation Q.262

4.2 ANALYSIS OF DIGITAL INFORMATION FOR ROUTING

4.2.1 General requirements for the international transit exchange

In an international transit exchange, an analysis of some of the digits is required to determine the routing to the desired international incoming exchange or to another international transit exchange. See Recommendation Q.11, section 1.2.

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. Since the initial address message will contain all digits required for routing the call (see Recommendation Q.261, section 4.1.1), selection of the outgoing circuit can start as soon as this message has been received.

It should be noted that, in addition to the digital information, other routing information is contained in the initial address message, e.g. country code indicator, nature-of-circuit indicator, calling-party's-category indicator, and echo-suppressor indicator, some or all of which must be analyzed as described in Recommendation Q.261, section 4.1.1.

It will not normally be necessary for a No. 6 transit exchange to analyze digits in more than the initial address message. Subsequent address messages can be forwarded to the next international exchange without analysis as soon as the outgoing circuit is determined. If, however, the address messages are rearranged, for example by the combining of address messages, the No. 6 transit exchange must verify the sequence of digits and change the sequence number of the outgoing subsequent address messages as appropriate.

If address information is received " en bloc " at a No. 6 transit exchange, it is normally transmitted " en bloc "; on the other hand, if received in overlap, it is normally forwarded in overlap.

4.2.2 Maximum number of digits to be analyzed in an international transit exchange

a) the maximum number of digits (see Recommendation Q.11, section 1.2) which has to be analyzed in an international transit exchange to determine the routing at this exchange is as follows:

$$I_1\ N_1\ N_2\ N_3$$
$$I_1\ I_2\ N_1\ N_2$$
$$I_1\ I_2\ I_3\ N_1\ N_2$$

where I_1, I_2, I_3 = digits of the country code
$N_1, \ldots, N_n$ = digits of the national (significant) number.

Note. — In the case of countries with more than one incoming international exchange where code 11 or code 12 traffic requires for routing in the international transit exchange a digit analysis beyond the country code, N_1 is the extra digit designating the incoming international exchange (see the Annex to this Recommendation, examples 1b and 3).

b) Accordingly, the maximum number of digits that has to be analyzed at an international transit exchange is five.

4.2.3 Digit analysis for routing at the outgoing international exchange

The maximum number of digits which has to be analyzed in the outgoing international exchange to determine the routing is also five, as in section 4.2.2 for the international transit exchange.

4.2.4 Digit analysis for routing at the incoming international exchange

The country code will not be sent on the final link in the international connection and therefore the country-code indicator must be set to " 0 ".

ANNEX

(to Recommendation Q.262)

Example of the digit analysis in an international transit exchange

A list of possible cases for the digit analysis in an international transit exchange is the following (the letters given to the international exchanges correspond to the figure and the letters given to the digits correspond to section 4.2.2 of this Recommendation):

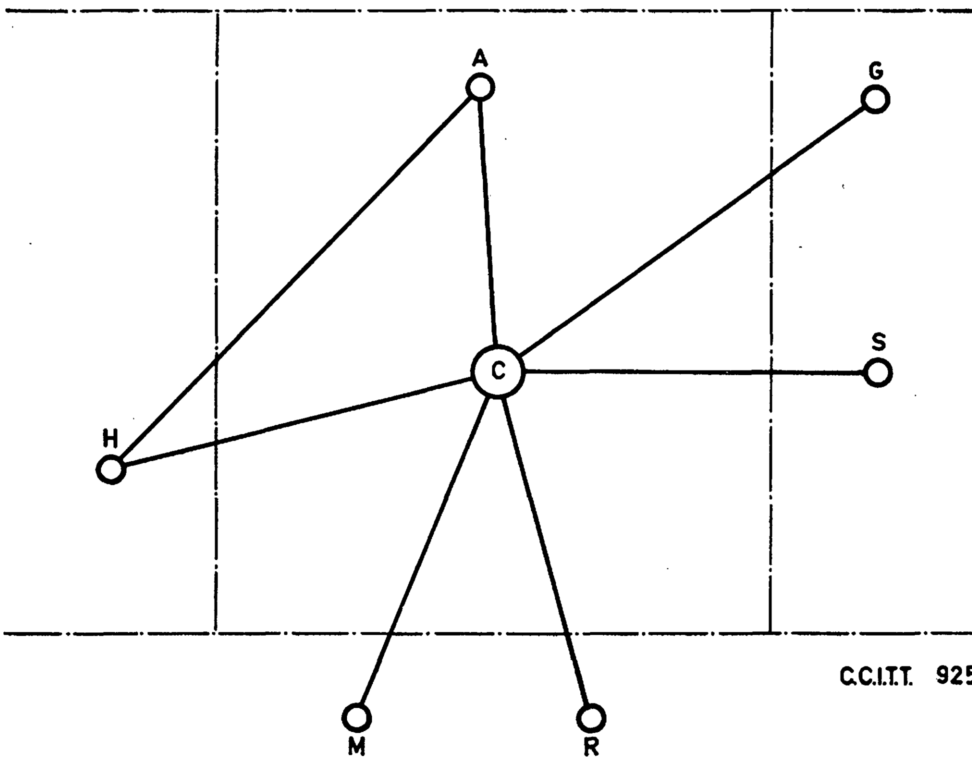

FIGURE 13/Q.262. — **Example of the digit analysis in an international transit exchange**

1. Transit traffic via C in one country routed to 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: $\underline{I_1\ I_2\ N_1\ N_2}$ . . . . .
Analyzed

b) * Semi-automatic calls to code 11 or code 12 operators.

Examples: $\underline{I_1\ I_2\ N_1\ C_{11}}$ or $\underline{I_1\ I_2\ N_1\ C_{12}}$
Analyzed Analyzed

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 as indicated by the calling party category.

Example: $\underline{I_1\ I_2}$
Analyzed

3. [1] 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.

Examples: $\underline{N_1\ C_{11}}$ ST or $\underline{N_1\ C_{12}}$ X X ST
Analyzed Analyzed

[1] It is recognized that the existing design of some present-day equipments does not permit the insertion of the extra digit N_1.

In this situation, agreement will be required between the Administrations concerned that this insertion of N_1 would not be provided for at a particular outgoing international exchange as long as the equipment limitation applied.

Recommendation Q.263

4.3 DOUBLE SEIZING WITH BOTH-WAY OPERATION

4.3.1 Double seizing

Since system No. 6 circuits have the capability of both-way operation, it is possible that the two exchanges will attempt to seize the same circuit at approximately the same time.

4.3.2 Unguarded interval

Considering that with signalling system No. 6:

a) circuit propagation time may be relatively long,

b) the initial address message may consist of up to 6 signal units,

c) there may be a significant queueing delay, and

d) quasi-associated operation may add extra cross-office delay(s),

the unguarded interval during which double seizing can occur may be relatively long in some instances. The exchange must therefore detect double seizing and take action as defined in section 4.3.5.

4.3.3 Detection of double seizing

A double seizure is detected by an exchange from the fact that it receives an initial address message for a circuit for which it has sent an initial address message. For detection of a double seizure when out of sequence messages are received, see Annex 2, *Reasonableness check tables*.

4.3.4 Preventive action

Double seizing is minimized by the use of an opposite order of selection at each terminal exchange of a both-way circuit group. It is necessary to use this method of selection in cases where system No. 6 uses a voice-frequency link with long propagation time.

4.3.5 Action to be taken on detection of double seizing

It is expected that each exchange will control one-half of the circuits in a both-way circuit group. On detection of a double seizure, the call being processed by the control exchange [1] for that circuit will be completed and the received initial address message will be disregarded. Under these conditions, the call being processed by the control exchange will be allowed to complete although the continuity of the circuit may have been checked in the direction from non-control to control only. The call being processed by the non-control exchange will be backed off (continuity check transceiver removed, check loop connected, switches released, etc., but a clear-forward signal not sent) and an automatic repeat attempt made either on the same or on an alternative route.

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[1] For the purpose of resolution of double seizing on both-way circuits, a suitable method is that one exchange as determined by bilateral agreement will control *all* circuits with odd-numbered (binary numbers) labels and the other exchange those with even-numbered labels. This designation of control may also be used for maintenance control purposes (see Recommendations Q.78 *bis* and M.8).

Recommendation Q.264

4.4 POTENTIAL FOR AUTOMATIC REPEAT ATTEMPT

The potential for automatic repeat attempt as defined in Recommendation Q.12 is provided in system No. 6. Backward signals are included to provide information on which to base a decision as to whether or not it would be advantageous to invoke an automatic repeat attempt.

An automatic repeat attempt will be made

— upon failure of the continuity check (section 4.1.4),

— on receipt of the confusion signal (while setting up a call, section 4.7.6.4),

— on detection of double seizing (at the non-control exchange) (section 4.3.5),

— in some cases on receipt of a message refusal signal (section 4.6.2.3),

— and on receipt of a blocking signal after sending an initial address message and before any backward signals have been received (section 4.6.1).

The potential for automatic repeat attempt on receipt of the circuit-group-congestion, the switching-equipment congestion or the call-failure signals is provided.

Recommendation Q.265

4.5 SPEED OF SWITCHING AND SIGNAL TRANSFER IN INTERNATIONAL EXCHANGES

4.5.1 General

It is recommended that the equipment in the international exchanges (terminal or transit) shall have a high switching speed so as not to lose the advantage of the high speed of system No. 6.

Although the speech path of circuits served by system No. 6 is not split, the speech path of circuits using in-band line signalling is split during the transmission of line signals (see Recommendation Q.27). To avoid clipping the initial verbal response of the called party, it is necessary to remove splits inserted during transmission of the answer signal as rapidly as possible. Consequently, the answer signal should be transferred across the No. 6 exchange as rapidly as possible to avoid delaying removal of the splits in any interconnected circuits which utilize in-band line signalling.

The operation of switching devices to attach and disconnect continuity-check equipment must be as rapid as possible to minimize post-dialling delay.

The signals switching-equipment congestion or circuit-group congestion should be returned as soon as practicable following receipt of the information necessary to determine the routing.

4.5.2 Outgoing international exchange

At the outgoing international exchange:

— if overlap operation is used, the sending of the initial address message shall take place as soon as sufficient digits are received (normally a minimum of 4) and analyzed to permit the selection of an outgoing circuit;

— if " en bloc " operation is used, the initial address message should be sent as soon as all the digits of the address including the end-of-pulsing (ST) signal are available and the outgoing circuit has been chosen.

4.5.3 International transit exchange

At the international transit exchange, the selection of an outgoing circuit should begin as soon as the digits necessary to determine the routing have been received and analyzed.

4.5.4 Incoming international exchange

At the incoming international exchange:

— if overlap operation is used in the national network, the setting-up of the national part of the connection should start as soon as a sufficient number of digits has been received for routing;

— if " en bloc " operation is used in the national network, the setting-up of the national part of the connection should start as soon as all of the digits have been received.

Recommendation Q.266

4.6 BLOCKING AND UNBLOCKING SEQUENCES AND CONTROL OF QUASI-ASSOCIATED SIGNALLING

4.6.1 Blocking and unblocking sequences

The blocking (unblocking) signal is provided to permit the switching equipment or maintenance personnel to remove from (and return to) traffic the distant terminal of a circuit because of a fault or to permit testing. It is also used in connection with the continuity check of the speech path as described in Recommendation Q.261, section 4.1.4, and in Recommendation Q.271.

Since the circuits served by system No. 6 have both-way capability, the blocking signal can be originated by either exchange. The receipt of the blocking signal will have the effect of prohibiting calls outgoing from that exchange until an unblocking signal is received, but will not in itself prohibit calls incoming to that exchange. Acknowledgement sequences are always required for both the blocking and unblocking signals, using the blocking-acknowledgement signal, and the unblocking-acknowledgement signals, respectively. The acknowledgement is not sent until the appropriate action, either blocking or unblocking, has been taken. The clear-forward signal should not override the blocking signal and return circuits to service which might be faulty. The blocked circuit will be returned to service on transmission of the unblocking-acknowledgement signal at one exchange and on receipt of the unblocking-acknowledgement signal at the other exchange.

In the event of the receipt of a blocking signal

— after an initial address message has been sent and

— before a backward signal relating to that call has been received,

an automatic repeat attempt will be made on another circuit. The exchange receiving the blocking signal should clear forward the original attempt in the normal manner after sending the blocking-acknowledgement signal.

If the blocking signal is sent while the speech circuit is engaged on a call and after at least one backward signal relating to that call has been sent, steps will be taken by the exchange receiving the signal to prevent the circuit being seized for subsequent calls outgoing from that exchange.

The fact that the circuit is engaged on a call will not delay transmission of the blocking (unblocking)-acknowledgement signal.

Blocking of a circuit by use of the blocking signal should not exceed 5 minutes, after which an alarm should be given at each terminal of the circuit. Should a call be in progress on the circuit involved, the 5 minutes time will commence when that call is cleared. If the work on the circuit must exceed 5 minutes, the circuit should be withdrawn from service by the Circuit Control Station.

4.6.2 Control of quasi-associated signalling

This procedure permits a signal transfer point to advise a cooperating exchange that it is unable to transfer signals to a specified destination. This may be caused by the failure of the regular and all reserve routes to that destination.

4.6.2.1 *Transfer-prohibited signal*

When a signal transfer point is unable to transfer quasi-associated traffic for a particular group of circuits, this signal transfer point sends a *transfer-prohibited signal* to the exchange concerned. Since this signal refers to a group of circuits, the band number of the relevant group is sufficient. The circuit number part of the label field is used to provide the codes for up to 16 signals (see section 3.4.4.2).

The transfer-prohibited signal may have the effect at the receiving exchange of rerouting quasi-associated signals via another signalling path.

4.6.2.2 *Transfer-allowed signal*

When the signal transfer point is once more able to transfer signals, it sends a *transfer-allowed* signal to each exchange concerned. The transfer-allowed signal will have the same band number as the transfer-prohibited signal.

On receipt of a transfer-allowed signal, the receiving exchange will return a *transfer-allowed-acknowledgement* signal, and restore signalling to the normal route.

The signal transfer point will repeat the transfer-allowed signals at periods of 4 to 15 seconds until a transfer-allowed-acknowledgement signal is received. If a transfer-allowed-acknowledgement signal is not received within one minute of sending a transfer-allowed signal, the repetition of the transfer-allowed signal is ceased and maintenance personnel alerted.

4.6.2.3 *Message-refusal signal*

If a telephone message is received by a signal transfer point intended for a destination toward which a transfer-prohibited condition exists, a *message-refusal signal* shall be returned to the exchange from which this telephone message was received. The message-refusal signal uses the label of the circuit concerned.

On receipt of a message-refusal signal at the terminal exchange of the circuit identified in the label, that exchange will, if possible, send the most recent signal message in memory associated with the affected circuit over the next available reserve signal path. If this procedure is not possible, and if the call is in the process of being established, a clear-forward signal should be sent and an automatic repeat attempt made of the call over this reserve path.

Recommendation Q.267

4.7 UNREASONABLE AND SUPERFLUOUS MESSAGES

4.7.1 General

The characteristics of the common channel signalling system may give rise to irregularities such as:

— *unreasonable messages*, i.e. messages with:

an inappropriate signal content,
an incorrect signal direction, or
an inappropriate place in the signal sequence;

— *superfluous messages.*

4.7.2 Reasonableness check tables

In order to resolve ambiguous situations which may arise from these irregularities, special procedures must be defined. These procedures, some of which are mandatory, are included in the reasonableness check tables given in Annex 2, which cover all possible stages in the signalling sequences.

The justification for using such tables follows from the dependability requirements in Recommendation Q.276, section 6.6.1.

4.7.3 Retransmissions and undetected errors

The following three cases may be considered as examples of the occurrence of unreasonable or superfluous messages:

— in case a signal unit received in error is retransmitted and the next signal unit of the same call is received in advance of the retransmitted signal unit, the signal units are received in reverse order and thus appear unreasonable;

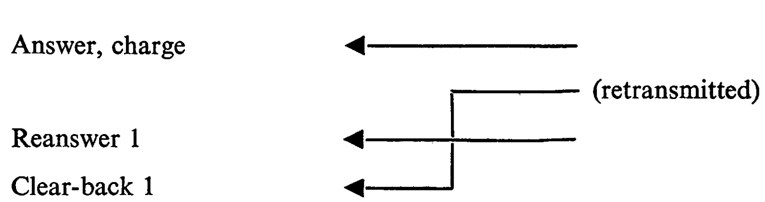
— the incidence of an undetected error may alter the meaning of a signal unit, which then becomes unreasonable;

— in case the acknowledgement for a transmitted signal unit is not received (due to an ACU being received in error or drift compensation), this signal unit may be received twice, so that the second appearance of the signal unit is superfluous.

Examples:

a) *Disturbed signal sequence*

When a reanswer signal is received before a clear-back signal is retransmitted owing to a detected error:



The reanswer signal is conditionally accepted pending receipt of the clear-back signal.

b) *Undetected error*

When a forward-transfer signal is received in an unreasonable place or direction in a call sequence owing to an undetected error:

Initial address message	——————▶	
Continuity	——————▶	
Forward-transfer	◀——————	(undetected error)

The forward-transfer signal is rejected.

c) *Superfluous message*

When two initial address messages are received owing to an ACU being received in error or to drift compensation:

Clear-forward (call 1)	——————▶	
Release-guard (call 1)	◀——————	
Initial address message (call 2)	——————▶	
Initial address message (call 2)	——————▶	(retransmitted)

The receipt of two initial address messages would call for the contents to be compared. Should the two be identical, one or the other is discarded.

4.7.4 Spill-over of messages from one call sequence to another

In the event of a new call following immediately after the completion of a previous call, there could be a spill-over of messages from the first call to the second, viz. if a signal unit of the first call is received correctly a second time owing to a retransmission. This could lead to ambiguous situations as illustrated in the following examples. The reasonableness check tables given in Annex 2 contain the procedures for these cases.

Examples

a) Initial address message (call 1)	——————▶	(received correctly)
Clear-forward (call 1)	——————▶	
Release-guard (call 1)	◀——————	
Initial address message (call 1)	——————▶	(retransmitted)
Initial address message (call 2)	——————▶	

This sequence has a similar appearance to the one arising when an initial address message is received a second time owing to an ACU being received in error or to drift compensation without an intervening clear-forward signal; see example c in section 4.7.3. The contents of the two initial address messages should be compared. Should the two be different, the call can be rejected by sending a *confusion signal* in the backward direction.

On receipt of the confusion signal, the No. 6 exchange will send a clear-forward signal for the circuit in question, after which an automatic repeat attempt of the call will be made.

b) Another example of a spillover could occur if an ACU acknowledging a clear-forward signal is received in error and another call is initiated on the circuit just cleared. The sequence would be:

Clear-forward (call 1)	——————▶	
Release-guard (call 1)	◀——————	
Initial address message (call 2)	——————▶	
Clear-forward (call 1)	——————▶	(retransmitted)
Release-guard (call 2)	◀——————	

The processor receiving the release-guard signal does not know whether it was generated in response to a retransmitted clear-forward signal or whether it was the result of an incoming undetected error.

In this case, the exchanges disagree as to the state of the circuit (seizure or release) and the specified procedure must be followed to remove the ambiguity.

4.7.5 Other ambiguous situations

Another ambiguous situation could arise for example if, after transmitting a clear-forward signal, an ACU is received in error resulting in the superfluous retransmission of the initial address message. If the latter is followed by a backward signal, for example the congestion signal, the sequence would be:

Initial address message (call 1)	——————▶	
Clear-forward (call 1)	——————▶	
Release-guard (call 1)	◀——————	
Initial address message (call 1)	——————▶	(retransmitted)
Congestion	◀——————	

The processor receiving the congestion signal will find the associated circuit in the idle condition and assume the signal to be invalid. The processor at the other end will keep the circuit busy while waiting for the clear-forward signal.

In this case, the exchanges disagree as to the state of the circuit (idle or busy) and the specified procedure must be followed to remove the ambiguity.

4.7.6 Procedures for the treatment of unreasonable and superfluous messages

4.7.6.1 *Rejecting*

Messages or signal units recognized to be unreasonable or superfluous are discarded.

4.7.6.2 *Waiting*

Unreasonable messages or signal units which may become meaningful at a later stage of the signal sequence are provisionally held. The waiting time should be longer than the retransmission delay of the delayed message. The provisionally-held signal units are processed if the arrival of retransmitted signals within the waiting period makes them meaningful. Otherwise, if they are still meaningless at the end of the waiting period, they are rejected with the exception of the case where the held signal is a clear-forward signal. In this case, the release-guard signal must be sent.

4.7.6.3 *Clearing*

If due to an abnormal signal sequence an ambiguous situation arises, which would result in a circuit being held unduly for a prolonged time, the circuit should be cleared in the normal way.

4.7.6.4 *Sending the confusion signal*

If none of the above procedures is suitable for resolving the situation created by the receipt of an unreasonable message (section 4.7.1), the confusion signal is sent back to the preceding No. 6 exchange. The confusion signal will not be sent subsequent to sending the address-complete signal or other signal causing the release of address and routing information at the preceding No. 6 exchange (see section 4.8.1).

On receipt of the confusion signal, the preceding No. 6 exchange will send the clear-forward signal, after which an automatic repeat attempt will be made of the call to be completed as in section 4.7.4 a; otherwise the clear-forward signal will be sent.

4.7.7 Mandatory procedures

Of the procedures contained in the reasonableness check tables, only those are mandatory which apply to situations in which

— processors at either end of the link disagree as regards the state of a circuit, or

— co-operation between the processors at either end of the link is required to resolve the ambiguous situation.

Compelled sequences such as clear-forward release-guard must always be completed irrespective of whether the occurrence of the first signal appears reasonable or not.

Recommendation Q.268

4.8 RELEASE OF INTERNATIONAL CONNECTIONS AND ASSOCIATED EQUIPMENT

4.8.1 Normal release conditions

Connections are normally released in the forward direction as a result of the receipt of a clear-forward signal from the preceding exchange. In addition, provision is made for the normal release of connections (or circuits) as follows:

— on continuity check failure: Recommendation Q.261, section 4.1.4,

— on receipt of an address-incomplete signal: Recommendation Q.261, section 4.1.6,

— on receipt of one of the congestion signals: Recommendation Q.261, section 4.1.7,

— on receipt of one of the called-party's-line-condition signals: Recommendation Q.261, section 4.1.8,

— on receipt of the blocking signal after sending an initial address message: Recommendation Q.266, section 4.6.1,

— in some cases, on receipt of the message-refusal signal: Recommendation Q.266, section 4.6.2.3,

— in some cases described under the treatment of unreasonable and superfluous messages: Recommendation Q.267, section 4.7.6.3, and Annex 2,

— on receipt of a confusion signal: Recommendation Q.267, section 4.7.6.4.

If the conditions for the normal release of connections as described above are not fulfilled, release is provided as follows:

— in the release under abnormal conditions: section 4.8.4,
— on receipt of a call-failure signal: section 4.8.3,
— on failure to receive a clear-forward signal after receiving a clear-back signal: Recommendation Q.118, section 4.3.2,
— on failure to receive an answer signal: Recommendation Q.118, section 4.3.1.

Address and routing information are released from memory in each of the exchanges of a connection as described in the following subsections:

4.8.1.1 *Outgoing international exchange*

Address and routing information stored at the outgoing international exchange can be erased on receipt of one of the following backward signals as covered in section 4.1:

a) one of the address-complete signals,
b) the address-incomplete signal,
c) one of the congestion signals (unless an automatic repeat attempt is to be made, see section 4.4),
d) one of the called-party's line-condition signals, or
e) the answer signal (received out of sequence),

or when the connection is cleared earlier.

4.8.1.2 *Incoming international exchange*

Address and routing information stored at the incoming international exchange can be erased on receipt of one of the above backward signals (or equivalent) from a national common channel system, or when one of the following signals as covered in section 4.1 has been originated and sent to the outgoing international exchange:

a) one of the address-complete signals,
b) address-incomplete signal, or
c) one of the congestion signals,

or on receipt of a clear-forward signal.

4.8.1.3 *International transit exchange*

Address and routing information stored at an international transit exchange can be erased on receipt of one of the backward signals, 4.8.1.1 a to e above, on receipt of a clear-forward signal, or when one of the congestion signals is originated in that exchange. If the succeeding circuit in the connection utilizes system No. 5, the address and routing information can be released on sending the end-of-pulsing signal (ST) over the No. 5 circuit as specified in Recommendation Q.152.

4.8.2 Abnormal release conditions — clear-forward, release-guard sequences

4.8.2.1 *Inability to release in response to a clear-forward signal*

If an exchange is unable to return the circuit to the idle condition in response to a clear-forward signal, it should remove the circuit from service and send the blocking signal. Upon receipt of the blocking-acknowledgement signal, the release-guard signal is sent in acknowledgement of the original clear-forward signal.

4.8.2.2 *Inability to release in response to a backward signal*

If an exchange is unable to release a circuit in response to an address-incomplete, congestion, called-party's-line condition, call-failure or confusion signal, it should remove the circuit from service by sending the blocking signal. Upon receipt of the blocking-acknowledgement signal, the clear-forward signal should be sent in reply to the original backward signal.

4.8.2.3 *Failure to receive a release-guard signal in response to a clear-forward signal*

If a release-guard signal is not received in response to a clear-forward signal before 4 to 15 seconds, the clear-forward signal will be repeated.

If, after sending a clear-forward signal, a release-guard signal is not received within a period of one minute after the first clear-forward signal, the maintenance personnel shall be alerted. The repetition of the clear-forward signal is ceased, the circuit is taken out of service, and optionally the blocking signal is sent.

4.8.3 Call-failure signal

The *call-failure signal* is sent as the result of time-out situations described in section 4.8.4. The call-failure signal is also sent whenever a call attempt fails and other specific signals do not apply, viz.:

— the confusion signal,

— the address-incomplete signal,

— the congestion signals, or

— the called-party's line-condition signals.

Reception of the call-failure signal at any No. 6 exchange will cause the clear-forward signal to be sent and

a) an automatic repeat attempt to be made, or

b) the appropriate signal or the appropriate tone or announcement to be sent to the preceding international exchange or to the national network.

The call-failure signal from system No. 6 will be converted to a busy-flash signal for transmission over a preceding link using system No. 4 or system No. 5. If the preceding link uses system No. 6, the call-failure signal is passed back.

4.8.4 Abnormal release condition — other sequences

If the condition for normal release as covered in section 4.8.1 are not fulfilled, release will take place under the following conditions:

4.8.4.1 *Outgoing international exchange*

An outgoing international exchange shall

a) release all equipment and clear forward the connection on failure to meet the conditions for normal release of address and routing information as covered in section 4.8.1.1 before 20 to 30 seconds after sending the latest address message,

b) repeat the blocking or unblocking signal on failure to receive an acknowledgement signal in response to either the blocking or unblocking signals before 4 to 15 seconds. (See section 4.6.1 for the blocking/unblocking sequence.) If an acknowledgement signal is not received within a period of one minute after sending the initial blocking or unblocking signal, maintenance personnel should be alerted, the repetition of the blocking or unblocking signal should be ceased and the circuit taken out of service as appropriate,

c) release all equipment and clear forward the connection on failure to receive a clear-forward signal from the national network after having received a clear-back signal as provided in Q.118, or

d) release all equipment and clear forward the connection on failure to receive an answer signal within the interval specified in Q.118.

4.8.4.2 *Incoming international exchange*

An incoming international exchange shall

a) release all equipment, clear forward the connection into the national network and send back a call-failure signal in the following cases:

— on failure to receive a continuity signal before 10 to 15 seconds after receipt of the initial address message, or

— on failure to receive an address-complete or called-party's-line-condition signal from the national network (where expected) before 20-30 seconds after receipt of the latest address message, unless the timing for sending the address-incomplete signal (see section 4.1.6) is provided, or

b) send the call-failure signal on failure to receive a clear-forward signal for the incoming circuit before 4 to 15 seconds after sending an address-incomplete, congestion, call-failure, confusion signal or a called-party's-line-condition signal indicating inability to complete the call. If a clear-forward signal is not received within a period of one minute after sending the call-failure signal, the repetition of the call-failure signal should be ceased, maintenance personnel should be alerted, the circuit should be removed from service and optionally blocked.

4.8.4.3 *International transit exchange*

An international transit exchange shall

a) release all equipment, clear forward the connection and send back the call-failure signal in the following cases:

— on failure to receive a continuity signal before 10 to 15 seconds after receipt of the initial address message, or

— on failure to meet the conditions for normal release as covered in section 4.8.1.3 before 20 to 30 seconds after sending the latest address message, or

b) send the call-failure signal on failure to receive a clear-forward signal for the incoming circuit before 4 to 15 seconds after sending an address-incomplete, congestion, call-failure, or confusion signal or a called-party's-line-condition signal indicating inability to complete the call. If a clear-forward signal is not received within a period of one minute after sending the call-failure signal, the repetition of the call-failure signal should be ceased, maintenance personnel should be alerted, the circuit should be removed from service and optionally blocked.

CHAPTER V

Continuity check of the speech path

Recommendation Q.271

5.1 GENERAL

Because the signalling in system No. 6 does not pass over the speech path, facilities should be provided for making a continuity check of the speech path prior to the commencement of conversation. The check is not intended to eliminate the need for routine testing of the transmission path.

This specification relates only to that part of an international connection served by signalling system No. 6. The part of the speech path to be checked may include a TASI circuit.

As the presence of active echo suppressors in the circuit would interfere with the continuity check, it is necessary to disable the suppressors during the check and to re-enable them, if required, after the check has been completed.

5.2 RELIABILITY OF THE SPEECH PATH ACROSS THE EXCHANGE

Administrations shall ensure the reliability of a connection through a switching machine (cross-office check) either on a per call basis or by a statistical method. With either method, the probability of the connection being established with an unacceptable speech path, transmission quality should not exceed 10^{-5} as the long-term average.

5.3 CONTINUITY CHECK OF THE SPEECH CIRCUIT BETWEEN EXCHANGES

The continuity check of the speech circuit will be done, link-by-link, on a per call basis prior to the commencement of conversation. The loop checking method used is specified in the following sections.

5.4 LOOP CHECKING METHOD

The transceiver (check-tone transmitter and receiver) is connected to the GO and RETURN paths of the outgoing circuit at the first and each succeeding exchange, excluding the last exchange, in that part of the international connection served by signalling system No. 6. The check loop should be connected to the GO and RETURN paths of the incoming circuit at each exchange except the first in that part of the international connection served by signalling system No. 6. A continuity check is considered successful when a tone is sent on the GO path and is received on the RETURN path within acceptable transmission and timing limits.

5.5 TRANSMISSION REQUIREMENTS FOR THE CONTINUITY CHECK

5.5.1 Transmitting equipment

The check-tone frequency will be 2000 ± 20 Hz.

The sending level of the check tone will be −12 ± 1 dBm0.

5.5.2 Check loop

The check loop will have a loss of 0 dB, taking into account any difference between the relative levels of the two paths at the point of attachment.

5.5.3 Receiving equipment

The check-tone receiver will have the following characteristics:

5.5.3.1 *Operating requirements*

Signal frequency: 2000 ± 30 Hz

Signal level range: The absolute power level N of the check tone shall be within the limits
$(-18 + n) \leqslant N \leqslant (-6 + n)$ dBm
where n is the relative power level at the receiver input

Recognition time: 30 to 60 ms

The frequency and level range tolerances allow for variations at the sending end and for variations in line transmission that are considered acceptable.

5.5.3.2 *Non-operating requirements*

Signal frequency: outside the frequency band 2000 ± 200 Hz

Signal level: below or equal to $-22 + n$ dBm

The limit is 10 dB below the nominal absolute level of the check tone at the input of the receiver. If the level falls below this point, transmission is considered unacceptable.

Signal duration: shorter than 30 ms.

The level range of $(-18 + n) \leqslant N \leqslant (-6 + n)$ dBm will serve as a GO/NO-GO check on the links in that part of the international connection served by signalling system No. 6.

5.5.3.3 *Release requirements*

If the receiver is used to test for the removal of check tone (see Recommendation Q.261, section 4.1.4):

— after recognition of tone, interruptions of up to 15 ms shall be ignored; this will prevent switching through the speech path prematurely;

— the indication of tone removal should not be delayed more than 40 ms, and

— the release level of the receiver should be lower than $-27 + n$ dBm.

5.6 CONTINUITY SIGNAL

The procedure for sending the continuity signal is given in Recommendation Q.261, section 4.1.4.

5.7 TIMING CONSIDERATIONS FOR THE CONTINUITY CHECK

5.7.1 Time-out period of the continuity check

The continuity check is considered to have failed if the receiver has not responded within a period determined by the Administration concerned. This period should not exceed 2 seconds.

The time-out period of the continuity check should always exceed the continuity recognition time, T_{CR}, given by:

$$T_{CR} = 2T_p + T_{IAM} + T_{TC} + T_L + T_R - T_T$$

where: T_p = one-way propagation time of the speech circuit and the signalling link (where they are the same)

T_{TC} = TASI clip time for two TASI systems in series (for connections not using TASI, $T_{TC} = 0$)

T_R = receiver response time

T_L = loop connecting time (maximum)

T_T = transceiver connecting time (minimum)

T_{IAM} = emission time of the longest initial address message.

If retransmission of an IAM is to be included in T_{CR}, the following formula may be used:

$$T_{CR} = 4T_p + 2T_{IAM} + T_{ACU} + T_x + T_y + T_L + T_R - T_T$$

where: T_{ACU} = emission time of an ACU (length of an ACU)

T_x = time between receiving an IAM and emitting an ACU

T_y = time between receiving an ACU and emitting an initial address message.

5.7.2 Switching times of continuity check equipment

The connection and disconnection of the equipment used for the continuity check and also the disabling and subsequent enabling of echo suppressors should be related to the following stages of progress in the establishment of the connection:

a) *Preparation at No. 6 exchange applying the transceiver.* — Action should be initiated at the termination of the handling time T_h of the initial address message, i.e. when it is inserted in the output buffer and is available for emission.

b) *Preparation at No. 6 exchange connecting the check loop.* — Action should be initiated at the moment of recognition of the initial address message received.

c) *Disconnection at No. 6 exchange connecting the check loop.* — Action follows the receipt of the continuity signal or the clear-forward signal, or the emission of signals indicating that the call cannot be established, e.g. circuit-group congestion signal.

d) *Disconnection at No. 6 exchange applying the transceiver.* — Action should be initiated on the successful completion or the failure of the continuity check. Exceptionally, if disconnection has not previously occurred, action should be initiated at the moment of recognition of the address-complete signals, the answer signals, signals indicating that the call cannot be established, or on the emission of a clear-forward signal.

It is recommended that the mean time, both for the connection and for the disconnection, is less than 100 ms. A mean time of 200 ms should not be exceeded. See Recommendation Q.261.

CHAPTER VI

Signalling link

Recommendation Q.272

6.1 REQUIREMENTS FOR THE DATA LINK

6.1.1 General

a) The data link shall be made up of standard international voice-frequency channels, either 3 kHz or 4 kHz spaced, and associated modems. The overall transmission characteristics of the voice-frequency channels must be equalized if necessary to meet the recommendations of section 6.1.3.

b) The overall loop propagation time of the data link shall not exceed 740 ms when a data transmission rate of 2400 bits per second is used (see also section 6.7.3).

c) To reduce the possibility of the initial verbal answer of the called party being distorted or clipped, the propagation time of the data link should be as low as possible and should not be greater than that of any speech circuits with which it is associated.

d) The data link shall be dedicated to the use of a system No. 6 signalling link between two points, the only switching to be provided being that required for the security arrangements (see Recommendation Q.292).

e) A means must be furnished for disabling the echo suppressors which might be associated with the circuits used for the data links. Disabling must be accomplished by local action by the processor at each terminal.

6.1.2 Error rate characteristics of the data channel

The data transmitted at 2400 bits per second with four-phase PSK *(phase shift keying)* modulation over a data channel as specified should meet a long-term bit error rate of less than 1 in 10^5 in normal operation (see Recommendation Q.295, section 9.2.5). This figure excludes interruptions exceeding 350 ms in length.

6.1.3 Transmission characteristics of the voice-frequency channel

The transmission characteristics of the voice-frequency channels used in the data link are based on Recommendation M.102.

However, for the system No. 6 data rate and modulation method (see Recommendations Q.273 and Q.274), Recommendation M.102 is not an absolute requirement, but rather a useful guide in the selection of channels. The equalization for attenuation distortion and delay distortion of the channels can be restricted to the frequency band 1000 to 2600 Hz (see Figures 14 and 15/Q.272).

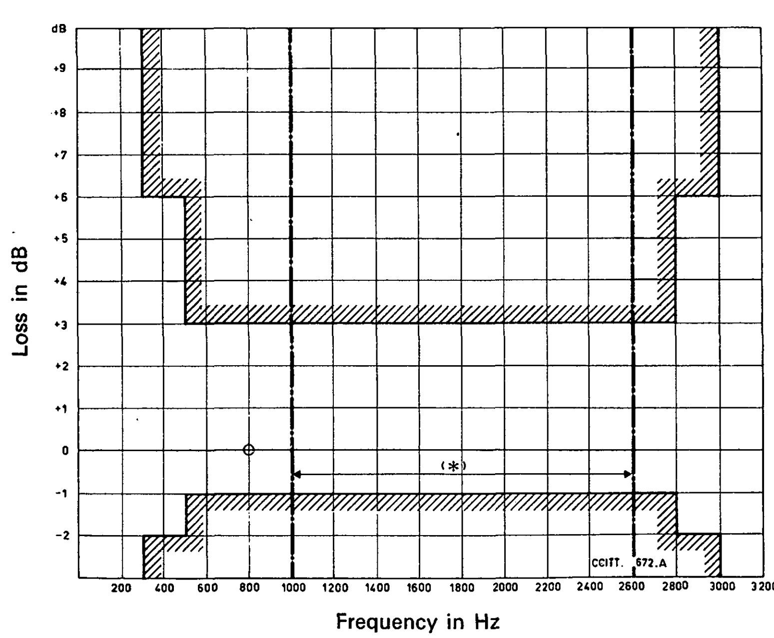
a) *Overall loss at 800 Hz* — The voice-frequency channel loss at 800 Hz should be normally zero.

Recommendation M.102 covers the loss of the extensions between renters' premises and the international exchanges as well as the international section and allows up to 13 dB total loss. In the system No. 6 application, these extensions do not exist.

b) *Variation of overall loss at 800 Hz* — The variation with time of the overall loss at 800 Hz should be as small as possible but should not exceed the following limits:

Short-term variation (over a period of a few seconds)	±3 dB
Long-term variation (over long periods including daily and seasonal variations)	±4 dB

c) *Attenuation/frequency distortion* — The variation of the overall loss of the channel with frequency over the range of 1000 to 2600 Hz relative to the attenuation at 800 Hz should not exceed the limits shown in Figure 14/Q.272.

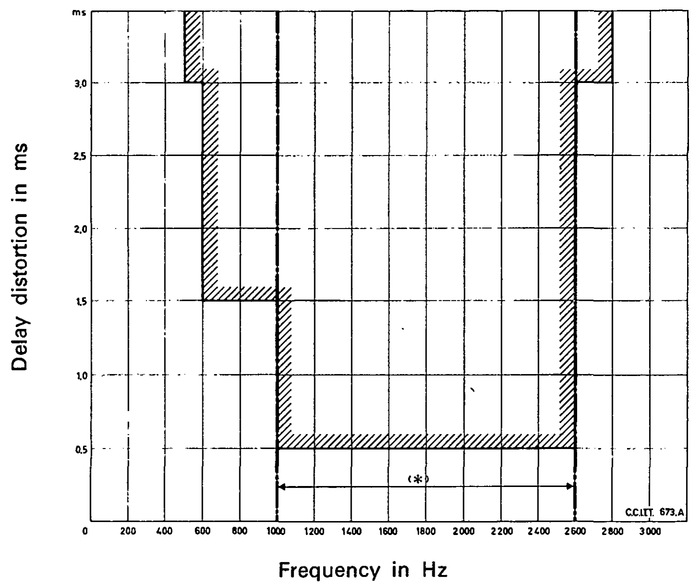


(*) Frequency band with defined characteristics for signalling system No. 6. The tolerance scheme is taken from Recommendation M.102.

FIGURE 14/Q.272. — **Permissible variation of overall loss with frequency for the voice-frequency channel**

d) *Delay/frequency distortion* — The delay/frequency distortion in the band of frequencies from 1000 to 2600 Hz relative to the minimum group delay in that band should not exceed the limits given in Figure 15/Q.272. It may be necessary to select channels and/or provide suitable delay distortion equalizers to ensure that these limits are not exceeded.

Where the full-time reserved link is a TASI speech circuit taken into use for signalling purposes, this characteristic may not be met unless all TASI channels in the route meet the transmission requirements specified above. In addition, it may be necessary to restrict the number of 3-kHz-spaced channels used in a data link.



(*) Frequency band with defined characteristics for signalling system No. 6. The tolerance scheme is taken from Recommendation M.102.

FIGURE 15/Q.272. — **Permissible variation of overall delay distortion with frequency for the voice-frequency channel**

e) *Uniform spectrum random circuit noise* — According to Recommendation M.102, for distances over 10 000 km, the value of the uniform spectrum noise for the voice-frequency channels should not exceed a mean value of 9.7 millivolts psophometric at a zero relative level point, measured across a 600-ohm pure resistance (−38 dBm0p).

However, shorter circuits will have substantially less random noise. An appropriate figure, which displays random noise versus length, is given in Recommendation M.102, Figure 4, and is presented there as a guide to the random noise performance which may be expected.

f) *Impulse noise* — Impulsive noise on the voice-frequency channel should not exceed 18 peaks in 15 minutes, greater than −21 dBm0. Measurements should be made during peak hours.

According to Recommendation M.102, impulsive noise should be measured with an instrument complying with Recommendation H.13. The value given above is a provisional limit for maintenance purposes; final values are still under study.

6.1.4 Nominal data carrier power level

The nominal data carrier power level is −15 dBm0 (see Recommendation Q.15).

Recommendations H.41, M.102 and V.2 allow a power level of −10 dBm0 when no more than 5% of the channels in a multichannel system are used for non-speech applications simultaneously in both directions. If the percentage of channels in this type of service is considerably more than 5%, the power should be reduced. Recommendation Q.15 allows a mean absolute power level of −15 dBm0.

Recommendation Q.273

6.2 DATA TRANSMISSION RATE

6.2.1 Preferred rate

The preferred data transmission rate on analogue channels is 2400 bits per second.

6.2.2 Exceptionally allowed rates

The data transmission rates of 2000 bits per second and of 4000 bits per second are exceptionally allowed as:

a) the rapid development of pulse code modulation transmission systems may make it desirable to use a sub-multiple of 8000 bits per second;

b) the data rates of 2000 bits per second and 4000 bits per second may be used for the common channel signalling systems within national (or regional) networks and these networks may carry international traffic as well.

The requirement to be met by a 2000- and a 4000-bits-per-second data link has not yet been specified. However, the rate of 4000 bits per second may not be used over a satellite circuit (see Recommendation Q.277, section 6.7.3, Note 2).

Recommendation Q.274

6.3 MODULATION METHOD

The modulation technique described in this Recommendation uses *phase shift keying* to transmit serial binary data over analogue telephone channels. The binary data signal is encoded by first grouping it into bit pairs (dibits). Each dibit is represented by one of four possible carrier phase shifts. Thus, the output from the phase modulator consists of a serial train of phase-shifted carrier pulses at half the data bit rate. The phase shift between two consecutive modulation elements contains the information to be transmitted.

The data receiver uses differentially coherent detection to recover the sense of the binary data from the line signal. This type of detection has proven to be relatively insensitive to the types of distortions and interference encountered on telephone type transmission media. It also allows rapid recovery from such catastrophic impairments as drop-outs and large phase hits.

Receiver timing recovery can be accomplished in several ways. A very rapid timing recovery scheme can be provided using certain properties of the transmitted spectrum.

Receiver timing information can also be extracted from the zero crossings, on a dibit basis, of the received baseband data signals. The latter method is capable of providing synchronization holdover through extended drop-outs and periods of high noise.

6.4 MODEM REQUIREMENTS

The requirements for a 2400 bits per second modem are given below.

6.4.1 Principal requirements

The principal requirements of a modem used for system No. 6 are as follows:

a) Use of differential four-phase modulation (see Recommendation V.26, alternative B);

b) Use of differential coherent four-phase demodulation;

c) Full duplex operation over a four-wire data link;

d) A modulation rate of 1200 bauds;

e) A bit rate of 2400 bits per second.

6.4.2 Frequency requirements

a) The basic timing frequency shall be 2400 Hz (one cycle per bit);

b) The carrier frequency shall be 1800 Hz;

c) The carrier envelope frequency shall be 600 Hz (see section 6.4.4);

d) All frequencies generated in the modem shall be stable to within ± 0.005% of the nominal value. They must have a constant phase relationship with respect to one another. This implies that all frequencies should be derived from a basic clock or that they be phase-locked.

6.4.3 Encoding phase relationships

The encoding phase relationship must be as follows:

Dibit	Phase change
00	+ 45°
01	+135°
11	+225°
10	+315°

The phase change is the actual on-line phase shift in the transition region from the end of one signalling element to the beginning of the following signalling element.

6.4.4 Line signal envelope

The data carrier pulse shape can be closely approximated by the following expression for a signal element centred at $t = 0$ (see Figure 16/Q.274):

$$\text{Envelope}\ (t) = \frac{\cos \dfrac{2\pi f_d \cdot t}{2} - \cos \dfrac{2\pi f_d \cdot \frac{3}{4}T}{2}}{1 - \cos \dfrac{2\pi f_d \cdot \frac{3}{4}T}{2}}$$

$$\text{for } -\tfrac{3}{4}T \leqslant t \leqslant \tfrac{3}{4}T$$

and

$$\text{Envelope}\ (t) = 0 \text{ for } -T \leqslant t \leqslant -\tfrac{3}{4}T \text{ and } \tfrac{3}{4}T \leqslant t \leqslant T$$

where f_d = the dibit rate of 1200 Hz
and T = the dibit period of 1/1200 s.

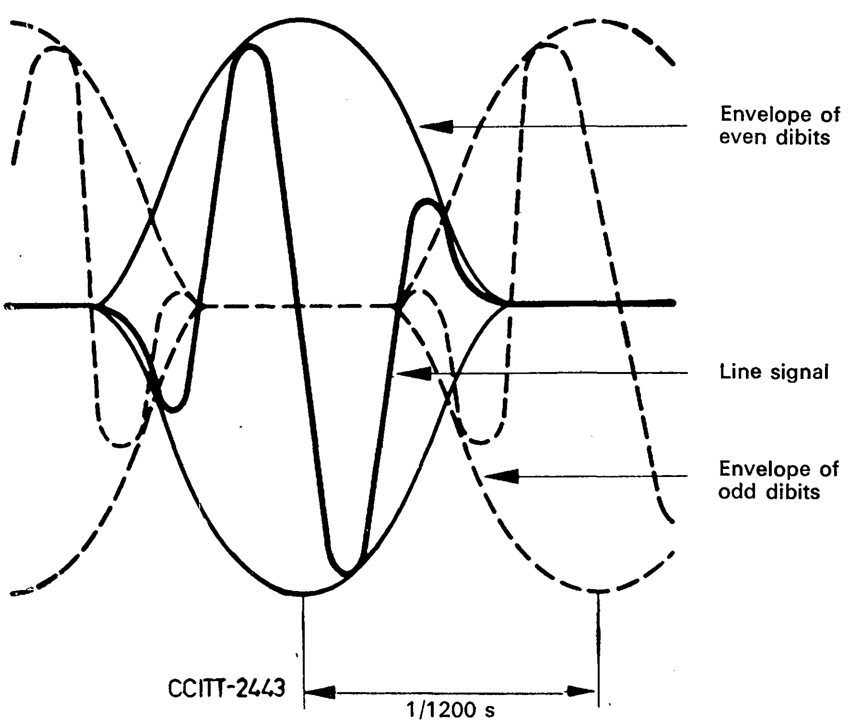


FIGURE 16/Q.274. — **Composite line signal**

6.4.5 Line power spectrum

The line power spectrum produced by the transmission of random data is shown in Figure 17/Q.274. The spectral lines produced by the transmission of repeated dibits (using the encoding phase relationships of section 6.4.3) are also shown.

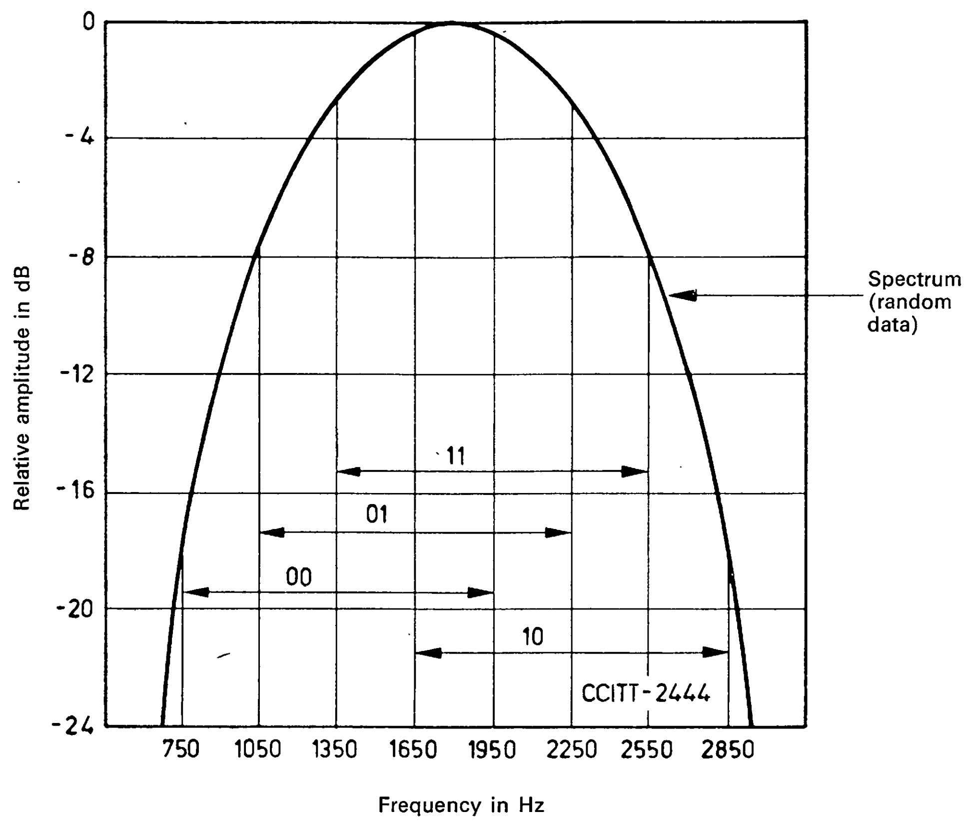


FIGURE 17/Q.274. — **Line power spectrum**

6.4.6 Transmitter requirements

a) The transmitter output level shall be —15 ± 1 dBm0 (see also Recommendation Q.272, section 6.1.4).

b) In the data transmitter, the bit timing and carrier frequency are derived from the same source to facilitate receiver timing recovery.

6.4.7 Receiver requirements

a) The receiver sensitivity range shall be —15 ± 8 dBm0 (see section 6.4.6 and Recommendation Q.272, section 6.1.3 b).

b) The modem receiver shall be capable of establishing bit synchronization as fast as possible, but in any case within 150 milliseconds while receiving synchronization signal units.

c) The receiver shall maintain bit synchronization with the distant transmitter during a loss of data carrier of one second or less after initial bit synchronization has been established.

6.4.8 Interface requirements

Each Administration may at its discretion integrate the modem into the signalling terminal equipment or use a separate modem. If the modem is a separate unit, then the interface requirements of Recommendation V.24 should be followed so far as possible.

As the eventual use of pulse code modulation transmission may so require, it is desirable that the transmitting signalling terminal derive its timing from the basic timing frequency of the modem transmitter.

The receiving signalling terminal should derive its timing from the modem receiver timing frequency.

Recommendation Q.275

6.5 DATA CARRIER FAILURE DETECTOR

6.5.1 General

A data carrier failure detector is required to supplement the eighth-bit cyclic code in the error detection system. A failure signal from the data carrier failure detector indicating unsatisfactory data transmission conditions should be given to the terminal for use in the error control equipment (see Recommendation Q.277, section 6.7.2).

6.5.2 Requirements

a) The data carrier failure detector is required to indicate failure when transmission becomes unsatisfactory because of decreased carrier level. A failure should be indicated when the received carrier is below the minimum sensitivity of the modem used, and should indicate no failure when the level is above −23 dBm0.

b) The detector is required to detect the loss of carrier even though the decrease in carrier power may be accompanied by an increase in noise power. If a signal guard technique is used to distinguish carrier power from noise power, the received spectrum from 300 Hz to 500 Hz should be used to detect the amount of noise power.

c) The indication of failure or of re-established carrier should have a nominal delay of 5 ms with limits of 4 ms minimum and 8 ms maximum.

6.5.3 Interface

The interface between the data carrier failure detector and the terminal should follow the provisions of Recommendation V.24, circuit 109.

Recommendation Q.276

6.6 SERVICE DEPENDABILITY

6.6.1 Dependability requirements

The following dependability requirements should be obtained with signalling links having the error rate characteristics as described in Recommendation Q.272, section 6.1.2. These requirements refer to each signalling link.

a) Signal units which carry telephone signal information and which are delayed as a consequence of correction by retransmission:

not more than one in 10^4 of such signal units to be delayed as a long-term average.

b) Signal units of any type which give rise to wrongly-accepted signals due to undetected errors and causing false operation (e.g., false clear-back signal):

not more than one error in 10^8 of all signal units transmitted.

c) As in item b but causing serious false operation (e.g., false metering or false clearing of a connection):

not more than one error in 10^{10} of all signal units transmitted.

d) Interruption to the signalling service (including both normal and reserve links):

interruption of duration between 2 seconds and 2 minutes—not more than once a year;

interruption of duration exceeding 2 minutes—not more than once in 10 years.

Items a, b and c assume one telephone signal per signal unit. Results for a multi-unit message will be at least comparable to those for one-unit messages transmitting the same information.

6.6.2 Retransmission considerations

The requirement 6.6.1 a is inserted to limit the percentage of the answer signals which are delayed through the retransmission process. The amount of retransmission depends on the number of bits in the signal units and on interferences such as those caused by short interruptions and intermittent bursts of noise up to the point at which changeover to the reserve link occurs.

6.6.3 Service-interruption considerations

Requirement 6.6.1 d depends very largely on the performance of the voice-frequency links assigned for signalling. Precautions should be taken in the design of the terminal equipments to ensure that their contribution to the total is relatively small.

Recommendation Q.277

6.7 ERROR CONTROL

6.7.1 Error detection by the use of check bits

The disturbance of a signal unit during transmission will be detected by the use of coders and decoders connected at the transmitting and receiving terminals, respectively. The coder will generate 8 check bits based on the polynomial $X^8 + X^2 + X + 1$ (see Table 2 for the matrix and for a typical implementation).

These check bits will constitute bits 21-28 of each signalling unit and are *inverted before transmission* to provide protection against a single bit slip of synchronization.

When the decoder at the receiving terminal has received all 28 bits of a signal unit after the check bits have been reinverted, it will indicate whether or not the signal unit has been checked correctly. This information will be stored for inclusion in the acknowledgement field of an ACU to be emitted in the return direction. An ACU will be transmitted after each 11 signal units to form a block (see Recommendation Q.251, section 1.1.2).

TABLE 2

EIGHT-BIT CHECK CODER

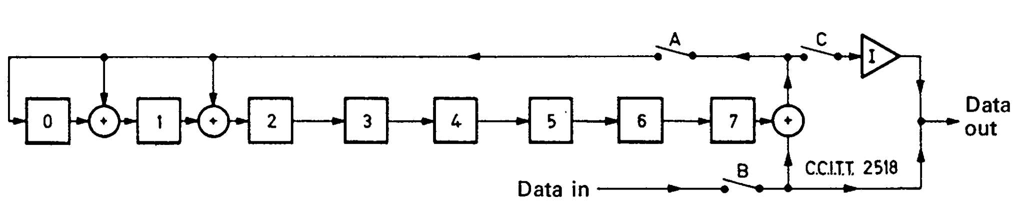
Eight-bit check code matrix

	1	b_1	b_2	b_3	b_4	b_5	b_6	b_7	b_8	b_9	b_{10}	b_{11}	b_{12}	b_{13}	b_{14}	b_{15}	b_{16}	b_{17}	b_{18}	b_{19}	b_{20}
c_7	1	0	1	1	0	1	0	1	0	1	0	0	0	1	1	1	0	0	0	0	0
c_6	1	1	0	1	1	0	1	0	1	0	1	0	0	0	1	1	1	0	0	0	0
c_5	1	0	1	0	1	1	0	1	0	1	0	1	0	0	0	1	1	1	0	0	0
c_4	1	1	0	1	0	1	1	0	1	0	1	0	1	0	0	0	1	1	1	0	0
c_3	1	0	1	0	1	0	1	1	0	1	0	1	0	1	0	0	0	1	1	1	0
c_2	1	0	0	1	0	1	0	1	1	0	1	0	1	0	1	0	0	0	1	1	1
c_1	1	0	1	1	1	1	1	1	1	0	0	1	0	0	1	0	0	0	0	1	1
c_0	1	1	1	0	1	0	1	0	1	0	0	0	1	1	1	0	0	0	0	0	1

The *ones* in a row of the matrix under b_1 .... b_{20} indicate those bits that should be *added modulo 2* to determine the check bit indicated at that row.

The *inversion* of the check bits is shown in this matrix by column 1.

Typical shift register coder implementation



When information bits are being transmitted: Switches A and B closed, C open.
When check bits are being transmitted: Switches A and B open, C closed.
Shift registers in coders should be zero set at start.

Eight-bit check code

Polynomial: $p(x) = (x+1)(x^7+x^6+x^5+x^4+x^3+x^2+1) = x^8+x^2+x+1$

Code name: Primitive polynomial plus parity check.

Information bits: $b_1 \ldots b_{20}$, check bits: $c_7 \ldots c_0$.

Sequence on the line: b_1 (first) $b_2 \ldots b_{19}\, b_{20}\, c_7\, c_6 \ldots c_1\, c_0$ (last).

6.7.2 Error detection by data carrier failure detector

A data carrier failure detector will supplement the error detection by the use of check bits. Indication of data carrier failure due to unsatisfactory transmission conditions will cause the rejection of signal units in the process of reception. Regardless of the result of decoding, the ACU should acknowledge the signal units as received incorrectly.

6.7.3 Error correction

Correction is achieved by retransmission of the messages which are not acknowledged to have been received correctly. The *block structure* and the contents of the ACU have been described in Recommendations Q.251, section 1.1.2, and Q.259, section 3.3.1. The acknowledgement indicators should be transmitted in the same sequence as the signal unit to which they refer.

A retransmission to comply with the information in the ACU will be made possible by storing at the transmitting terminal the signal units with their block reference numbers at the time of emission. This record must be maintained until the receipt of the associated ACU when the record of messages which are acknowledged to have been correctly received should be eliminated. In the case of multi-unit messages, the complete message should be retransmitted if any of its constituent signal units fail to check correctly. A multi-unit message may contain signal units which are transmitted in two adjacent blocks, but it must be ensured that the records of the constituent signal units of the multi-unit message remain until the acknowledgement indicators show that the complete multi-unit message has been received correctly.

In the unlikely event that a terminal is unable to accept a correctly received signal unit, e.g. due to input buffer congestion, the appropriate acknowledgement indicator bit in the outgoing ACU is marked as if the signal unit were received in error.

The maximum permitted delay between the emission of a signal unit and the subsequent handling of the received ACU containing the acknowledgement of that signal unit must not exceed the time taken to send 8 blocks (96 signal units). Of this time (96 signal units), the time for 64 signal units is available for the loop propagation time of the data link (see Note 1). At a data rate of 2400 bits per second, this caters for a loop propagation time of up to 740 ms (Note 2).

Note 1. — The number, 64 signal units, is based on the consideration that out of the total number of 96 signal units, 32 signal units are allocated as follows:

At the exchange emitting signal units:

emission of SU reception of ACU processing	not more than the time for sending 3 signal units

At the exchange receiving signal units:

reception of SU generation of ACU time in ACU queue emission of ACU time for drift compensation processing	not more than the time for sending 29 signal units

Note 2. — The time for sending 64 signal units is also equivalent to

890 ms at 2000 bit/s
445 ms at 4000 bit/s.

The messages, which are not acknowledged to have been correctly received should be presented for retransmission, at which time the record of their previous transmission should be eliminated. The exception to the general rule is that acknowledgement, synchronization and changeover system control signal units should never be retransmitted.

All signal units in a block except the SYU, ACU and changeover system control signal units must be retransmitted if the ACU referring to that block is not received correctly. This may arise owing to the fact that the ACU fails to check correctly on account of errors during transmission or owing to drift between the data streams in the two directions (see Recommendation Q.279).

The first three bits of the ACU (i.e. the heading code) may be used for identification purposes (see Recommendation Q.259, section 3.3.2.2). If the ACU checks to be error-free and the heading is correct the probability of an undetected error is extremely small.

Recommendation Q.278

6.8 SYNCHRONIZATION

6.8.1 General

The SYU will contain, in addition to the 8 check bits, a 16-bit pattern for bit and signal unit synchronization and a 4-bit number for block synchronization. The same 16-bit pattern will appear in every SYU. The 4-bit number will describe the position of the SYU within its block (see Recommendation Q.259, section 3.3.3.2).

6.8.2 Normal synchronization

This synchronization procedure is used whenever a signalling link is brought into service, either initially or after a total loss of synchronization.

Normal synchronization will be established in the following manner. Each terminal will emit either:

— a series of blocks containing eleven SYUs, plus one ACU, or

— a series of blocks of *faulty-link information* as covered in Recommendation Q.293, section 8.6.1, when changeover has been requested.

The instant of commencement of emission at the terminals is immaterial.

After bit synchronism has been established in the demodulator, the incoming bit stream will be monitored to find the SYU pattern. Once this pattern is found and verified the sequence number can be determined and the ACU position located.

In due course, on the incoming channel the transmitted ACU should be correctly received with its block number. The establishment of synchronization at a terminal will be signalled by information inserted in the ACU.

Until synchronization is achieved on the incoming channel, the transmitted ACU should contain a series of ones for the 11 acknowledgement indicators and the 3-bit cyclic number of the block being acknowledged should be set to zero, unless the terminal has lost synchronism and faulty-link information is being sent. In this condition, the block acknowledged number should be repeated for each new block as covered in Recommendation Q.293, section 8.6.1. The 3-bit cyclic number indicating the number of the block it completes should be systematically advanced by one for each new block.

When a terminal has established synchronization by recognition of the SYU pattern and has also received an ACU which checks correctly, it should include in the next ACU which it emits, the cyclic number of the block being acknowledged and an indication as to whether each of the signal units within that received block contains a detected error or not. The reception of an ACU which checks correctly and acknowledges one or several signal units indicates that both terminals are in synchronism. When initial synchronization has taken place, signalling traffic should not be offered to the link until the one-minute proving period has elapsed (see Recommendation Q.291, section 8.3.3).

If the signal unit error rate is acceptable at the end of the one-minute proving period, two load-transfer signals are emitted in the case of a regular link, or two standby-ready signals for synchronized reserve links. Acknowledgement of these signals by the other terminal is as covered in Recommendation Q.293, sections 8.6.2 and 8.8. Signalling traffic may then be offered to regular links, while synchronized reserve links may be marked as ready for service.

The one-minute and the emergency proving periods and the load-transfer signalling sequence are omitted for non-synchronized reserve links when a changeover is made from the regular link as covered in section 8.6.1, Recommendation Q.293.

Bit synchronization is maintained by the transition between dibits; loss of synchronization will result in signal units failing to check correctly; however, incorrect signal units are more likely to result from line interference than loss of synchronism. Monitoring of the bit stream should result in the recognition of the 16-bit pattern of an SYU and enable synchronization to be restored if it had been lost.

6.8.3 Signal unit resynchronization

Loss of signal unit synchronism will result in continuous failure of signal units to check. When the signalling terminal receives consecutive signal units in error, it may take unilateral action to resynchronize to the incoming bit stream. During this procedure, the signal unit error rate monitor unit must continue to count signal units in error.

6.8.4 Block resynchronization

Equipment must be provided to detect loss of block synchronism.

Loss of block synchronism will be recognized when a valid signal unit, which is not an ACU, is received in the 12th position in a block.

Loss of block synchronism may also be recognized by any of the following:

a) an ACU is received in other than the 12th position in a block;

b) the completed block number is not the next one expected;

c) an SYU sequence number is not the one expected.

When loss of block synchronism has been recognized—by any of the four events described above—the terminal will stop sending telephone signals and send only SYUs and repeated ACUs (see Recommendation Q.279).

When the terminal has identified the signal unit position in a block either by recognizing the SYU number or by identifying an ACU, and has also received an ACU which checks correctly, resynchronization is deemed to have been achieved.

After successful block-resynchronization, the block being transmitted is completed with SYUs and an ACU. At least one complete block of 11 SYUs shall be sent before resuming normal traffic.

The first ACU sent after resynchronization has been achieved will have the following characteristics:

a) the indicator bits are all set to 1,

b) the completed block number is set to the next in sequence,

c) the acknowledged block number will correspond to the latest received ACU.

Upon resynchronization, a terminal may receive an ACU with an acknowledged block number, which differs from that expected. All messages sent in unacknowledged blocks should be retransmitted.

When block-resynchronization cannot be achieved within 350 ms, changeover (see Recommendation Q.293, section 8.6.1) and emergency restart procedures (see Recommendation Q.293, section 8.7) will take place as appropriate.

Note. — An all-zero signal, i.e. a signal unit consisting of 20 zeros with the correct check bits, may cause a discontinuity in the transmitted signal unit sequence.

A receiving terminal which can recognize such a signal may, optionally, take steps to ensure that synchronism is not lost, for example by inhibiting the incoming signal unit and block counters during reception of these signal units.

Recommendation Q.279

6.9 DRIFT COMPENSATION

6.9.1 General

The difference in clock rates at the two terminations of a signalling link will result in a drift between the bit streams transmitted in the two directions.

The slower terminal will find at some stage that it has two blocks awaiting acknowledgement. When this occurs, only the second (later block) should be acknowledged (*skipping* of an ACU). On receipt of the acknowledgement of the second block, the sending terminal will initiate the transmission of all messages in the first block as if they were received in error before proceeding with any necessary retransmission relating to the second block.

Moreover, the faster terminal will find at some stage that it has no complete new block to acknowledge in the ACU it is about to transmit. In this case, the acknowledgement fields for the indicators and block number (bits 4 to 17) from the previous block are repeated (*repeating* of an ACU). This ACU will be recognized to be a repetition by the cyclic number (bits 15 to 17) and should be ignored by the slow terminal (see Recommendation Q.259, section 3.3.2).

6.9.2 Drift compensation hysteresis

When the time difference between the moment at which the second block is received and the moment at which the acknowledgement should be sent is very small (e.g. less than one signal unit), drift compensation may be required at frequent intervals. In order to avoid alternating skipping and repeating ACUs too frequently, it is recommended that a certain interval elapses between the opposite decisions "to skip" and "to repeat" ACUs (drift compensation hysteresis). This interval must be sufficiently long to avoid unnecessary drift compensations, but short enough that acknowledging of the concerned block is not delayed too much.

CHAPTER VII

Signal traffic characteristics

Recommendation Q.285

7.1 SIGNAL PRIORITY CATEGORIES

7.1.1 Rules for signal priority

The following rules for establishing priority categories must be followed in normal operation; within any of the priority categories, signals are transmitted in order of their arrival at the output buffer (see Recommendation Q.251, section 1.1.1):

a) Acknowledgement signal units (12th signal unit of each block) have absolute priority for emission at their fixed predetermined position;

b) Faulty link information (Recommendation Q.293, section 8.6.1) has priority over all other signals;

c) The answer signal, charge and answer signal, no charge have priority over other waiting telephone signals and signalling-system-control signals except those cited in a and b above;

d) All other telephone signals, one-unit or multi-unit messages, and all other signalling-system-control signals, except synchronization signal units, have priority over management or other signals concerned with the bulk handling of traffic;

e) Any signal which is to be retransmitted will take precedence over other waiting signals in the same priority category;

f) Management signals have priority over synchronization signal units;

g) Synchronization signal units have no priority.

7.1.2 Break-in

a) Potential for a priority one-unit message to break into a multi-unit message is provided in the design of the format, but initially this feature will not apply except for ACU;

b) In the event that a multi-unit message is used for a network-management signal, all telephone signals must have the potential to break into this message;

c) In the rare event that a SYU breaks into a multi-unit message (e.g. owing to severe processor overload), the multi-unit message may be accepted as valid.

Recommendation Q.286

7.2 SIGNALLING CHANNEL LOADING AND QUEUEING DELAYS

7.2.1 Loading potential

According to Recommendation Q.257, section 3.1.3.3, the system No. 6 design provides the potential in circuit labels to identify 2048 telephone circuits. Considering that the load per signalling system will vary according to the traffic characteristics of the circuits served and the number of signals in use, it is not practicable to specify a general maximum limit of circuits that a system can handle. The maximum number of circuits to be served must be determined for each situation, taking into account the traffic characteristics which apply, so that the total signalling load is held to a level which will maintain an acceptable signalling delay value resulting from queueing.

7.2.2 Queueing delays

Common channel signalling systems handle the required signals for many circuits on a time-shared basis. With time-sharing, signalling delay occurs when it is necessary to process more than one signal in a given interval of time. When this occurs, a queue is built up from which signals are transmitted in order of their time of arrival and of their priority. Formulae, which are in close agreement with computer simulation tests and are recommended for calculating average queueing delays for the signals listed and the variables noted, are given in the Annex to this Recommendation.

ANNEX

(to Recommendation Q.286)

Queueing delay formulae for telephone signals

Answer signal: One-unit message with priority

$$Q_w = \frac{1 + (D - 1)a_d}{(1 - a_c)(1 - a_c - a_w)} \times \frac{T_e}{2} \tag{1}$$

Other telephone signals: One-unit message without priority

$$Q_o = \frac{1 + (D - 1)a_d}{(1 - a_c - a_p)(1 - a_c - a_w)} \times \frac{T_e}{2} \tag{2}$$

Address signal: Multi-unit message without priority

$$Q_d = Q_o + \frac{(D - 1)a_c}{1 - a_c} \times T_e , \tag{3}$$

where Q_w, Q_o, Q_d = average queueing delay,
a_w = traffic of answer signals,
a_d = traffic of multi-unit address messages,
a_p = traffic of all telephone signals,
a_c = traffic of acknowledgement signal units,
T_e = emission time of a signal unit,
D = number of SUs composing a multi-unit address message.

When multi-unit address messages are of different length, the average queueing delay for the messages composed of D_i SUs is given by formula (3) using D_i for D. In formulae (1) and (2), the following values should be used:

$$D = \frac{\sum D_i a_{di}}{a_d}, \text{ and } a_d = \sum a_{di}$$

where a_{di} is the traffic of the messages composed of D_i SUs.

Note 1. — The unit of traffic is the erlang. The traffic a_p includes a_w, a_d and the traffic of other one-unit messages, but excludes a_c.

Note 2. — These formulae include the effects of systematic delay (due to synchronous operation and block composition) and of traffic delay, but do not include the emission time of the signal message and the delay resulting from eventual retransmission of signal messages.

Note 3. — In addition, formula (3) includes the effect of break-in by acknowledgement signal units.

Note 4. — Signal units of lower priority, e.g. management signal units and synchronization signal units, have no influence on the delay of telephone signals.

Example of queueing delays

The traffic model assumed is given in Table 3, from which the proportion of signal traffic may be obtained as shown in Table 4.

Using Table 4, average queueing delays are calculated as shown in Figure 18/Q.286.

TABLE 3

TRAFFIC MODEL

Sending procedure			"En bloc"				Overlap			
Type of call			AW	SB	CC	AB	AW	SB	CC	AB
Per cent calls			30	10	5	5	30	10	5	5
Messages per call	Address	5-SU	1	1	1	0				
		4-SU					1	1	1	1
		2-SU					1	1	0	1
		1-SU					3	3	0	0
	Answer		1	0	0	0	1	0	0	0
	Other		4.5	4	4	0	4.5	4	4	3

Note 1. — AW = answered, SB = subscriber busy and not answered, CC = circuit congestion, AB = abortive.

Note 2. — The assumptions used in this model are chosen for illustrative purposes, and should not be considered to be typical.

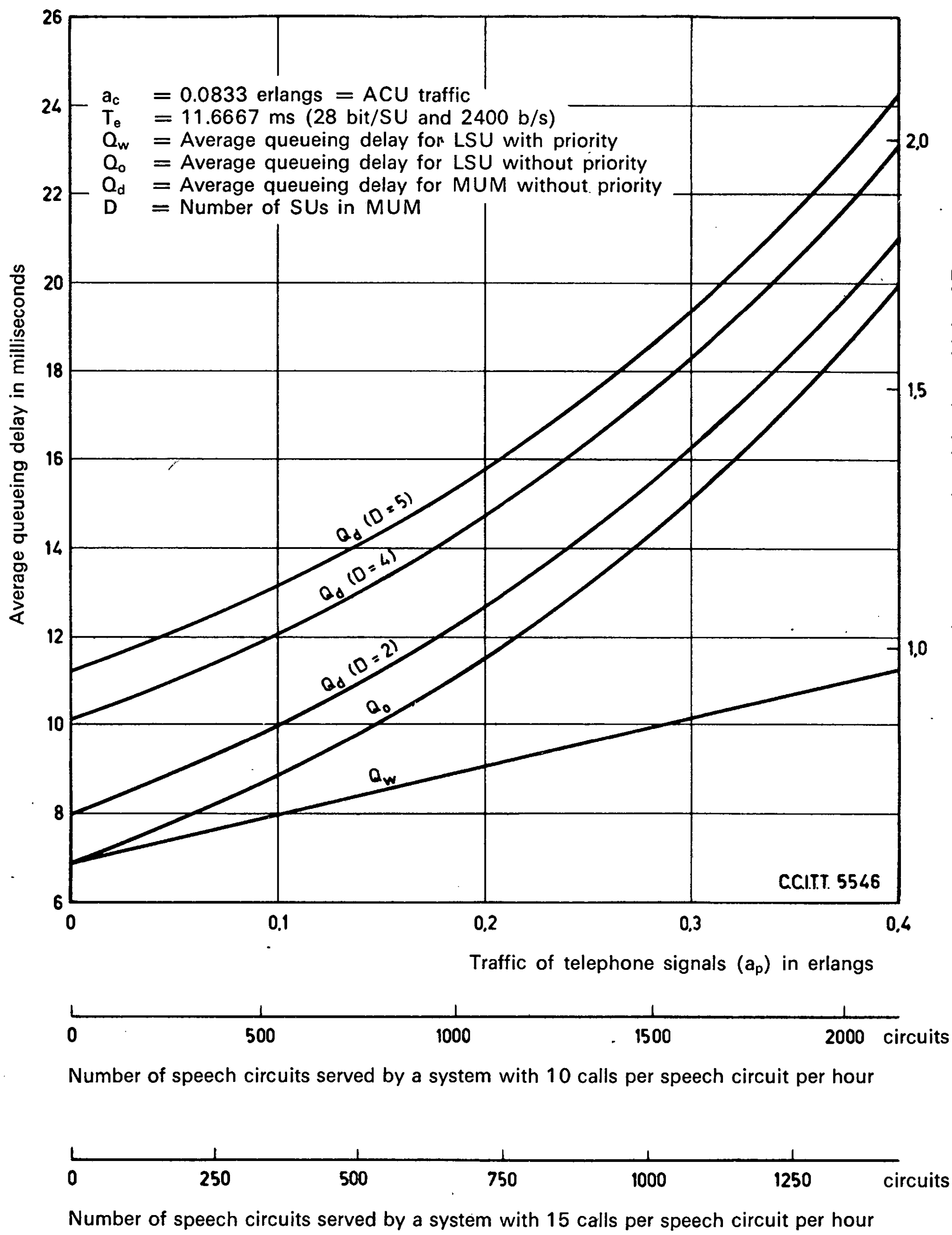


FIGURE 18/Q.286. — **Average queueing delays for each channel of traffic model shown in Table 3**

TABLE 4

PROPORTION OF TRAFFIC

Type of message		SUs per call	Percent traffic
Answer		0.60	5.5
Address	D = 5 D = 4 D = 2	2.25 2.00 0.90	20.4 18.2 8.2
Other		5.25	47.7
Total per call		11.00	100.0

Note. — In this table, "other" includes the one-unit address messages.

Recommendation Q.287

7.3 SIGNAL TRANSFER TIME REQUIREMENTS

The cross-office signal transfer should be fast so as not to lose the advantage of the fast signalling capability of the system No. 6. While no firm time requirements in regard to the various components of signal transfer time have been established, the Annex to this Recommendation contains design objectives in terms of average and 95% level time values for T_h and T_c for the answer signal, other one-unit messages and the initial address message at the data rate of 2400 bits per second. These figures are to be viewed as reasonable objectives and not as firm requirements.

ANNEX

(to Recommendation Q.287)

Estimates for transfer times

1. *Design objectives*

The design objectives for the handling time T_h and the cross office transfer time T_c are shown in Table 5.

TABLE 5

DESIGN-OBJECTIVES (T_h and T_c)

Type of message		Answer	Other one-unit messages	IAM of 5 SU
T_h in ms	Average	12	25	25
	95% level	25	60	60
T_c in ms	Average	40	60	120
	95% level	70	140	200

Note. — These figures have to be viewed as reasonable estimates and not as firm requirements.

2. *Calculation for cross-office transfer time*

Average value:

The average value of the cross-office transfer time, $T_{c\,AV}$, is calculated by the following formula:

$$T_{c\,AV} = T_r + T_{h\,AV} + T_{s\,AV}. \qquad (1)$$

The average value of the sender transfer time, $T_{s\,AV}$, is approximated as follows:

$$T_{s\,AV} = T_{q\,AV} + T_m + T_e, \text{ for one-unit messages} \qquad (2\text{ a})$$

$$T_{s\,AV} = T_{q\,AV} + T_m + (D \times T_e), \text{ for multi-unit messages} \qquad (2\text{ b})$$

where T_e = emission time of a signal unit,
T_m = time for encoding and modulation and, where present, parallel to serial conversion,
T_r = receiver transfer time,
D = number of SUs composing a multi-unit message.

The average queueing delay, $T_{q\,AV}$, is equivalent to Q_w, Q_o or Q_d which is calculated by the formula in the Annex to Recommendation Q.286.

95% level value:

The 95% level value of the cross-office transfer time, $T_{c\,95\%}$, is approximated by the following formula:

$$T_{c\,95\%} = T_{c\,AV} + \sqrt{(\Delta T_h)^2 + (\Delta T_q)^2},$$

where $\Delta T_h = T_{h\,95\%} - T_{h\,AV}$,
$\Delta T_q = T_{q\,95\%} - T_{q\,AV}$.

The 95% level value of the queueing delay, $T_{q\,(95\%)}$, may be determined by simulation.

Example:

Table 6 shows a calculated example of $T_{c\,AV}$ and $T_{c\,95\%}$ for $a_p = 0.4$ erlang with the traffic model in the Annex to Recommendation Q.286. As a result of simulation for this model, it has been determined that $T_{q\,95\%} = 3.5 \times T_{q\,AV}$. The values of $T_{h\,AV}$ and $T_{h\,95\%}$ are those assumed for Table 5 and $T_r = T_m = 2$ ms is assumed.

TABLE 6

CALCULATED EXAMPLE (T_c)

Type of message		Answer	Other one-unit messages	IAM of 5 SU
T_c in ms	Average	38	60	111
	95% level	69	121	181

CHAPTER VIII

Security arrangements

Recommendation Q.291

8.1 GENERAL

Since a common signalling link carries the signals for many speech circuits, a failure of this link will affect all the speech circuits served. Therefore, arrangements must be made to ensure continuity of service for the circuits.

The security arrangements involve the provision of reserve facilities, that may be one or more of the following:

— another signalling link, used in the quasi-associated or load sharing mode,

— a dedicated reserve signalling link, or

— a circuit, normally used for speech, to be withdrawn when required for use as a signalling link.

When the regular signalling link fails, all waiting messages marked for retransmission as well as all unacknowledged signal units should be retransmitted over the reserve facility. Subsequent signalling traffic destined for the failed link should then be transferred to the reserve facility. Signalling traffic should be directed to the reserve facility only after the proper preparations have been made.

When no signalling link is available for carrying during the period of changeover to a non-synchronized reserve or a nominated speech circuit, or during an emergency restart condition, measures must be taken to prevent the storage capacity of the failed signalling system from being exceeded so as to prevent messages from being lost. It is recommended that all free speech circuits should be removed from service during this period (by local busying at each end), to permit the traffic to overflow to other routes which are serviceable. When there is no overflow facility, appropriate circuit-group-congestion signals should be returned.

8.2 BASIC SECURITY ARRANGEMENTS

The basic security requirement is taken from the dependability requirements for continuity of signalling service (Recommendation Q.276, section 6.6.1 d).

Steps should be taken to open up a reserve facility as soon as possible after detection of a fault.

Once the reserve facility has been taken into service, the regular signalling link should not be brought back into service for signalling traffic until it has been checked to be giving satisfactory performance for about one minute.

Should it happen that the reserve signalling link also fails, another reserve facility should be opened up. When there is no other reserve facility available, an attempt to transfer to any suitable signalling link, using the emergency restart procedure described in Recommendation Q.293, section 8.7, must take place.

8.3 TYPE OF FAILURES, RECOGNITION OF FAILURE AND ABNORMAL ERROR RATES

8.3.1 Type of failure

The interruption of signalling service may be caused by several types of faults affecting the voice-frequency channels, the data modems or the signalling terminal equipment.

The failure may be indicated as follows:

a) loss of data carrier,

b) continuous failure of signal units to check correctly,

c) unacceptable intermittent failure of signal units to check correctly, or

d) loss of block synchronism.

8.3.2 Recognition of failure

Monitoring equipment is provided to recognize all types of signalling channel failures.

At each terminal, the monitoring will be performed on the incoming signalling channel by

a) monitoring the signal unit error rate, and

b) detection of loss of block synchronism.

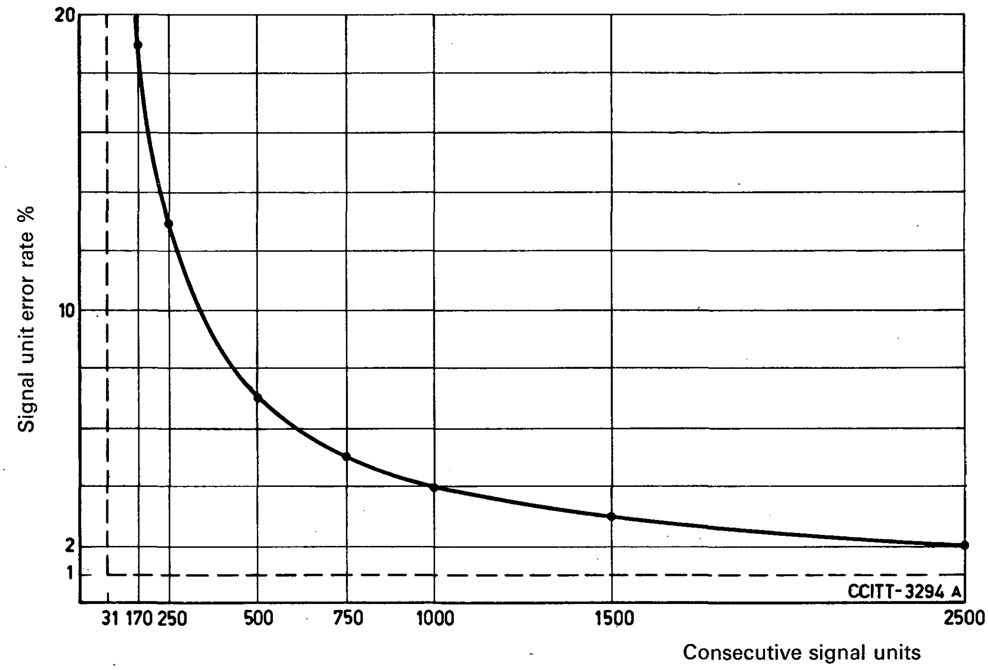
The *signal unit error rate monitor* recognizes unacceptably high percentages of signal units received incorrectly. A signal unit is recognized as being received incorrectly as a result of an indication from the check bit decoder or the carrier failure detector (see Recommendation Q.277, sections 6.7.1 and 6.7.2). The signal unit error rate monitor should have the hyperbolic error rate/signal unit characteristic shown in Figure 19/Q.291. The signal unit error rate monitor shall be reset to zero whenever:

— the monitor output has been recognized, indicating that the signal unit error rate, as detected by the decoder or the data carrier failure detector, has become unacceptable, or

— synchronization of the signalling link has been achieved, or

— after a signalling link failure.

Loss of block synchronism is detected as described in Recommendation Q.278, section 6.8.4.



31 ± 1 consecutive signal units received in error will initiate changeover.

Note. — The curve is based on a uniform distribution of errors.

FIGURE 19/Q.291. — **Signal unit error rate monitor characteristic**

8.3.3 Recognition of end of failure

a) *One-minute proving period*

Monitoring equipment is provided at each terminal to recognize satisfactory performance of the signalling link after initial synchronization or after a link failure. The signalling link shall not be placed into service unless the monitor has indicated that no more than 10 signal units in error (0.2% error rate) have been received in a proving period of one minute (approximately 5000 signal units).

In the event that the monitor indicates that more than 10 signal units in error have been received before the one-minute proving period has elapsed, then the error rate monitor shall be reset and the one-minute proving period recommenced.

b) *Emergency proving period*

An emergency proving period is used in conjunction with the emergency restart procedure (see Recommendation Q.293, section 8.7). The emergency proving period is a 2 to 3 second period during which the error rate on the link is such that the error rate monitor does not give an output. The emergency proving period begins when a regular or reserve link achieves synchronism. In the event that the monitor gives an output before the emergency proving period has elapsed, the error rate monitor shall be reset and the emergency proving period recommenced.

c) *No proving period*

No proving period is required when

— changeover to a reserve link is caused by failure of a signalling link (as specified in Recommendation Q.293, section 8.6.1), or when

— block resynchronization is achieved (as specified in Recommendation Q.278, section 6.8.4).

Recommendation Q.292

8.4 RESERVE FACILITIES PROVIDED

The reserve facilities provided can be subdivided into three groups following below in the order of ready availability:

a) quasi-associated reserve signalling links,

b) full-time reserved voice-frequency links,

c) nominated direct circuits.

Within each group, one or more arrangements can be distinguished which differ in the preparatory actions to be taken to bring the reserve facility into active service.

The choice of the particular facilities to be used can be governed by several factors, e.g. the possibility of using quasi-associated signalling links, the number of circuits served, the geographical distance between the No. 6 exchanges, etc. The choice of method(s), therefore, will be made by the Administrations involved according to the circumstances which apply.

As a matter of principle, the reserve facility to be used should follow a route different from the route of the regular signalling link.

8.4.1 Quasi-associated reserve signalling links

The method of using a quasi-associated signalling link as a reserve facility is directly derived from the principles accepted for system No. 6 (Recommendation Q.253).

This method assumes an adequate signalling network and requires prior agreements on its adoption between the Administration(s) through whose signal transfer point(s) the signalling traffic may overflow.

Methods of controlling quasi-associated signalling are described in Recommendation Q.266, section 4.6.2.

8.4.2 Full-time reserved voice-frequency links

A voice-frequency link is permanently assigned to provide the reserve signalling link.

The following arrangements can be distinguished:

a) *Load sharing*

Both voice-frequency links are equipped with modems and signalling terminals and are in use on the basis of duplicate working with load sharing. Each link in this method is the reserve for the signal load on the other link.

The circuits shall be assigned identical labels on both links and each circuit shall be assigned to one of the parallel signalling links as its regular link. The exchange must be capable of accepting signalling traffic for the labels over either link at any time.

b) *Synchronized reserve*

The voice-frequency link is equipped with modems and signalling terminals, thus forming a reserve signalling link.

The link is not in use, but its channels are synchronized.

c) *Non-synchronized reserve*

The voice-frequency link is not equipped with modems and signalling terminals. A switching operation is thus required to convert the voice-frequency link into a signalling link, before synchronizing of the signalling channels can start.

Arrangements a and b are considered to be more usual than c and will no doubt be the general rule in the case of a full-time reservation of a voice-frequency link. However, for international exchanges at which very many signalling links terminate, Administrations may prefer not to use the arrangements a and b above but to pool available modems and signalling terminals for common use to a number of reserve voice-frequency links.

8.4.3 Nominated direct circuits

A nominated direct circuit is permanently assigned to be converted into a signalling link, when required. The following arrangements can be distinguished:

a) *Speech circuit reserve*

The nominated circuit is normally in speech condition. Switching action and synchronizing must be performed in case the voice-frequency link of the speech circuit is required for the reserve signalling link. The switching action is allowed only when the voice-frequency link is not in use for speech. For this reason, Administrations should ensure that the nominated speech circuit has a high probability of being free (for example, by using a last-choice circuit).

The available modems and signalling terminals may be pooled for common use to a number of speech circuit groups.

b) *TASI-through reserve*

The nominated circuit is a TASI-through circuit. This circuit is not to be used for speech. When it is required to open up a reserve signalling link, data carrier power is applied in the normal way. This power will be sufficient to operate the speech detector at each end and cause TASI channels to be associated with the circuit for as long as the power is applied.

Arrangement b cannot be ranked as a general solution since it depends on having a TASI system between the two international exchanges involved.

Recommendation Q.293

8.5 INTERVALS AT WHICH SECURITY MEASURES ARE TO BE INVOKED

The following action points are defined:

T_o = time when signalling fault indication starts,

T_w = time when warning of failure is issued (for example, to busy a nominated speech circuit reserve),

T_d = time when decision to changeover is made,

T_u = time when signalling traffic is offered to the reserve link.

The intervals T_w-T_o and T_u-T_d are not specified. It is recognized that these intervals will vary from one method or arrangement to another.

The interval T_d-T_o does not include the time for the processor to react. Its value is determined in the case of:

— continuous failure, by 31 ± 1 signal units being in error;

— intermittent failure, by the instant the signal unit error rate monitor gives an output indicating that the signal unit error rate has become unacceptable;

— loss of block synchronism, by the failure to achieve block resynchronization within about 350 ms.

8.6 CHANGEOVER AND CHANGEBACK PROCEDURES

8.6.1 Changeover from faulty signalling links

a) Consider two exchanges A and B with a fault in signalling link AB, *affecting both directions.*

Each exchange at time T_d initiates the synchronization procedure (Recommendation Q.278), where applicable, on the reserve signalling link. When both ends are in synchronism over the reserve link, the processors switch over without any proving period and use this link.

On detection of failure of a working link at time T_o, each terminal *starts sending faulty-link information* on the link just failed. This information consists of a number of changeover signals (completing the block being sent) plus ACU, followed by a continuous stream of alternating blocks of changeover signals and of SYUs (11 changeover signals+ACU, 11 SYUs+ACU, 11 changeover signals+ACU, etc.).

When a terminal is unable to accept a correctly received signal unit, the relevant bit in the ACU acknowledging the signal unit shall be set to 1. If the terminal has lost synchronism, all ACU indicator bits will be set to 1. In this case, the block completed number in the transmitted ACU shall continue to be incremented for each new block while the block acknowledged number will be repeated for each block. When synchronization is again established on the incoming channel, the acknowledgement indicators are set as covered in Recommendation Q.278, section 6.8.2, the block acknowledged number of the transmitted ACU is changed to agree with the block completed number of the validly received ACU and normal updating is resumed.

With the reserve facility properly prepared, each exchange retransmits on the reserve facility all waiting signals marked for retransmission and all signals not acknowledged by the other exchange, followed by new signalling traffic from the failed link as specified in Recommendation Q.291, section 8.1.

b) Consider a fault affecting *only one direction*, for example A to B. The fault will be detected at terminal B and at a time T_d this terminal will act as under section 8.6.1 a.

Upon receipt of two changeover signals on the working signalling channel within a period of 3 seconds, exchange A commences the synchronization procedure, when applicable, on the reserve signalling link. Exchange A sends only blocks of SYUs (plus ACUs) on the failed channel A to B. Correctly received signal units which a terminal is unable to accept will result in setting the relevant acknowledgement indicator bit to 1 in the outgoing ACU. Otherwise, the ACUs completing the blocks of SYUs are formed in the normal manner. Exchange A will proceed to retransmit all the failed link messages as described in Recommendation Q.291, section 8.1, and transfer all subsequent signalling traffic destined for the failed link to the reserve link for the duration of the failure.

c) If more than one type of reserve is provided, signalling should first be restored on a synchronized reserve such as a quasi-associated route or a full-time reserve link if available. Nominated speech circuits will be made busy to outgoing traffic at each end immediately, or as soon as free, until transfer to a nominated reserve signalling link has been accomplished. At time T_d, an operable reserve will be selected, by hunting through the available choices in a fixed predetermined order as specified by the Administrations concerned. Nominated direct circuits in use for speech are skipped over in the selection process.

If a synchronized reserve or quasi-associated route is selected, a later transfer to a non-synchronized full-time reserve link or a nominated direct circuit may be effected as described in section 8.6.3.2.

When a failure is encountered on a reserve signalling link, faulty-link information is sent in the same manner as on a regular signalling link encountering a failure. If the reserve link is carrying signalling traffic, the procedure as covered in Recommendation Q.291, section 8.2, will be initiated.

8.6.2 Changeback to the regular link

When either terminal has regained synchronism on the failed regular link, it will begin both its one-minute and emergency proving periods. When the received signal unit error rate has remained acceptable for the one-minute proving period, the exchange will *cease sending faulty-link information* by replacing the changeover signals (if it is sending changeover signals) with SYUs (plus ACUs).

To return to the regular link, the exchange A initiating the changeback sends two load-transfer signals on the *regular* link. From this time until changeback is either completed or abandoned, exchange A must be in a position to receive and process all signals on both the regular link and the reserve in use. When exchange B receives a load-transfer signal and knows the regular link is operational, it responds with a load-transfer acknowledgement signal on the regular link, then immediately transfers its signalling traffic from the reserve to the regular link. When exchange A receives one load-transfer-acknowledgement signal, it transfers its signalling traffic from the reserve to the regular link. Should an exchange receive a load-transfer signal on the link that is carrying traffic, then this signal shall be acknowledged.

Until the load-transfer and acknowledgement signal sequence has been satisfactorily completed as described above, signalling continues over the reserve link. After this signal sequence is completed, exchanges A and B continue to monitor the reserve link until all signals initially transmitted on the reserve link have had the opportunity to be acknowledged. Signals sent on the reserve link acknowledged as having been received in error are retransmitted on the reserve link. After 5 ± 1 seconds, when all signals have had opportunity to be acknowledged as correctly received, each end will return reserve voice-frequency links with switched terminals and modems to their original status. A nominated speech circuit must be returned to service for outgoing traffic without delay by completing an unblocking sequence even though blocking signals have not previously been exchanged for the circuit. Any resultant failure indications occurring on the reserve link during the 5 ± 1-second time interval may be ignored.

In the event exchange B decides not to changeback when it receives a load-transfer signal, it withholds the load-transfer-acknowledgement signal. Exchange A must therefore time for an interval of approximately 2 minutes for the receipt of a load-transfer-acknowledgement signal. If the time interval elapses without receiving a load-transfer-acknowledgement signal, exchange A will transmit two more load-transfer signals and recycle the timing.

If exchange A decides to terminate the changeback procedure at any time before the process is completed, it will interrupt the changeback procedure and transmit faulty link information as for a normal changeover. Exchange B will respond to the faulty-link information even though it has agreed to changeback and has started sending messages on the regular link. In the event of changeover before the load-transfer signalling sequence is completed, both exchanges will remain on the reserve link from which the changeback commenced.

If the changeback procedure is interrupted or terminated as above before the procedure is completed, the regular link should continue to meet the one-minute proving period requirement.

In the event that both exchanges A and B start changeback procedures at about the same time, either exchange, having transmitted two load-transfer signals, shall respond to a received load-transfer signal with a load-transfer-acknowledgement signal and shall transfer signalling traffic to the regular link on the receipt of either a load-transfer signal or a load-transfer-acknowledgement signal.

8.6.3 Changeover from working signalling links

8.6.3.1 *Manual changeover procedure*

a) In the event that it is desired to changeover to a reserve link for rearrangements, changes, maintenance, etc., on the regular link, the exchange A desiring to changeover will send a manual-changeover signal on the working link. When exchange B receives this signal, and agrees to the changeover, it responds with a manual-change-over acknowledgement signal.

- in the case of a quasi-associated route or other synchronized reserve link, if its operation is suitable, or
- in the case of a non-synchronized first choice reserve, after synchronization procedure has been commenced.

If a quasi-associated route or other synchronized reserve link is selected, exchanges A and B transfer their signalling traffic subsequent to this signal interchange.

If a non-synchronized reserve signalling link is selected and the manual-changeover-acknowledgement signal has been received, two load-transfer signals are sent by exchange A on this link when the link is in synchronism and has passed the one-minute proving period. Exchange B will respond to a received load-transfer signal with a load-transfer-acknowledgement signal and transfer its signalling traffic to the selected reserve, if it has also passed the one-minute proving period. On receipt of one load-transfer-acknowledgement signal, exchange A will transfer its signalling traffic.

For all cases, both exchanges A and B continue to monitor the regular link for 5 ± 1 seconds, until all signals initiated on this link have the opportunity of being acknowledged as correctly received. Signals acknowledged as having been received incorrectly are retransmitted on the regular link.

A subsequent transfer from the first choice reserve to a secondary reserve may be provided by using the procedure described in section 8.6.3.2. Exchange A initiates the subsequent load-transfer to the secondary reserve.

b) If exchanges A and B simultaneously send manual-changeover signals, both exchanges must send manual-changeover-acknowledgement signals. In the quasi-associated route or other synchronized reserved link case, exchanges A and B transfer their signalling traffic subsequent to the receipt of the manual-changeover-acknowledgement signal. For all other cases, each end, subsequent to receipt of a manual-changeover-acknowledgement signal on the regular link, will transmit two load-transfer signals on the selected reserve which will be acknowledged by the other end.

When either end receives a load-transfer signal, while expecting a load-transfer-acknowledgement signal from the other end after sending two load-transfer signals, it may transfer its signalling traffic from the regular to the reserve link after sending a load-transfer-acknowledgement signal.

c) In the event that a manual-changeover signal is not acknowledged by the other exchange, a suitable interval shall elapse (e.g. one minute), before the request is repeated. If the second manual-changeover signal is not acknowledged, the maintenance staff at the exchange requesting changeover should be alerted.

d) The end initiating a manual-changeover is the end responsible for initiating changeback to the regular link as described in section 8.6.2. In the event of simultaneous manual-changeover, either end can initiate the changeback to the regular link.

8.6.3.2 *Load-transfer procedure (automatic)*

a) An automatic load-transfer from a first choice quasi-associated reserve or other synchronized reserve to a secondary reserve may be provided by agreement if desired by the Administrations concerned. This procedure may be used to limit the signalling traffic load at the signal transfer point or to free the synchronized reserve.

b) Subsequent to the initial transfer of signalling traffic to a synchronized reserve, both exchanges attempt to achieve synchronization on a secondary reserve facility. If more than one facility is provided, the two exchanges use the following selection procedure to establish synchronization on a secondary facility.

Each exchange will select the first choice non-synchronized reserve and will attempt to synchronize for a prearranged time interval of 5 ± 0.25 seconds at one exchange and 7.5 ± 0.25 seconds at the other. The selection sequence and the time interval will be fixed by bilateral agreement. If synchronization is not accomplished within the specified time interval, an attempt is made to synchronize on each of the available reserves in turn. If unsuccessful on the last choice non-synchronized reserve, the selection cycle is repeated unless the regular link has become operable. The difference in timing at the two exchanges ensures that even in the event the exchanges do not attempt synchronization on the same reserve initially, both exchanges will ultimately meet on the reserve for a minimum interval of 2 seconds.

When synchronization is established on the reserve and the error rate has been acceptable during the one-minute proving period, load-transfer and load-transfer-acknowledgement signals are interchanged on the selected reserve prior to transfer of the traffic as described in section 8.6.3.1. Signal units originally transmitted on the synchronized reserve are retransmitted as necessary on the same reserve.

8.7 EMERGENCY RESTART PROCEDURE

a) The *emergency restart procedure* is intended to re-establish signalling communication between two exchanges without waiting for the one-minute proving period, whenever the regular and all reserve signalling links have failed or non-synchronized reserve links cannot be synchronized within 2 to 3 seconds of failure of the working link. Any link between the two exchanges which has achieved synchronism and has passed the emergency proving period (see Recommendation Q.291, section 8.3.3) will be selected to re-establish signalling communication. Maintenance personnel are alerted whenever an emergency restart condition exists. Either exchange may unilaterally commence the emergency restart procedure and the other exchange must respond even though it is unaware of an emergency signalling situation.

b) If faulty-link information is being sent on a previously failed link, it will continue to be sent until that link has passed its emergency proving period.

If at any time after the emergency proving period the signal unit error rate monitor indicates an unsatisfactory performance of the link, faulty-link information is again sent on the link and the changeover or emergency restart procedure is begun.

To minimize the number of calls affected by the emergency restart condition, Recommendation Q.291, section 8.1, should be followed, particularly the recommendation to remove free speech circuits from service.

The following procedure is designed to attempt emergency restart on as many signalling links as possible at the same time. Both exchanges will simultaneously connect terminals to as many voice-frequency links as possible between the two exchanges. Quasi-associated signalling routes are excluded from this procedure. The regular link and all synchronized reserve links have terminals permanently assigned to them. Terminals for non-synchronized reserve links will be assigned from a pool of reserve terminals. Assume that the total number of links is n and the available number of reserve terminals is T. If $T \geqslant n$, then a reserve terminal is assigned to each of the n non-synchronized reserve links and synchronization is simultaneously attempted on all links. If $T < n$, then $T - 1$ reserve terminals are assigned to as many non-synchronized reserve links, and one terminal will be cycled through the remaining non-synchronized reserve links following the procedure described in section 8.6.3.2 b.

Idle status of previously engaged nominated speech circuits at each exchange during the emergency restart procedure is recognized either by reception of a clear-forward signal from a preceding exchange or by reception of a clear-back signal from a succeeding exchange.

c) When one or more links have passed the emergency proving period, two emergency-load-transfer signals are sent periodically (2-3 second intervals) over each link. Each exchange must be capable of receiving and processing signals on any link over which the emergency-load-transfer signals have been sent. Although both exchanges may send emergency-load-transfer signals, only one exchange (designated the *emergency restart control exchange* by mutual agreement of the two Administrations) will acknowledge these signals. The non-control exchange must respond by sending emergency-load-transfer signals over the same signalling link, whenever it receives these signals and the link has passed the emergency proving period.

Both exchanges continue sending pairs of emergency-load-transfer signals at 2-3 second intervals over links which have passed the emergency proving period until the control exchange has sent two load-transfer-acknowledgement signals and one has been received by the non-control exchange.

Upon receiving two emergency-load-transfer signals within 3 seconds on one or more links, the control exchange will select one of these links which has passed the emergency proving period and respond with two load-transfer-acknowledgement signals. The control exchange may now start sending signalling traffic over this link. The non-control exchange may also commence signalling traffic when it receives a load-transfer-acknowledgement signal.

A guard period of 5 ± 1 seconds shall be commenced on transfer of traffic to the selected link During this guard period, any emergency-load-transfer signals, received at the control exchange on the link on which traffic has been resumed, shall be acknowledged. Emergency-load-transfer signals received on any other link, between the two exchanges, or received by the non-control exchange on any link, shall be ignored. If, during the guard period, the signal unit error rate monitor indicates an unsatisfactory performance of the link carrying traffic or if faulty-link information is received on that link, then the guard period is terminated and section 8.7 b, paragraph 2, applies.

After the emergency restart procedure has been terminated, changeback, automatic load-transfer or subsequent failure are treated in the normal manner. If the selected link is the regular or a synchronized reserve signalling link, the load-transfer and standby-ready signalling sequences are not initiated on the respective links.

If an exchange receives two emergency-load-transfer signals, it must respond in the manner described and transfer signalling traffic to the indicated signalling link, even though it may not be in the emergency restart state.

8.8 FAILURE OF A SYNCHRONIZED RESERVE LINK

On detection of failure of a synchronized reserve link, the terminal starts sending faulty-link information as described in section 8.6.1 a. Receipt of faulty-link information indicates that the link is not suitable for use as a reserve.

When both terminals are again in synchronism over the reserve link and the error rate has met the requirement for the one-minute proving period (see Recommendation Q.291, section 8.3.3), the faulty-link information will be replaced with blocks of SYU (plus ACU) to indicate that the proving period has been completed.

To confirm that the proving period has been completed at both exchanges, the exchange A finishing the proving period sends two standby-ready signals on the *reserve* link. When exchange B receives a standby-ready signal and knows the reserve link is usable, it responds with a standby-ready-acknowledgement signal on the reserve link. When exchange A receives one standby-ready-acknowledgement signal, it has confirmation that the reserve link is available for use.

CHAPTER IX

Testing and maintenance

Recommendation Q.295

9.1 OVERALL TESTS OF SIGNALLING SYSTEM No. 6

9.1.1 Automatic operational tests of circuits served

Information can be gained on faulty operation of system No. 6 from overall operational tests of international circuits served by the system. Such tests can be performed by the use of the automatic operational test device (ATME 2 - Recommendation O.22). In accordance with Recommendation Q.258, the information to be transmitted in the IAM is the following:

Country-code indicator	No country code included
Nature-of-circuit indicator	As appropriate
Echo suppressor indicator	Outgoing half-echo suppressor not included
Calling-party's-category indicator	Test call
Address signals	X+ST

This format allows 16 types of tests, both for transmission and signalling. If more are required, an additional address signal can be used.

The following X address signal codes are assigned:

0000 System No. 6 continuity check, see Recommendation Q.261, section 4.1.4

0001 ATME 2, Signalling check and transmission test

0010 ATME 2, Signalling check only

All test calls are completed with the clear-forward and release-guard sequence regardless of the outcome of the test.

All test calls must be allowed to be completed (for example to the responding equipment of ATME 2), even if there is a failure of the continuity check.

9.1.2 Signal unit error rate monitor

The signal unit error rate monitor, which is described in Recommendation Q.291, section 8.3.2, also provides a means of detecting deterioration of the data link. When the error rate exceeds 0.2% for a period of 6 to 10 minutes, an alarm should be given to alert maintenance personnel.

9.2 DATA LINK

The data link is composed of two one-way data channels. In general, the maintenance functions are performed independently for each direction of transmission.

For maintenance purposes, each data channel may be considered to be composed of:

a) a voice-frequency channel,

b) the modulator and the demodulator at both ends,

c) a data carrier failure detector.

The data channel and its constituent parts must be tested to ensure that they meet the requirements of Recommendation Q.272.

9.2.1 Maintenance safeguard

Since interruptions of the data link will affect many speech circuits, the data channels must be treated with the utmost care. Appropriate special measures should be taken to prevent unauthorized maintenance access which could result in interruptions to service. These special measures may include marking or flagging the equipment and appearances on distribution frames or test bays where access is possible (see Recommendation M.102).

9.2.2 Voice-frequency channel line-up and maintenance

The recommendations for the line-up and maintenance of the voice-frequency channel are taken from Recommendation M.102 — *International circuits provided for private data transmission*, taking also into account Recommendation Q.272, section 6.1.3.

9.2.2.1 *Line-up*

The voice-frequency channel line-up must be done in such a way as to ensure that the attenuation/frequency and delay/frequency distortions meet the requirements of Recommendation Q.272, section 6.1.3, within the frequency band 1000 to 2600 Hz. In addition, the uniform spectrum random noise and impulsive noise requirements of Recommendation Q.272 must be met at the receiving end.

9.2.2.2 *Maintenance*

To ensure proper operation of the common channel signalling system, it will be necessary to schedule preventive maintenance for the voice-frequency channel. The tests to be made as a routine measure are:

Test	*Periodicity*
a) Overall loss at 800 Hz	See Recommendation M.61, Table A, column 3
b) Attenuation/frequency distortion	Annually
c) Delay/frequency distortion	Annually
d) Noise	See Recommendation M.61, Table A, column 3

9.2.3 Data carrier failure detector test

No tests are specified at this time for the data carrier failure detector. However, local tests should be applied to ensure that the data carrier failure detector meets the requirements given in Recommendation Q.275.

9.2.4 Modem tests

Modems should be tested locally to ensure that the requirements of Recommendation Q.274 are met. Appropriate arrangements should be provided so that tests may be made independently of the voice-frequency channel and other equipment.

9.2.5 Data channel line-up and maintenance

9.2.5.1 *Line-up*

After verifying that the voice-frequency channel meets the requirements (section 9.2.2.1), the data channel error rate should be checked for a period of 15 minutes (without interruption) using the equipment described in section 9.2.6. The error rate requirement is given in Recommendation Q.272, section 6.1.2.

9.2.5.2 *Routine maintenance*

The tests described in the preceding section should be made each time that routine noise tests of the voice-frequency channel are required (see section 9.2.2.2).

9.2.6 Data test equipment

The equipment for testing the data channel error rate consists of a pseudo-random bit stream generator to be connected to the input of the transmitting end of the data channel and a monitor to be connected to the output of the corresponding receiving end.

The bit stream to be generated, as specified in Recommendation V.52, is reproduced in the Annex to this Recommendation.

ANNEX

(to Recommendation Q.295)

Pseudo-random test pattern

In order to test circuits for data transmission on an international basis, it is necessary to standardize the test patterns to be used. Such a pattern should be a pseudo-random one having the following characteristics:

1) it should contain all or at least the majority of eight-bit sequences likely to be met in the transmission of actual data;

2) it should contain sequences of zeros and ones as long as possible compatible with ease of generation;

3) the pattern should be of sufficient length such that at modulation rates higher than 1200 bits per second its duration is significant compared with line noise disturbances.

Accordingly, a 511-bit test pattern is chosen. The pattern is generated in a nine-stage shift register whose fifth and ninth stage outputs are added together in a modulo-two addition stage, and the result is fed back to the input of the first stage. The modulo-two adder is such that the output produces an output " 0 " when the two inputs are similar and an output " 1 " when the two inputs are dissimilar.

Table 7 shows the state of each stage of the shift register during the transmission of the first 15 bits. The pattern over a longer period is

1 1 1 1 1 1 1 1 1 0 0 0 0 0 1 1 1 1 0 1 1 1 1 1 0 0 0 1 0 1 1 1 0 0 1 1 0 0 . . . .

It is clear from the table that this pattern is the sequence of bits in stage 9 of the shift register but it also represents the sequence in any other stage shifted in time. The choice of stage to be connected to the output is therefore a matter of circuit convenience.

TABLE 7

SHIFT-REGISTER STAGES DURING PSEUDO-RANDOM TEST PATTERN GENERATION

Output

1	2	3	4	5	6	7	8	9
1	1	1	1	1	1	1	1	1
0	1	1	1	1	1	1	1	1
0	0	1	1	1	1	1	1	1
0	0	0	1	1	1	1	1	1
0	0	0	0	1	1	1	1	1
0	0	0	0	0	1	1	1	1
1	0	0	0	0	0	1	1	1
1	1	0	0	0	0	0	1	1
1	1	1	0	0	0	0	0	1
1	1	1	1	0	0	0	0	0
0	1	1	1	1	0	0	0	0
1	0	1	1	1	1	0	0	0
1	1	0	1	1	1	1	0	0
1	1	1	0	1	1	1	1	0
1	1	1	1	0	1	1	1	1

ANNEX 1 TO SIGNALLING SYSTEM No. 6 SPECIFICATIONS (See Recommendation Q.261)

TABLE 1. — **SEMI-AUTOMATIC (SA) AND AUTOMATIC (A) TERMINAL TRAFFIC**
(error-free operation assumed)

Outgoing international exchange		Incoming international exchange
	NORMAL CALL TO A FREE SUBSCRIBER	
Address signals from the national network are analyzed. The outgoing circuit is seized. The initial address message is sent: — all address signals including ST in " en bloc " operation, or — all available address signals in overlap operation. The echo suppressor, if present, is disabled so that the speech path continuity check may be performed.	Initial address message[a] →	The address message is analyzed to determine: — the circuit to be seized — country code not included — nature-of-circuit (satellite or terrestrial) — echo suppressor control — calling-party's-category. The echo suppressor, if present, is disabled so that the speech path continuity check may be performed. The loop for the speech path continuity check is attached to the incoming circuit.
The transceiver for the speech path continuity check is attached, and the check tone is transmitted on the outgoing circuit.	Check tone[a] - - - →	Set-up of the call in the national network begins when enough address signals are received for routing (overlap operation).
	← - - - Check tone	
When the speech path continuity check and cross-office check have been completed, the continuity signal is sent, and the transceiver is removed. The speech path is switched through. (When the continuity check fails, the blocking signal is sent forward. An automatic repeat attempt is made.) The echo suppressor, if present, is enabled as appropriate. The remaining address signals in overlap operation are sent forward.	Continuity →	The check loop is removed and the echo suppressor, if present, is enabled. Address signals are passed into the national network. The speech path is switched through.
	Subsequent address messages →	The address messages are analyzed to determine that all the required address signals have been received (where applicable)[b]. Set-up of the speech path is completed. Subsequent supervisory signals are handled by the processor as appropriate.
On receipt of the address-complete signal, registers (if any) are released and the speech path through connected in interconnected conventional circuits, the address signals are erased. Subsequent supervisory signals are handled by the processor as appropriate.	← Address complete	

[a] Solid arrows denote common channel signals; dotted arrows are tones, sent via the speech path (check tone and audible tones).

[b] Address-complete signal may come from the national network.

TABLE 1 *(concluded)*

Outgoing international exchange		Incoming international exchange
The operator (SA), or the calling subscriber (A) hears ringing tone.	Audible ringing tone ◄- - - - - - -	Ringing tone of the country of destination is sent back.
		Signals from the national network are passed to the outgoing international exchange as follows.
On receipt of the answer signal, charging,[a] measurement of call duration and conversation begin.	Answer ◄———	The called subscriber answers (charge or no charge).
" Clear-back " is recognized. SA: A clearing supervisory signal is given to the controlling operator. A: After 1-2 min, if there is no clear-forward signal, the international connection is released and charging and measurement of the call duration are ceased.	Clear-back ◄———	The called subscriber hangs up. SA and A: After 2-3 minutes, if there is no clear-forward signal, the national part of the connection is released.
The outgoing operator (SA) or the calling subscriber (A) clears. When the outgoing equipment is released, the clear-forward signal is sent.	Clear-forward ———►	" Clear-forward " is recognized. The connection is released, and " clear-forward " is sent to the national network of destination.
" Release-guard " is recognized, and the outgoing circuit is made available for new traffic.	Release-guard ◄———	When the incoming equipment has released, a release-guard signal is sent back. The circuit is made available for new traffic.

[a] Unless a no-charge answer or address-complete signal has been received.

TABLE 2. — SEMI-AUTOMATIC (SA) AND AUTOMATIC (A) TRANSIT TRAFFIC

(error-free operation assumed)

Outgoing international exchange		International transit exchange		Incoming international exchange
		CALL TO A FREE SUBSCRIBER		
Address signals from the national network are analyzed. The outgoing circuit is seized. The initial address message is sent: — all address signals including ST in " en bloc " operation or — all available address signals in overlap operation.	Initial address message →	The address message is analyzed to determine: — the circuit to be seized — country code included — nature-of-circuit (satellite or terrestrial) — echo suppressor control — calling-party's-category.		
The echo suppressor, if present, is disabled so that the speech path continuity check may be performed.				
The transceiver is attached and the check tone is transmitted on the outgoing circuit.	Check tone - - →	The incoming half-echo suppressor, if present, is disabled; the loop for the speech path continuity check is attached. When enough address signals have been received to select a route, the outgoing circuit is seized. The address message is sent. The outgoing half-echo suppressor, if present, is disabled.	Initial address message →	The address message is analyzed to determine: — the circuit to be seized — country code not included — nature-of-circuit (satellite or terrestrial) — echo suppressor control — calling-party's-category.
When the speech path continuity check and the cross-office check have been completed, the continuity signal is sent and the transceiver is removed. (When the continuity check fails, the blocking signal is sent forward. An automatic repeat attempt is made.)	← - - Check tone	The transceiver is attached and the check tone is transmitted.	Check tone - - →	The echo suppressor, if present, is disabled and the loop is attached so that the speech path continuity check may be performed. When enough address signals are received to select the national route, a circuit is seized and the available address signals are passed into the national network (overlap operation).
	Continuity →	On receipt of continuity signal, the loop is removed.		

TABLE 2 *(continued)*

Outgoing international exchange		International transit exchange		Incoming international exchange
The echo suppressor, if present, is enabled as appropriate. The speech path is switched through.	Subsequent address messages →	Address signals are passed to the incoming international exchange.	Subsequent address messages →	Address signals are passed into the national network.
		Cross-office check.		
		The transceiver is removed.	← Check tone	
			Continuity →	On receipt of continuity signal, the loop is removed. The echo suppressor, if present, is enabled as appropriate. The last address signal, if withheld, is passed into the national network.
		(When the continuity check fails, the blocking signal is sent forward. An automatic repeat attempt is made.)		
		The speech path is switched through.		
On the receipt of the address-complete signal, registers (if any) are released and the speech path is through connected in interconnected conventional circuits. The address signals are erased. Subsequent supervisory signals are handled by the processor as appropriate.	← Address-complete	" Address-complete " is passed on to the outgoing international exchange. The address signals are erased. Subsequent supervisory signals are handled by the processor, as appropriate.	← Address-complete	The address messages are analyzed to determine that all required address signals have been received (where applicable).[a] On receipt of continuity signal, set-up of the speech path is completed. Subsequent supervisory signals are handled by the processor as appropriate.
The operator (SA) or the calling subscriber (A) hears the audible ringing tone.	← - - -	Audible ringing tone ← - - -	- - -	Audible ringing tone of the incoming national network is sent back.

[a] The address-complete signal may come from the national network.

TABLE 2 *(continued)*

Outgoing international exchange		International transit exchange		Incoming international exchange
				Signals from the national network are passed to the outgoing international exchange as follows:
On receipt of the answer signal, charging,[a] measurement of call duration and conversation begin.	Answer ←	" Answer " is passed on to the outgoing international exchange.	Answer ←	The called subscriber answers (charge or no charge).
" Clear-back " is recognized. SA: A clearing supervisory signal is given to the controlling operator. A: After 1-2 min, if there is no clear-forward signal, the international connection is released and charging and measurement of the call duration are ceased.	Clear-back ←	" Clear-back " is passed on to the outgoing international exchange.	Clear-back ←	The called subscriber hangs up. SA and A: After 2-3 min, if there is no clear-forward signal, the national part of the connection is released.
The outgoing operator (SA) or the calling subscriber (A) clears. When the outgoing equipment is released, the clear-forward signal is sent.	Clear-forward →	" Clear-forward " is passed on to the incoming international exchange after release of the connection and outgoing equipment.	Clear-forward →	" Clear-forward " is recognized, the connection is released, and " clear-forward " is sent to the national network of destination.
" Release-guard " is recognized, and the outgoing circuit is made available for new traffic.	Release-guard ←	When the incoming equipment has released, " release-guard " is sent back to the outgoing international exchange. The incoming circuit is made available for new traffic.		
		" Release-guard " is recognized, and the outgoing circuit is made available for new traffic.	Release-guard ←	When the incoming equipment has released, the release-guard signal is sent back. The circuit is made available for new traffic.

[a] Unless a no-charge answer or address-complete signal has been received.

TABLE 2 *(continued)*

Outgoing international exchange		International transit exchange		Incoming international exchange
		CALL TO A BUSY SUBSCRIBER		
The signal sequence is the same as for a call to a free subscriber up to the point where all of the address signals have been passed into the incoming national network.				
			Subscriber-busy signal (electrical) ◄——	*First case:* The incoming national network returns the subscriber-busy signal (electrical).
SA: A busy indication is given to the operator. A: The calling subscriber hears the local national busy tone sent by the outgoing (national or international) exchange.	◄—— Subscriber-busy signal (electrical)	" Subscriber-busy " (electrical) is passed back to the outgoing international exchange. The circuit is cleared automatically.	Clear-forward ——►	" Clear-forward " is recognized, the connection is released, and " clear-forward " is sent to the national network of destination. When the incoming equipment has released, " release-guard " is sent back. The circuit is made available for new traffic.
		" Release-guard " is recognized, and the outgoing circuit is made available for new traffic.	◄—— Release-guard	
The circuit is cleared automatically.	Clear-forward ——►	When the incoming equipment has released, " release-guard " is sent back to the outgoing international exchange. The incoming circuit is made available for new traffic.		
" Release-guard " is recognized and the outgoing circuit is made available for new traffic.	◄—— Release-guard			
The operator (SA) or the calling subscriber (A) hears the busy tone of the distant country and clears. The clear-forward sequence follows as above.	◄– – – –	Busy tone – – – –	– – – –	*Second case:* The busy tone of the incoming national network is sent back.

TABLE 2 *(concluded)*

Outgoing international exchange		International transit exchange		Incoming international exchange
		CONGESTION (For simplicity, the continuity check is not shown).		
Address signals from the national network are analyzed. The outgoing circuit is seized. The initial address message is sent.	Initial address message →	When enough address signals have been received to select a route, an attempt is made to seize an outgoing circuit. When blockage occurs in the switching equipment, the switching-equipment-congestion signal is sent backward.		
Appropriate action is taken. (For example, an indication is given to the calling subscriber or an automatic repeat attempt is made, etc.)	← Switching-equipment-congestion			
	← Circuit-group-congestion	When the circuit group is fully occupied, the circuit-group-congestion signal is sent backward (if overflow is inappropriate).		
SA: An indication is given to the operator. A: An indication is given to the calling subscriber.	← National-network-congestion	The national-network-congestion signal is passed backward. For the other congestion signals, appropriate action is taken. (For example, the congestion signal is sent backward or an automatic repeat attempt is made, etc.)	← National-network-congestion	If congestion occurs in the national network, the national-network-congestion signal is sent backward.
			← Switching-equipment-congestion	If blockage occurs in the switching equipment at the international exchange, the switching-equipment-congestion signal is sent backward.
The outgoing operator (SA) or the calling subscriber (A) clears.				
Appropriate action is taken. (For example, an indication is given to the calling subscriber, or an automatic repeat attempt is made, etc.)	← Switching-equipment-congestion			

ANNEX 2 TO SIGNALLING SYSTEM No. 6 SPECIFICATIONS (see Recommendation Q.267)

REASONABLENESS CHECK TABLES

1. The following tables are provided:

Table 1 refers to signal reception for an incoming call or an idle circuit,

Table 2 refers to signal transmission for an incoming call or an idle circuit,

Table 3 refers to signal reception for an outgoing call,

Table 4 refers to signal transmission for an outgoing call,

Table 5 contains the actions to be taken for blocking and unblocking sequences,

Table 6 deals with timing intervals.

The *abbreviations* used for the signals in these tables are explained in the List of abbreviations on the inside of the flap of the cover at the end of this Part XIV.

2. The reasonableness check tables consist of rows and columns.

The row on top of the table contains the telephone signals which may be received or transmitted.

The first and second columns from the left indicate the state of the circuit.

The first column contains the Circuit State Sequence Number (CSSN), and, in the second column, the state of the circuit is detailed by the signals already received (R) or sent (S).

CSSN 00 represents the idle condition of the circuit,

CSSN 11 to 17 represent possible states for an incoming call,

CSSN 51 to 62 represent possible states for an outgoing call,

CSSN 91 to 98 represent possible states for blocking and unblocking sequences.

In the intersections of rows and columns (small rectangles), the actions to be taken are shown. The *symbols* used are explained at the end of the reasonableness check tables (page 145). If the codes at the intersection require advance to another CSSN, the necessary actions must be taken to achieve the new CSSN. See example 2 below.

3. Examples

Example 1

On receipt of an IAM (first signal column, Table 1) at CSSN 11 (the state at which an IAM is received, or an IAM and one or more SAMs are received), the state is maintained (CSSN 11) and the new IAM is discarded if it is identical to the one previously received, or a confusion signal is sent backwards if the new IAM differs from the previous one.

Example 2

If the circuit is idle (CSSN 00, Table 1), and a confusion signal (COF) is received, the code 62 and PS appear at the intersection. In order to advance to CSSN 62 (Table 4), it is necessary to send a clear-forward signal. The PS indicates that the selection of the circuit must be prevented until the requirements of CSSN 62 are met (receipt of release-guard signal (RLG) to allow the circuit to return to idle (CSSN 00).

TABLE 1

SIGNAL RECEPTION FOR AN INCOMING CALL OR AN IDLE CIRCUIT

	CSSN	State of the circuit	Signal received																				
			IAM	SAM	COT	FOT	CLF	CGC, NNC	ADI, SEC, SSB, SST, VNN, LOS	COF	ADC, ADN, ADX	AFC, AFN, AFX	ANC, ANN	CB 1	RA 1	CB 2	RA 2	CB 3	RA 3	RLG	CFL	MRF
Idle	00	Idle–RLG(S), RLG(R)	11	00 WP			00 WP	62 PS	62 PS	62 PS											62 PS	
Incoming call	11	IAM(R) or IAM(R) + SAM(R)	11 CP	11	12		00														62	
Incoming call	12	IAM(R) + COT(R) or IAM(R) + SAM(R) + COT(R)	12 CP	12		12	00														62	
Incoming call	13	COT(R) + ADC(S) or ADN(S) or ADX(S)				13	00														62	RR
Incoming call	14	COT(R) + AFC(S) or AFN(S) or AFX(S)				14	00														62	RR
Incoming call	15	ADI(S), SEC(S), CGC(S) NNC(S), SSB(S), SST(S) VNN(S), LOS(S), COF(S)					00														62	RR
Incoming call	16	ANC(S) or ANN(S)				16	00														62	
Incoming call	17	CFL(S)					00														62	RR

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Table 2

SIGNAL TRANSMISSION FOR AN INCOMING CALL OR AN IDLE CIRCUIT

	CSSN	State of the circuit	Signal transmitted																		
			IAM	SAM	COT	FOT	CLF	CGC, NNC	ADI, SEC, SSB, SST, VNN, LOS	COF	ADC, ADN, ADX	AFC, AFN, AFX	ANC, ANN	CB 1	RA 1	CB 2	RA 2	CB 3	RA 3	RLG	CFL
Idle	00	Idle-RLG(S), RLG(R)	51	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Incoming call	11	IAM(R) or IAM(R) + SAM(R)	X	X	X	X	X	15	15	15	X	X	X	X	X	X	X	X	X	X	17
Incoming call	12	IAM(R) + COT(R) or IAM(R) + SAM(R) + COT(R)	X	X	X	X	X	15	15	15	13	14	16 TL	X	X	X	X	X	X	X	17
Incoming call	13	COT(R) + ADC(S) or ADN(S) or ADX(S)	X	X	X	X	X	15	X	X	X	X	16	13 TL	13 TL	13 TL	13 TL	13 TL	13 TL	X	17
Incoming call	14	COT(R) + AFC(S) or AFN(S) or AFX(S)	X	X	X	X	X	X	X	X	X	X	16	14 TL	14 TL	14 TL	14 TL	14 TL	14 TL	X	17
Incoming call	15	ADI(S), SEC(S), CGC(S) NNC(S), SSB(S), SST(S) VNN(S), LOS(S), COF(S)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	17
Incoming call	16	ANC(S) or ANN(S)	X	X	X	X	X	X	X	X	16	16	X	16	16	16	16	16	16	X	X
Incoming call	17	CFL(S)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	17

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TABLE 3

SIGNAL RECEPTION FOR AN OUTGOING CALL

	CSSN	State of the circuit	Signal received																		
			IAM	SAM	COT	FOT	CLF	CGC, NNC	ADI, SEC, SSB, SST, VNN, LOS	COF	ADC, ADN, ADX	AFC, AFN, AFX	ANC, ANN	CB 1	RA 1	CB 2	RA 2	CB 3	RA 3	RLG	CFL	MRF
Outgoing call	51	IAM(S) or IAM(S) + SAM(S)	11 RT	51 WA	51 WA		51 WA / 51 SR	62	62	62 RT										62 RT	62	RS
	52	IAM(S) + COT(S) or IAM(S) + SAM(S) + COT(S)	11 RT	52 WA	52 WA		52 WA / 52 SR	62	62	62 RT	53	54	55	52 WO	52 WO	TR	TR	TR	TR	62 RT	62	RS
	53	ADC(R) or ADN(R) or ADX(R)						62					55	53 WO	53 WO	TR	TR	TR	TR		62	
	54	AFC(R) or AFN(R) or AFX(R)											55	54 WO	54 WO	TR	TR	TR	TR		62	
	55	ANC(R) or ANN(R)									55	55		56	55 WO	55 WO	TR	TR	TR			
	56	CB 1(R)												TR	57	56 WO	56 WO	TR	TR			
	57	RA 1(R)												TR	TR	58	57 WO	57 WO	TR			
	58	CB 2(R)												TR	TR	TR	59	58 WO	58 WO			
	59	RA 2(R)												59 WO	TR	TR	TR	60	59 WO			
	60	CB 3(R)												60 WO	60 WO	TR	TR	TR	61			
	61	RA 3(R)												56	61 WO	61 WO	TR	TR	TR			
	62	CLF(S)	62 WA / 62 SC				62 SR													00		RR

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TABLE 4

SIGNAL TRANSMISSION FOR AN OUTGOING CALL

	CSSN	State of the circuit	Signal transmitted																	
			IAM	SAM	COT	FOT	CLF	CGC, NNC	ADI, SEC, SSB, SST, VNN, LOS	COF	ADC, ADN, ADX	AFC, AFN, AFX	ANC, ANN	CB 1	RA 1	CB 2	RA 2	CB 3	RA 3	RLG	CFL
Outgoing call	51	IAM(S) or IAM(S) + SAM(S)		51	52		62														
	52	IAM(S) + COT(S) or IAM(S) + SAM(S) + COT(S)		•52		52	62														
	53	ADC(R) or ADN(R) or ADX(R)				53	62														
	54	AFC(R) or AFN(R) or AFX(R)				54	62														
	55	ANC(R) or ANN(R)				55	62														
	56	CB 1(R)				56	62														
	57	RA 1(R)				57	62														
	58	CB 2(R)				58	62														
	59	RA 2(R)				59	62														
	60	CB 3(R)				60	62														
	61	RA 3(R)				61	62														
	62	CLF(S)					62														

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TABLE 5

BLOCKING AND UNBLOCKING SEQUENCES

CSSN	State of the circuit	Signal received				Signal transmitted			
		BLO	BLA	UBL	UBA	BLO	BLA	UBL	UBA
91	BLA(S)	91 SB		94 SN		97	X	X	X
92	BLA(R) + BLA(S)	92 SB		93 SN		X	X	98	X
93	BLA(R)	92 SB		93 SN		X	X	96	X
94	Not blocked	91 SB		94 SN		95	X	X	X
95	BLO(S)	97 SB	93	95 SN		95	X	X	X
96	UBL(S)	98 SB		96 SN	94	X	X	96	X
97	BLA(S) + BLO(S)	97 SB	92	95 SN		97	X	X	X
98	BLA(S) + UBL(S)	98 SB		96 SN	91	X	X	98	X

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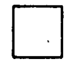
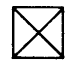
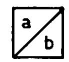
Note. — These states can overlap call processing states.

Symbols for Tables 1 to 5

 : Discard received signal.

 : Inhibit signal sending.

 : Double seizure case (a: noncontrol, b: control).

CP: ComPare received IAM with previous IAM:
— if identical, discard;
— if different, send confusion signal.

PS: Prevent outgoing circuit Selection.

RR: Retransmit the Refused signal on different signalling link, if possible (see Recommendation Q.266, section 4.6.2.3).

RS: Reattempt outgoing call on a different Signalling link.

RT: ReaTtempt outgoing call on a different circuit. Accept received IAM in double seizure case.

SB: Send Blocking-acknowledgement signal.

SC: Send Confusion signal.

SN: Send uNblocking-acknowledgement signal.

SR: Send Release-guard signal.

TL: Transfer received signaL at an intermediate common channel exchange. Inhibit sending signal at the last common channel exchange.

TR: Transfer Received signal at an intermediate common channel exchange. Discard received signal at the first common channel exchange.

WA: WAit (see Table 6).

WO: Wait at the first common channel exchange Only (see Table 6). Transfer received signal at an intermediate common channel exchange.

WP: Wait (see Table 6). Prevent outgoing circuit selection.

TABLE 6

TIMING INTERVAL

CSSN	Signal received	State of the circuit	Timing interval *(Note 1)*	Stop timing on receipt of	Actions to be taken	
					Time out	Time in
00	SAM	Receipt of SAM in idle	500 ms $+2T_p$	IAM	Discard Remain at CSSN 00	Advance to CSSN 11
00	CLF	Receipt of CLF in idle	500 ms $+2T_p$	IAM	Send RLG Remain at CSSN 00	Discard IAM Send RLG Remain at CSSN 00
51 52	SAM	Receipt of SAM after IAM (S) or IAM(S)+SAM(S) at non-control exchange	500 ms $+2T_p$	IAM	Discard Remain at CSSN 51 or CSSN 52	Double seizure *(Note 2)*
51 52	COT	Receipt of COT before IAM at non-control exchange	500 ms $+2T_p$	IAM	Discard Remain at CSSN 51 or CSSN 52	Double seizure *(Note 3)*
51 52	CLF	Receipt of CLF after IAM(S) or IAM(S)+SAM(S) at non-control exchange *(Note 4)*	500 ms $+2T_p$	IAM	Send RLG Remain at CSSN 51 or CSSN 52	Double seizure Send RLG. Remain at CSSN 51 or 52
52 53 54	CB1, RA1	Receipt of CB1 or RA1 before ANC or ANN	500 ms $+2T_p$	ANC, ANN	Discard Remain at CSSN 52 or CSSN 53 or CSSN 54	*(Note 5)*
55 to 61	CB1, CB2, CB3 RA1, RA2, RA3	Sequence check of CB_i and RA*j*	500 ms $+2T_p$	Missing CB*i* or RA*j*	Discard Remain at CSSN 55 to CSSN 61	*(Note 6)*
62	IAM	Receipt of IAM after CLF(S) at non-control exchange	500 ms $+2T_p$	RLG	Discard Remain at CSSN 62	Accept IAM Advance to CSSN 11

Notes for Table 6

Note 1. — The timing interval must allow for the maximum loop propagation time of the signalling link (cable or satellite).

In the case of signals which are transferred by intermediate exchanges without detailed analysis and are resequenced at the first or last common channel exchange, such as SAM, ANC, CB1, etc., the worst case link may be any of the several links in the connection.

The timing interval is determined considering the following relations:

$T_{rt} = 26T_e + 2T_c + 2T_p$ (for LSU),

$= 30T_e + 2T_c + 2T_p$ (for 5-SU IAM),

$< 500 \text{ ms} + 2T_p$,

where T_{rt} is the maximum retransmission time for an erroneous signal.

Note 2. — Accept incoming call and advance to CSSN 11.
Reattempt outgoing call on a different circuit.

Note 3. — Accept incoming call and advance to CSSN 12.
Reattempt outgoing call on a different circuit.

Note 4. — If a confusion, congestion, called-party's-line-condition or address-incomplete signal is received during the waiting period, release of the outgoing call attempt and sending clear-forward signal are delayed until time-out or receipt of an IAM.

*Note 5.** — At the first common channel exchange, advance to CSSN 56 if clear-back 1 has been received or to CSSN 57 if re-answer 1 has been received. In the latter case send the answer signal backwards, irrespective of whether clear-back 1 has been received or not.

*Note 6.** — Advance the CSSN to the highest in sequence CSSN 55-61 and send the appropriate clear-back or re-answer signal backwards if the state transition to the new highest CSSN makes this necessary.

* This text is slightly different from the text of Specifications of Signalling System No. 6 as published in February 1973. The modifications were decided by Study Group XI at their meeting of October-November 1973.

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GLOSSARY OF TERMS
SPECIFIC TO SIGNALLING SYSTEM C.C.I.T.T. No. 6

ACKNOWLEDGEMENT SIGNAL UNIT (ACU): The twelfth signal unit of a block, which carries information as to whether or not the signal units in the block indicated were received correctly.

ASSOCIATED SIGNALLING: A mode of operation of system No. 6 in which the signals carried by the system relate to a group of speech circuits which terminate in the same No. 6 exchanges as the signalling system.

BLOCK: A group of 12 signal units on the signalling channel.

CHANGEBACK: The procedure of transferring signalling traffic from a reserve signalling link to the regular signalling link, when the regular link is again serviceable.

CHANGEOVER: The procedure of transferring signalling traffic from one signalling link to another, when the link in use fails or is required to be cleared of traffic.

CHECK LOOP: A device which is attached to interconnect the GO and RETURN paths of a circuit at the incoming end of a circuit to permit the outgoing end to make a continuity check on a loop basis.

COMMON CHANNEL EXCHANGE: An exchange utilizing a common channel signalling system, which has the facilities of system No. 6 from an interworking standpoint.

COMMON CHANNEL EXCHANGE, FIRST: The exchange closest to the calling party in each common channel section of a connection where, unless it is the calling party's exchange, interworking with other signalling systems takes place.

COMMON CHANNEL EXCHANGE, INTERMEDIATE: A transit exchange where interworking between common channel signalling systems takes place.

COMMON CHANNEL EXCHANGE, LAST: The exchange closest to the called party in each common channel section of a connection where, unless it is the called party's exchange, interworking with other signalling systems takes place.

COMMON CHANNEL SIGNALLING: A signalling method, using a signalling link common to a number of speech circuits, for the transmission of all signals necessary for the traffic via these circuits.

CONTINUITY CHECK: A check made of the circuit or circuits in a connection to verify that a speech path exists.

CROSS-OFFICE CHECK: A check made across the exchange to verify that a speech path exists.

DATA CARRIER FAILURE DETECTOR: A monitoring device designed to indicate that the level of the data carrier is below the minimum sensitivity of the receiver.

DATA CHANNEL: A one-way path for data signals which includes a voice-frequency channel and an associated data modulator and demodulator.

DATA LINK: A combination of two data channels operating together in a single signalling system.

DRIFT COMPENSATION: The process of adjusting for the difference in relationship of the backward acknowledgement information contained in the ACU to the forward signal units it acknowledges which occurs as a result of drift in the bit rates of the data channels.

EMERGENCY RESTART: The procedure of re-establishing signalling communication, when the regular and all reserve signalling links fail.

ERROR RATE MONITOR: A device which receives an indication for each signal unit found in error and which measures the rate of occurrence of errors according to a prescribed rule.

FAULTY-LINK INFORMATION: Information sent on a signalling link to indicate a failure of that link. The information consists of alternate blocks of changeover signals and of synchronization signal units.

FIELD: A subdivision of a signal unit, which carries a certain type or classification of information—e.g. label field, signal information field, etc.

FULLY DISSOCIATED SIGNALLING: A form of non-associated signalling in which the path that signals may take through the network is only restricted by the rules and configuration of the signalling network.

INITIAL ADDRESS MESSAGE (IAM): A multi-unit message which is sent as the first message in a call set-up, consisting of a minimum of three and a maximum of six signal units, and containing enough information to route the call through the international network.

INITIAL SIGNAL UNIT (ISU): The first signal unit of a multi-unit message.

LABEL: The 11-bit binary code within a signal message used to identify the particular speech circuit with which the message is associated. The label is subdivided into a band number and a circuit number.

LOAD TRANSFER: The transfer of signalling traffic from one signalling link to another.

LONE SIGNAL UNIT (LSU): A signal unit carrying a one-unit message.

MANAGEMENT SIGNALS: Signals concerning the management or maintenance of the speech circuit network and the signalling network.

MULTI-UNIT MESSAGE (MUM): A signal message which consists of more than one signal unit.

NON-ASSOCIATED SIGNALLING: A mode of operation in which the signals for a group of speech circuits are sent over two or more common signalling links in tandem. The signals being processed and forwarded to the next link by equipment at one or more signal transfer points.

No. 6 EXCHANGE: An exchange utilizing signalling system No. 6.

No. 6 EXCHANGE, FIRST: The exchange closest to the calling party in each No. 6 section of a connection where, unless it is the calling party's exchange, interworking with other signalling systems takes place.

No. 6 EXCHANGE, INTERMEDIATE: A transit exchange where interworking to and from signalling system No. 6 takes place.

No. 6 EXCHANGE, LAST: The exchange closest to the called party in each No. 6 section of a connection where, unless it is the called party's exchange, interworking with other signalling systems takes place.

ONE-UNIT MESSAGE: A signal message which is transmitted entirely within one signal unit.

QUASI-ASSOCIATED SIGNALLING: A form of non-associated signalling in which the route the signals may take through the network is prescribed.

QUEUEING DELAY: The delay incurred by a signal message as a result of the sequential transmission of signal units on the signalling channel.

REASONABLENESS CHECK TABLES: Tables which define procedures used to avoid or resolve ambiguous call situations.

SECURITY ARRANGEMENTS: The measures provided to ensure continuity of service of the signalling system in the event of the failure of one or both of the data channels.

SIGNALLING CHANNEL: A data channel in combination with the associated signalling terminal equipment at each end.

SIGNALLING LINK: A combination of two signalling channels operating together in a single signalling system.

SIGNALLING SYSTEM: The combination of all of the equipment and channels necessary to provide signalling for one or more groups of circuits between two No. 6 exchanges. It thus includes a data link, signalling terminal equipment, and necessary portion of the processor at each No. 6 exchange.

(SIGNAL) MESSAGE: Signal information pertaining to a call, management action, etc., sent at one time on the signalling channel. A message may consist of one or more signals transmitted in one or more signal units.

SIGNAL TRANSFER POINT: A signal relay centre handling and transferring signals from one signalling link to another in a non-associated mode of operation.

SIGNAL UNIT (SU): The smallest defined group of bits on the signalling channel (28 bits), used for the transfer of signal information.

SUBSEQUENT ADDRESS MESSAGE (SAM): An address message, which may be either a one-unit or a multi-unit message, sent following the initial address message.

SUBSEQUENT SIGNAL UNIT (SSU): A signal unit of a multi-unit message other than the initial signal unit.

SYSTEM CONTROL SIGNAL UNIT (SCU): A signal unit carrying a signal concerning the operation of the signalling system—e.g. change-over, load-transfer.

SYNCHRONIZATION SIGNAL UNIT (SYU): A signal unit containing a bit pattern and information designed to facilitate rapid synchronization and which is sent on the signalling channel when synchronizing or when no signal messages are available for transmission.

TELEPHONE SIGNAL: Any signal which pertains to a particular telephone call or to a particular speech circuit.

TRANSCEIVER: A combination of a transmitter and a receiver used for the continuity check.

UNREASONABLE MESSAGE: A message with an inappropriate signal content, an incorrect signal direction, or an inappropriate place in the signal sequence.

ALPHABETICAL INDEX FOR SYSTEM No. 6

PART XV

SIGNALLING SYSTEM R1

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 C.C.I.T.T. 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 four-wire transmission path, the presence or absence of this frequency indicates a specific signal dependent upon when it

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

occurs in the signalling sequence and in certain cases upon its duration. When the circuit is idle, low level signalling tone is continuously present in both directions.

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 bloc [1], or en bloc overlap [1], or overlap sending may apply. This register signalling arrangement is used extensively with other in-band and out-band line signalling systems.

Compandors 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 C.C.I.T.T. recommendations.

[1] See Recommendation Q.151 note to section 3.1.1 for an explanation of these terms.

CHAPTER I

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)[1]

This line signal is sent to the outgoing exchange to indicate that the called party has answered [2].

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) [3]

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 [2] 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 time-out as discussed in section 1.8 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.

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[1] Notes on the answer and hang-up (clear-back) signals. — See corresponding notes in Recommendation Q.120, section 1.8.

[2] 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.

[3] In world numbering Zone 1, 13 to 32 seconds is used.

CHAPTER II

LINE SIGNALLING

Recommendation Q.311

2.1 2600 Hz LINE SIGNALLING—GENERAL

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	0 or 1
Busy, recorder (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 recorder (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 ± 5 Hz.

2.2.2 *Transmitted signal level of tone-on signals*

-8 ± 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 ± 1 dBm0.

2.2.3 *Transmitted signal durations*

The transmitted signal durations are shown on Table 1.

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;

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[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.

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;

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 EQUIPMENT [1]

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 section 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 $(-27+n \leqslant N \leqslant -1+n)$ 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.

[1] See also Recommendation Q.112.

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.

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 translation 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 paragraphs 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 section 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 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, section 2.4.1.

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 section 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 500 [1] call hours.)

b) On the average, not more than one false ring-forward (forward-transfer) signal shall occur per 70 [1] call hours of speech, at the *minimum* ring-forward recognition time.

c) Speech or other electrical signals such 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.

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

Recommendation Q.314

2.4 PCM LINE SIGNALLING—GENERAL

Individual channel line signalling is provided in the format of the C.C.I.T.T. primary multiplex operating at 1544 kbit/s (Recommendation Q.47). 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		
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	A
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		
12		0	1 to 7	8	B

Note 1. — The sequence shown is repetitive.

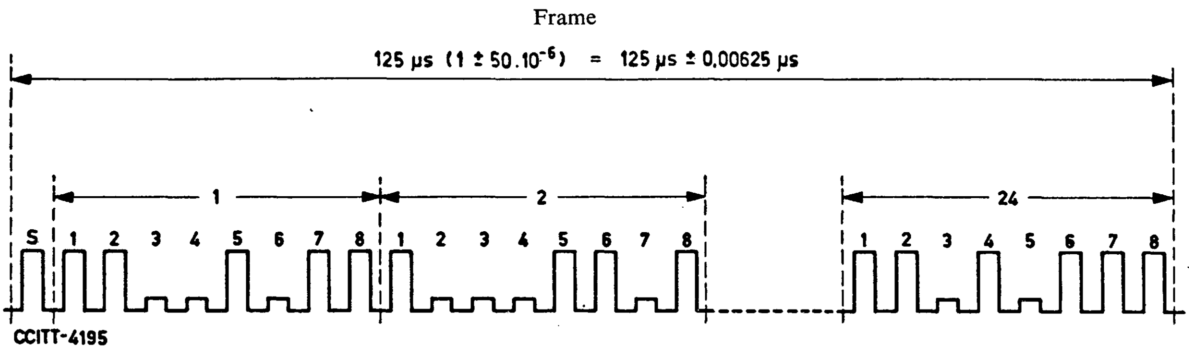
Note 2. — For system R1 the same signalling information is sent on signalling channels A and B.

2.5.2 *Transmitted signal duration*

The transmitted signal durations are given in Table 1 of Recommendation Q.312.

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 $\pm$ 0.4 Hertz
Output bit rate	1544 $(1 \pm 50 \times 10^{-6})$ kbit/s = 1544 kbit/s $\pm$ 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 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 stated 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 $\pm$ 100 ms. For terrestrial circuits the recommended time is 500 $\pm$ 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, state 1 signals should be recognized as valid signals subsequent to the minimum limits informed 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, section 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 Q.47 section 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 circuit shall be denied (guarded) for 750 to 1250 ms (1050 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 section 2.3.3, paragraph 2, of Recommendation Q.313 and to section 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 with 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 Recommendation Q.325, Section 3.6.2, Paragraph 1 c 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 Recommendation Q.325 section 3.6.2., paragraphs 1 a and 1 b.)

CHAPTER III

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 2. 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 chapter 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; [1]

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 below, 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 2

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.

[1] 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.)

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 ms $\pm$ 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 $\pm 1.5\% \pm 10$ Hz of the nominal signalling frequency;

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

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

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 connection 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 intra-regional 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 realease 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 receipt of the KP signal;

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 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 1 a 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 reorder (congestion) tone toward the originating end. If this condition (reorder) 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.

CHAPTER IV

TESTING ARRANGEMENTS

Recommendation Q.327

4.1 GENERAL ARRANGEMENTS FOR TESTING

The guiding principles for the maintenance of automatic circuits as covered in Part V (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, section 2.3.3.

2) *Register signal generator characteristics as follows:*

a) Signal frequencies should be within ±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.332, section 3.3.4, for normal operate values and in Recommendation Q.323, section 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 section 4.4.2, 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 ± 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.

CHAPTER V

INTERWORKING OF SYSTEM R1
WITH OTHER STANDARDIZED SYSTEMS

Recommendation Q.332

5. INTERWORKING

5.1 *General*

System R1 is capable of interworking with any of the C.C.I.T.T. standardized signalling systems.

Specifications on interworking of system R1 with other C.C.I.T.T. signalling systems are not yet available.

Typical information is found in Recommendation Q.180.

ANNEX TO THE SPECIFICATIONS OF SIGNALLING SYSTEM R1

Signalling sequences

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

n 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

Outgoing (or transit) exchange	Signal	Incoming (or transit) exchange
	CALL TO FREE SUBSCRIBER	
Idle	2600 Hz(0) ——▶ ◀—— 2600 Hz (0)	Idle
The connect (seizing) signal is sent forward after the circuit is selected (the speech path is open as long as the register is attached).	(1) - - - - ▶ ◀- - - - (1)	Receipt of the connect (seizing) signal causes the circuit to be made busy, a delay-dialling signal to be sent (removal of tone), and the selection process of the register to be started.
140 ms after receipt of the start-dialling (proceed-to-send) signal interregister signals are sent as follows: KP National significant number ST	◀—— 2600 Hz(0) MF 2/6 code ——▶	When a register is attached and ready to receive address information, a start-dialling (proceed-to-send) signal is returned (the speech path is open as long as the incoming register is attached). The address signals are received in the incoming register. The register starts setting up the call when sufficient information has been received to determine the routing. The incoming register releases and establishes the speech path as soon as it has sent forward all the necessary information.
The outgoing register releases after the ST (end-of-pulsing) signal has been sent. The speech path through the outgoing exchange is established.		
SA: The operator or A: the calling subscriber hears the ringing tone	◀· · · · · · · ·	The ringing tone of the country of destination is sent back.
SA: An " answer " indication is given to the controlling operator. A: Charging and measurement of the call duration begins after an appropriate delay.	◀- - - - (1)	The called subscriber answers; an answer signal (removal of tone) is sent back.
SA: A clearing supervisory signal is given to the controlling operator. A: After 13-32 seconds, if there is no disconnect (clear-forward) signal the connection is released and the charging and measurement of the call duration are ceased.	◀—— 2600 Hz (0)	The called subscriber clears, the hang-up (clear-back) signal is sent back.
The outgoing operator (SA) or calling subscriber (A) clears. A disconnect (clear-forward) signal is sent.	2600 Hz (0) ——▶	

Outgoing (or transit) exchange		Incoming (or transit) exchange
The outgoing access is maintained busy for 750 to 1250 ms (cable circuits) 1050 to 1250 ms (satellite circuits)		The disconnect (clear-forward) signal causes the release of the incoming equipment and the circuit. The disconnect signal is repeated to the next link.
	CALL TO A BUSY SUBSCRIBER OR CONGESTION The signal sequence is the same as for a call to a free subscriber, up to the release of the incoming register	
The operator (SA) or calling subscriber (A) hears the audible tone and clears. The disconnect (clear-forward) signal is sent.	◄ · · · · · · · · · · · · ◄ · · · · · · · · · · · ·	Busy subscriber. The audible busy tone of the country of destination is returned. Congestion. The audible congestion tone of the country of destination is returned.
	SPECIAL CONDITIONS	
1. Ring-forward (forward-transfer). Following a call established by operators, if the outgoing controlling operator wishes to recall the incoming operator, a ring-forward (forward-transfer) signal is sent.	2600 Hz (0) pulse (100±35 ms) ——————►	Recalls the incoming operator.
2. Double seizing. The outgoing end sends the connect (seizing) signal.	(1) – – – – – – ► ◄ – – – – – – (1)	The incoming end also sends the connect (seizing) signal.

Each end interprets the connect (seizing) signal as a delay-dialling signal. If the start-dialling (proceed-to-send) signal is not recognized within the specified timing interval, double seizing is assumed and the following may apply:

a) an automatic repeat attempt is made or;

b) a reorder (congestion) audible tone is given to the calling subscriber or operator and no automatic repeat attempt is made.

(See Recommendation Q.318.)

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PART XVI

SIGNALLING SYSTEM R2

CONTENTS

Chapter III. — LINE SIGNALLING, DIGITAL VERSION

SIGNALLING SYSTEM R2

INTRODUCTION — PRINCIPLES OF SIGNALLING SYSTEM R2

General

The following specifications and recommendations are based on the " Detailed Specifications of Signalling System R2 " published by the ITU (Geneva, 1969). They concern only the use of signalling system R2 for international telephone operation and no recommendations regarding its use in national networks are included, although its suitability for this purpose is one of the features of the system.

Consequently they include only information required for the manufacture of system R2 equipment for international use. Reference should therefore be made to the detailed specifications for any further information, e.g. the use of the system R2 in national networks.

The system R2 can be used as an international signalling system within international regions (world numbering zones). Moreover, the system R2 can be used for integrated international/national signalling if its is employed, with a few local adaptations, as a signalling system in the national networks of the region concerned. It is equally suitable for both automatic and semi-automatic working. The system is specified for one-way and both-way operation on four-wire FDM or PCM circuits. It is not designed for use on satellite circuits or TASI circuits.

In system R2, distinction is made between line signalling (supervisory signals) and interregister signalling (call set-up control signals).

Line signalling

Two versions of line signalling are specified:

— line signalling for FDM systems called the analogue version;
— line signalling for PCM systems called the digital version.

Although these versions do not include a forward-transfer signal, forward-transfer signalling may be introduced by bilateral agreement.

The *analogue version* is link-by-link using an out-band, low level continuous tone-on-idle signalling method. Signal transfer simply involves the passage 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 *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 Q.46). Protection against the effects of faulty transmission is provided by a " Transmission Fault Control ".

Interregister signalling

This is of the compelled in-band, end-to-end, 2 out of 6 (2/6) multifrequency code type with forward and backward 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 part of the multifrequency system on two-wire circuits.

The system 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.

The interregister signals are sent in overlap by the outgoing international R2 register as soon as the information required to send the first signal is available. Each backward signal may have supplementary meanings in addition to its role as an acknowledgement signal, e.g.

- request for the transmission or repetition of address information;
- information on the progress of call set-up (congestion, end of call set-up);
- request for information on the origin or nature of the call (subscriber, operator, location of outgoing international R2 register, data transmission, maintenance equipment, need to insert a half-echo suppressor);
- transmission of information concerning the called subscriber (subscriber's line out-of-order, transferred subscriber, unused number, no-charge call, etc.).

The outgoing international R2 register controls the setting up of the connection from end to end and communicates in turn with each of the incoming registers encountered in the transit exchanges. Each of the latter clears down as soon as it has set up the connection to the following exchange (see Figure 1). If the connection is extended into a national network, the outgoing international R2 register may also control the incoming national registers in the same manner, provided the same multifrequency interregister signalling is used and certain conditions are respected.

The interregister signalling specified for system R2 could be used with any line signalling system if necessary in the national network.

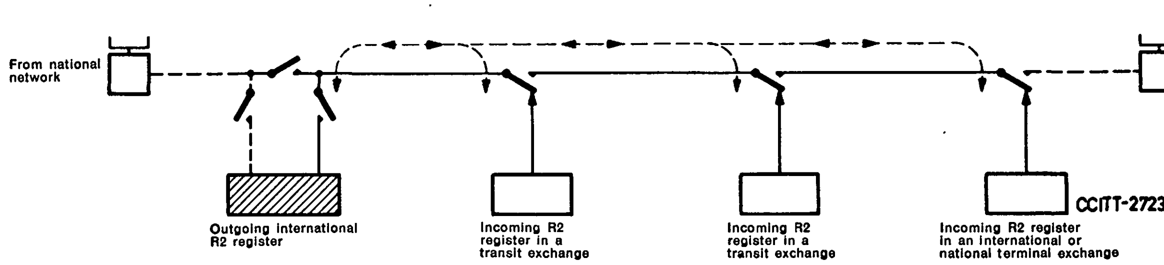

FIGURE 1. — **Principle of end-to-end R2 interregister signalling.**

CHAPTER I

DEFINITION AND FUNCTIONS OF SIGNALS

Recommendation Q.350

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.

1.2 BACKWARD LINE SIGNALS

1.2.1 *Seizing-acknowledgement signal* [1]

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.

[1] This signal is only used in the digital version of R2 line signalling.

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, section 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. It serves to protect an international circuit 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 party's number or the end of pulsing (code 15) signal.

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

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 *Signals identifying the origin of the call*

Signals sent in response to signals inquiring the origin of the call, indicating the country-code (and possibly the area trunk-code as well) of the exchange where the outgoing international R2 register is located.

1.3.4 *Signal indicating calling party's category*

A special group of signals providing, in addition to the information contained in the language or discrimination digit, supplementary information on the calling party's category in international and national service.

In international service, the following categories are provided:

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

1.3.5 *End-of-pulsing signal (Code 15)*

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.

1.4 BACKWARD REGISTER SIGNALS

1.4.1 *Signals requesting transmission of address signals*

Five backward signals 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 signals sent;
— signal requesting the repetition of the last but three address signals 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 are provided for this purpose:

— signal inquiring the calling party's category;
— signal requesting the transmission or repetition of the country-code indicator;
— signal inquiring the origin of the call (location of outgoing international R2 register);
— signal inquiring whether or not an 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 an incoming international exchange or a national exchange.

In all cases, reception of these signals causes release of the forward circuit chain and the sending back of the appropriate signal, audible tone, or recorded announcement, or possibly causes an automatic repeat attempt.

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.

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 busy

— a signal indicating that the line or lines connecting the called subscriber to the exchange are busy.

Subscriber line out of order

— a signal indicating that the subscriber's line is out-of-service or faulty.

Vacant national number

— a signal indicating that the number received is not in use (e.g. an unused trunk code or subscriber number that has not been allocated).

Subscriber-transferred (changed number)

— a signal indicating 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.

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 Recommendation Q.361.

1.5 FORWARD-TRANSFER SIGNAL

This signal is sent in the forward direction to the incoming international exchange when the outgoing operator at the outgoing international exchange needs the assistance of an operator at the incoming international exchange.

A forward-transfer signal does not normally form part of the system R2 but it may be introduced on certain relations by bilateral or multi-lateral agreement between the Administrations concerned. One possible procedure that has been adopted for use upon bilateral agreement within Europe, is to use the PYY in-band signal of system No. 4. This solution is only economical in regions where the forward-transfer facility is needed for a small proportion of the calls. Regions which have a need for the forward-transfer facility on a substantial proportion of the calls, should consider alternative means for providing this facility. Further information is to be found in the detailed specifications.

CHAPTER II

LINE SIGNALLING, ANALOGUE VERSION

Recommendation Q.351

2.1 LINE SIGNAL CODE

2.1.1 *General*

The 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. This 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.

2.1.2 *Line conditions*

Tone-on or tone-off denotes a certain signalling condition. The line thus has two possible conditions in each direction, i.e. a total of four signalling conditions. 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 conditions	
	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 condition to another corresponds to the transfer of a signal. 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.

Recommendation Q.352

2.2 CLAUSES FOR EXCHANGE LINE-SIGNALLING EQUIPMENT [1]

2.2.1 *Recognition time for transition of signalling condition*

The recognition time for a changed condition (transition from tone-on to tone-off or vice-versa) is 20 ± 7 ms. The recognition time is defined as the minimum duration 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 condition by the exchange equipment.

Thus the specified value does not include the response time of signalling receivers (see Recommendation Q.354). However, it is determined on the assumption that there is interruption control (see Recommendation Q.356).

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 it is recognized in this exchange.

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 " condition must be established on this link immediately it is recognized in this exchange.

The provisions set forth in section 2.2.2.6 must also be taken into consideration.

2.2.2.4 *Clear-forward operating condition*

The outgoing end restores the tone in the forward direction. When the changed signalling condition is recognized at the incoming end the release-guard sequence begins and release of the circuit beyond s initiated. In the outgoing exchange the circuit remains blocked until the release-guard sequence is terminated (see 2.2.2.6).

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.

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[1] Although the signalling condition (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.

2.2.2.6 *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.

a) *Release prior to answered condition*

The tone in the backward direction is removed at the incoming end as soon as restoration of the tone sent by the outgoing end has been recognized (see Figure 2/Q.352).

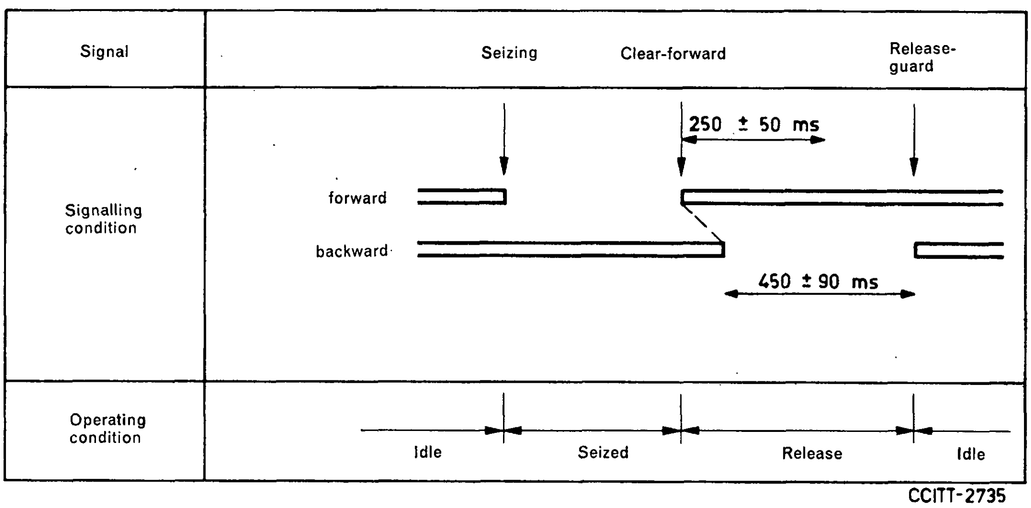


FIGURE 2/Q.352. — **Release-guard sequence prior to answered condition.**

When release operations at the incoming end have been completed but not before an interval of 450 ± 90 ms [1] has elapsed after the removal, the tone is again restored at the incoming end in the backward direction. The circuit returns to idle as soon as the restored tone is recognized, following recognition of the " tone-off " condition, at the outgoing end.

Establishing the " tone-off " interval at the incoming end and recognition at the outgoing end of the two successive changes in condition (transition from tone-on to tone-off followed by the inverse transition) together constitute the " release-guard " sequence ".

Transition from tone-off to tone-on in the backward direction must not be interpreted, at the outgoing end, as part of the release-guard sequence until an interval of 250 ± 50 ms [1] has elapsed after application of the tone in the forward direction.

b) *Release in answered condition*

The circuit returns to idle as soon as the outgoing end recognizes the tone restored in the backward direction after release operations have been completed at the incoming end. Transition in the backward direction from the " tone-off " to the " tone-on " signalling condition must not be interpreted as part of the release-guard sequence until the interval of 250 ± 50 ms described in a above has elapsed after application of the tone in the forward direction (see Figure 3/Q.352).

[1] The reasons for the delays and their calculation are given in the detailed specifications.

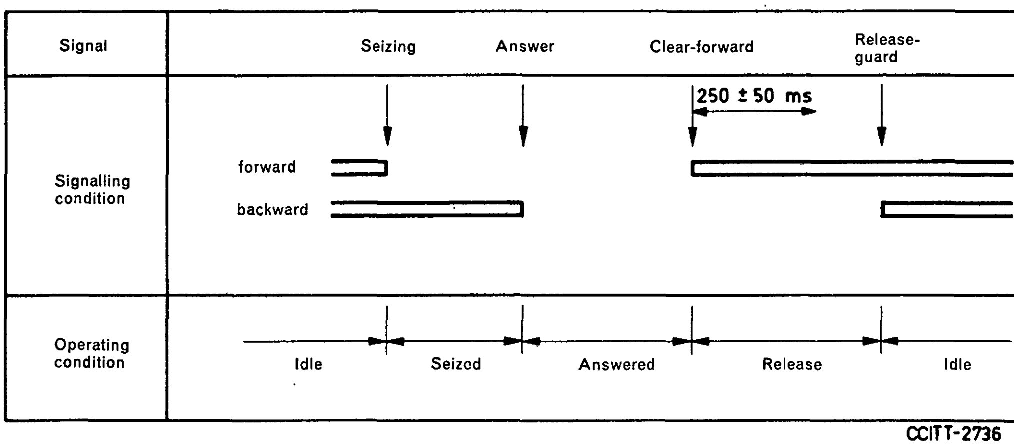


FIGURE 3/Q.352. — **Release in answered condition.**

c) *Release in clear-back condition*

The incoming equipment removes the tone in the backward direction at least for the interval 450 ± 90 ms and the release-guard sequence takes place as described in a.

2.2.3 *Abnormal conditions*

Note. — The situations described below are those in which interruption control of signalling channels (see Recommendation Q.356) does not function and which occur only during interruptions of individual channels or in the event of a fault in an individual line-signalling equipment.

2.2.3.1 If an exchange erroneously recognizes an answer signal (i.e. tone-off condition in the backward direction) before the outgoing R2 register has received an A-6 or a 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 the case of 2.2.2.6 a the signalling tone in the backward direction is not removed, the circuit will remain blocked. The action to be taken in such cases is described in Chapter VII of the detailed specifications.

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. 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 multifrequency signals follow.

a) When the interruption is greater than the incoming R2 register time-out (see 4.2.8 Recommendation Q.362) the register will release and the circuit must be brought into blocked condition by removal of the signalling tone in the backward direction.

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.

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 paragraphs 2.2.2.5, 2.2.3.3 and 2.2.3.4, 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 comes into play, alarm condition must first be established for the sending 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. See also detailed specifications.

A peculiarity of both-way working is that a blocking signal cannot be distinguished from a seizing signal at either end of a circuit, since the change in signalling condition 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 *Double seizure*

When the signalling equipment at one end of a both-way circuit seizures 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 and recognizing the " tone-on " condition of the incoming signalling channel.

However, each end must, even if immediately seized for an outgoing call, maintain " tone-on " condition 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 " condition 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. However, as specified in 2.2.5.4 a the clear-forward signal (" tone-on " condition) must not be sent until the " tone-off " condition 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) has elapsed, and the sending of the " tone-on " condition 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.

2.2.5.2 *Minimum duration of idle condition after release-guard*

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

2.2.5.3 *Blocking*

To avoid certain difficulties (see 2.2.5.4 a and b) and in contrast to specification 2.2.3.5, the " tone-off " signalling condition 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.

2.2.5.4 *Abnormal conditions*

a) When an interruption of the signalling channel in one of the two directions brings about a signalling condition corresponding to blocking, the release-guard sequence will be initiated the moment the interruption ends (see 2.2.5.3). The following additional requirements should then be met:

— when the " tone-off " signalling condition has lasted for an interval of less than 750 ± 150 ms the return to " tone-on " signalling condition must not initiate a release-guard sequence;

— once the signalling condition 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).

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.

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 condition 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 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.354

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 overloading of the system, intelligible cross-talk and unwanted tones.

One method recommended to avoid these effects 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.

Other methods may be used provided they give comparable results. For further details, see the detailed specifications.

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 4/Q.354.

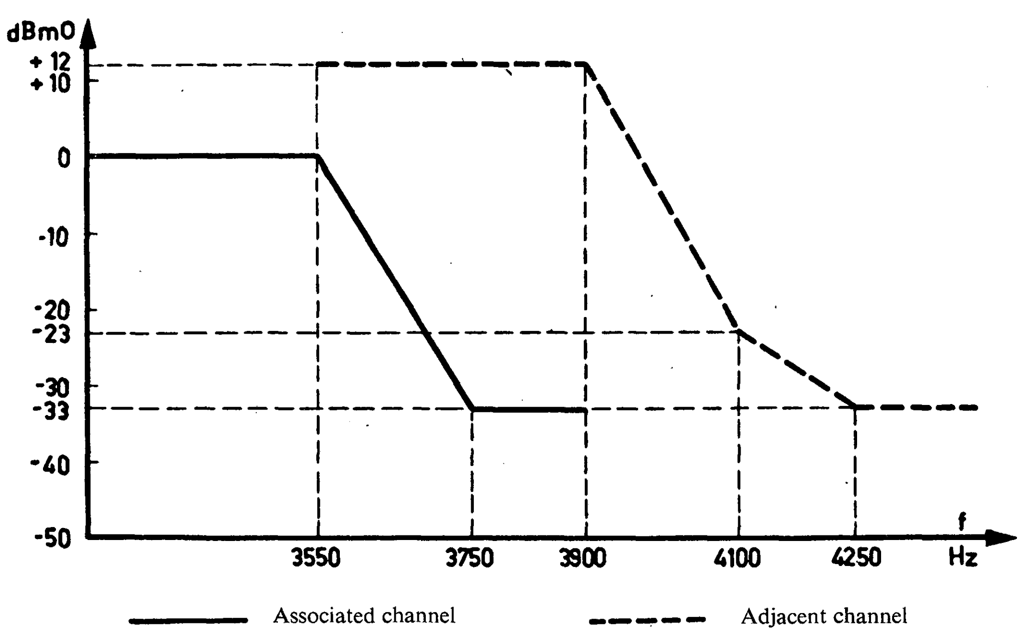


FIGURE 4/Q.354. — **Protection of the signalling channel at the sending end.**

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

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 4/Q.354 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 4/Q.354 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 4/Q.354 for the frequency $(4000-f)$.

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 5/Q.354 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.

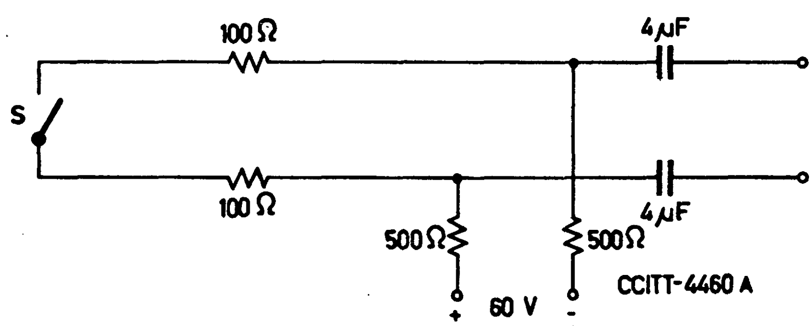


FIGURE 5/Q.354. — **Click generator.**

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 condition 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 condition the response time must be less than 7 ms.

Recommendation Q.355

2.3.2 SIGNAL RECEIVER

2.3.2.1 *Recognition of the " tone-on " condition*

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 " condition*

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 6/Q.355.

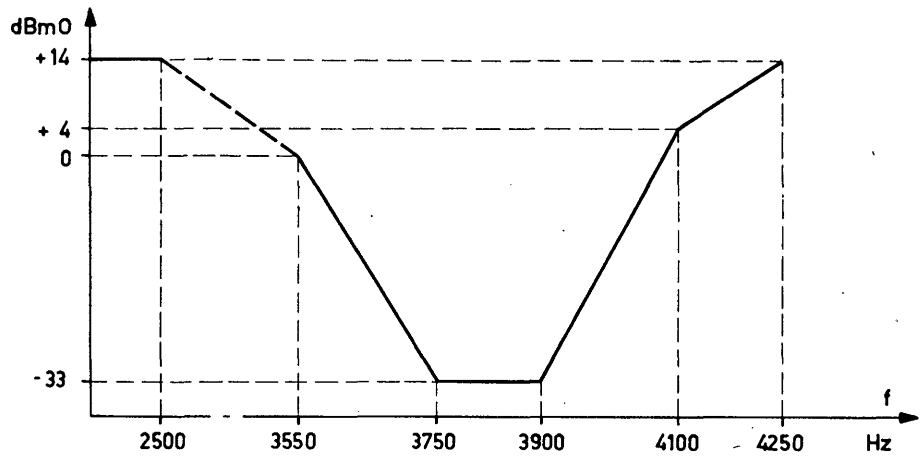


FIGURE 6/Q.355. — **Level limits for recognition of the " tone-off " condition.**

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 four-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 7/Q.355.

— a transient signal produced by the click generator (described in 2.3.1.5) 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.

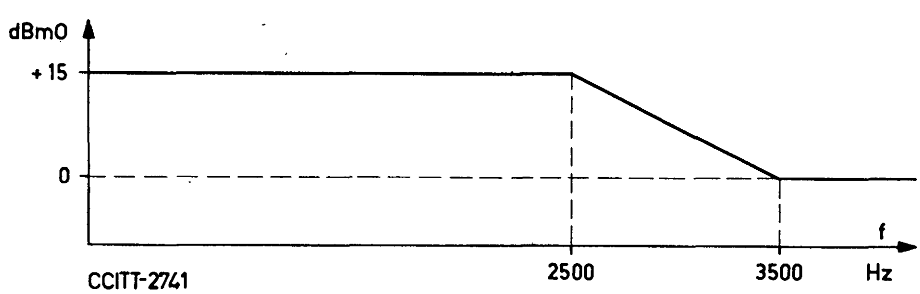


FIGURE 7/Q.355. — **Level limit for a sinusoidal disturbance signal to which the signalling receiver must remain insensible.**

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 condition command is applied to the sender and the moment when the changed signalling condition appears at the receiver output. For each of the two possible changes of signalling condition, 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 C.C.I.T.T. 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 must be met in the presence of any other pilot recommended by the C.C.I.T.T.

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

Recommendation Q.356

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 condition.

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*

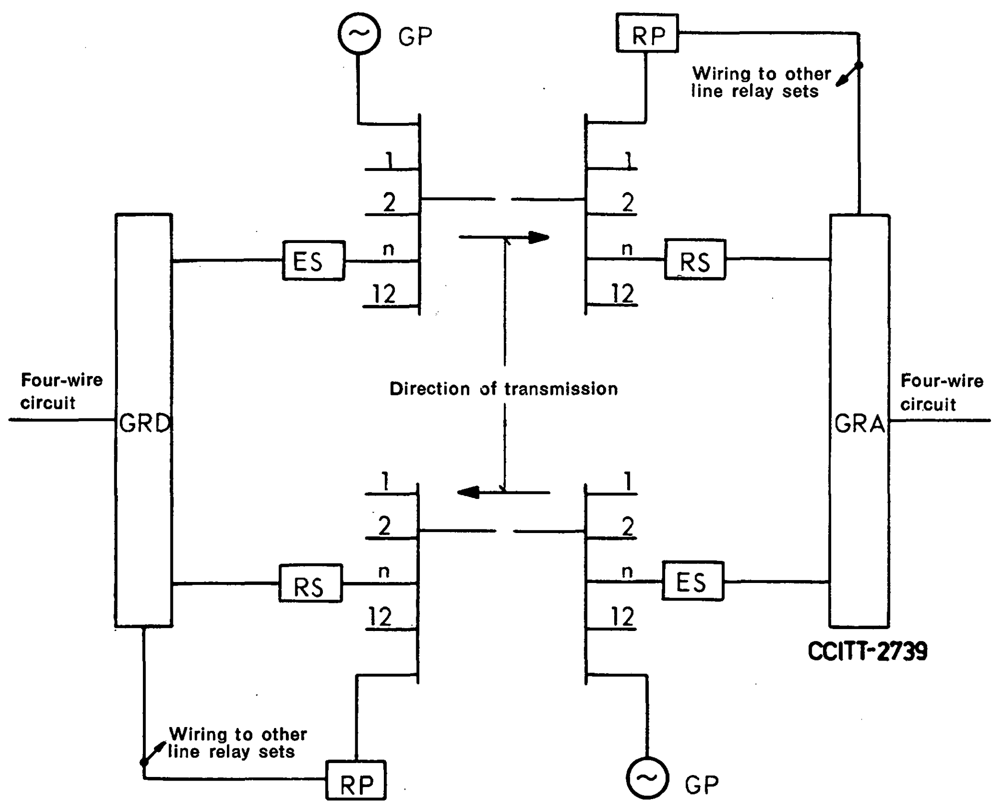
For each direction of transmission of a carrier circuit connection the equipment for interruption control comprises:

— 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 8/Q.356 shows functionally an arrangement where the pilot receiver controls the relay sets of interrupted circuits.



Legend
GP = Pilot generator
RP = Pilot receiver
RS = Signalling receiver
ES = Signalling sender
GRD = Outgoing relay set
GRA = Incoming relay set

FIGURE 8/Q.356. — **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 condition 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 condition 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.

Interruption control operates independently for each direction of transmission. At the incoming end interruption control thus 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 condition 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 " condition;

(ii) locking of the receiving unit in its position, i.e. in the " tone-on " condition.

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 " position.

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 " condition;

(ii) locking of the receiving unit in its position, i.e. in the " tone-off " condition;

(iii) start of a time-out device which after a certain interval clears the chain beyond the faulty circuit; this time-out device may be the one specified in Recommendation Q.118, 3.3.3.

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 (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 tone when interruption control reverts to normal the circuit returns to idle at the outgoing end as described in 2.2.2.6 b.

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 " condition;

(ii) locking of the receiving unit in its position, i.e. in the " tone-off " condition.

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 interruption control reverts to normal, the release-guard sequence is carried out as in 2.2.2.6 b or c.

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 " condition;

(ii) locking of the receiving unit in its position, i.e. in the " tone-off " condition;

(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 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 " condition; if at the instant interruption control operates, the " tone-on " condition exists in the backward direction, it will be switched to the " tone-off " condition following recognition of the clear-forward signal and locking in the " tone-off " condition can take place as prescribed;

(ii) locking of the receiving unit in its position, i.e. in the " tone-on " condition.

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 " condition 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 " condition. 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 " condition 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 " condition 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 condition existing at that moment on the signalling channel of the opposite direction is maintained — in contrast to specification 2.4.2.1 a i 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:

$$5 \text{ ms} \leqslant t\downarrow \leqslant t_{\text{rs min}} + 13 \text{ ms}$$

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, $t_{\text{rs min}}$ is the minimum response time of the signalling receiver for a drop in level, taking into account a possible variation of $\pm$ 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.

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:

$$t_{\text{rs max}} - 13 \text{ ms} \leqslant t\uparrow \leqslant 500 \text{ ms}$$

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, $t_{\text{rs max}}$ is the maximum response time of the signalling receiver for a rise in level, taking into account a possible variation of $\pm$ 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 $\pm$ 7 ms).

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.

CHAPTER III

LINE SIGNALLING, DIGITAL VERSION

Recommendation Q.357

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 system 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.356).

PCM multiplexes (see Recommendations Q.46/G.732 and Q.47/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 R2 line signalling without timing conditions is recommended for use on PCM systems and is specified below.

The digital version of 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 and 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 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.359).

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	
			1	1
Release-guard = idle	1	0	1	0
Blocked	1	0	1	1

Note 1. — The signalling code corresponding to state 1 on line of the *a* and *b* " receive " signalling channels, is also used locally for alarm purposes (see Recommendation Q.359).

* *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).

Recommendation Q.358

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.359).

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 (see paragraph 3.2.3.3). 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 paragraph 3.2.3.7.

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 paragraph 3.2.3.7.

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 condition in the backward direction; see also paragraphs 3.2.4.2, 3.2.3.2., 3.2.3.7 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 may 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 A-6 or 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) are 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 C.C.I.T.T. 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 (blocked) or for any other condition when the circuit does not return to idle after the clear-forward signal has been transmitted is given.

It is also recommended that a delayed alarm upon operation of the "Transmission Fault Control" device (TFC) as specified in Recommendation Q.359 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 the following paragraphs 3.2.6.1 and 3.2.6.2 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.357 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.357, to enable both-way working are given in paragraph 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 condition $a_b = 0$, $b_b = 0$ is recognized instead 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 condition for a minimum of 100 ms after which the clear-forward condition ($a_f = 1$, $b_f = 0$) 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 condition 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) *Blocking*

When a both-way circuit is blocked manually in its idle condition at one 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 so long as the blocking signalling condition persists in the B to A direction.

In order to avoid certain difficulties (see 3.2.6.2 below) end A should maintain the idle signalling condition in the traffic direction A to B.

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

c) *Minimum duration of release-guard signalling condition*

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 condition for at least 100 ms to ensure it is recognized at the other end.

3.2.6.2 *Special conditions*

a) When a circuit is idle and a change of $b_b = 0$ to $b_b = 1$ is recognized at end B, either due to a fault or because end A has established blocking condition, end B must not change $b_f = 0$ to $b_f = 1$. Observance of this requirement will ensure that the circuit does not become permanently blocked. This condition differs from that given in 3.2.4.2 a.

b) If realization of the signalling equipment allows the outgoing relay-set to be removed (at 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.359

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 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 Q.46. As signalling may be mutilated during the 4 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.358, a time limit of 6 ms must be set for the working of the TFC after loss of multiframe 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 $a_f = 1$, $b_f = 1$ 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 multiframe 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 seized circuits, when the calling subscriber clears the circuit becomes blocked.

3.3.3 *Transmission fault alarm*

According to Recommendation Q.46 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.356 when relay sets designed for R2 line signalling, analogue version, are used on PCM channels.

CHAPTER IV

INTERREGISTER SIGNALLING

Recommendation Q.361

4.1 INTERREGISTER SIGNALLING CODE

4.1.1 *General*

An outgoing international R2 register is defined as the first register at the outgoing end of a circuit (international or national) which controls the setting up of an international connection through circuits on which system R2 is employed. It controls the setting up of the connection over these circuits by sending forward and receiving backward multifrequency signals. It receives information via the preceding links of the connection by the signalling code used on these links.

An incoming R2 register is defined as a register situated at the incoming end of an international circuit on which the system R2 is used. It receives forward multifrequency signals via the preceding circuits and sends backward multifrequency signals to the outgoing international R2 register.

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 idle international circuit is selected and the seizing signal is sent. The sending of this signal is followed by the sending of the first forward register signal.

Interregister signalling is performed end-to-end by a compelled procedure between the outgoing international R2 register and the incoming R2 registers which come into action one after another.

Interregister signals are of the multifrequency type (frequency combinations) in a 2-out-of-6 code using six frequencies in the forward direction and six different frequencies in the backward direction, as shown in Tables 1, 2, 3, 4 and 5.

Both the forward and the backward frequency combinations have a primary meaning which, by the use of certain backward signals, may be changed to a secondary meaning. Each primary or secondary meaning of a frequency combination is considered to be an independent multifrequency interregister signal.

4.1.2 *Signalling code*

4.1.2.1 *Compelled signalling*

The compelled signalling operates as follows (see Figure 9/Q.361):

— on seizure of a circuit, the outgoing multifrequency register automatically starts sending the first forward multifrequency signal;

— as soon as the incoming multifrequency register to which the signal is addressed recognizes this signal, it starts sending a backward multifrequency signal which has its own meaning and at the same time serves as an acknowledgement signal;

— as soon as the outgoing multifrequency register recognizes the acknowledging signal, it stops sending the forward multifrequency signal;

— as soon as the incoming multifrequency register recognizes the cessation of the forward signal, it stops sending the backward signal;

— as soon as the outgoing multifrequency register recognizes the cessation of the acknowledging backward signal, it may, if necessary, start sending the appropriate next forward signal.

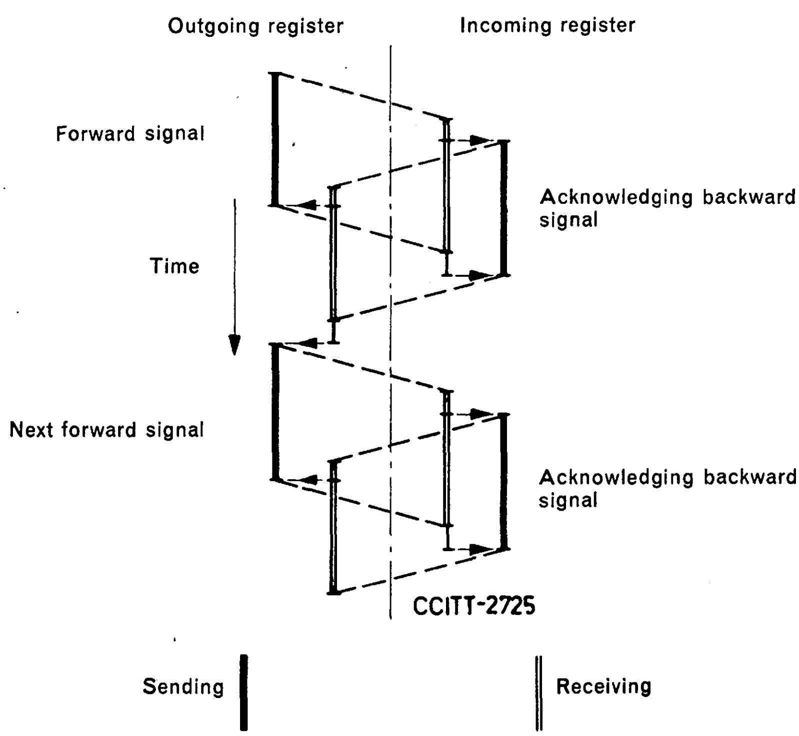


FIGURE 9/Q.361. — **Compelled signalling procedure.**

When the duration of the forward and backward signals is not controlled by the compelling mechanism mentioned above, it is either limited by the time-out delay for release of the registers or determined by the nature of the pulse imposed on them, in accordance with Recommendation Q.362.

Note. — In the detailed specifications, Figure 10 shows a complete compelled signalling cycle and information on the duration is given.

4.1.2.2 *Information transmitted by backward multifrequency signals*

Besides being a functional part of the compelled procedure, the acknowledging backward signals serve to convey special information concerning the required forward signals or the condition of the called subscriber's line.

TABLE 1

COMPOSITION OF THE R2 MULTIFREQUENCY CODE

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+12				x			y
14	3+11					x		y
15	4+11						x	y

TABLE 2

GROUP I FORWARD SIGNALS

Abbreviated designation of the signal	Meaning of the signal		Remarks (with regard to the order of transmission of the signals, see Recommendation Q.107)
	When first signal on an international circuit	When other than the first signal on an international circuit	
(a)	(b)	(c)	(d)
I-1	Language digit: French	Digit 1	Col. (b) — These signals make up the first signal transmitted on an international circuit when the circuit terminates in the country of destination of the call. When a circuit terminates in an international transit centre, however, these signals may be transmitted on the circuit after the transit call indication and the country code. See also Recommendation Q.107
I-2	English	" 2	
I-3	German	" 3	
I-4	Russian	" 4	
I-5	Spanish	" 5	
I-6	Spare (language digit)	" 6	
I-7	Spare (language digit)	" 7	
I-8	Spare (language digit)	" 8	
I-9	Spare (discriminating digit)	" 9	
I-10	Discriminating digit	" 0	
I-11	Country code indicator outgoing half-echo suppressor required	Code 11	Col. (b) — See Recommendation Q.115 and Note 1
I-12	Country code indicator no echo suppressor required	i Code 12 or ii request not accepted	Col. (c) — See Note 2 Col. (b) — See Recommendation Q.115 and Notes 1 and 3
I-13	Test call indicator (call by automatic test equipment)	Code 13 (call to automatic test equipment)	Col. (b) — See Recommendation Q.104; the test call indicator must not be regarded as an address signal
I-14	Country code indicator incoming half-echo suppressor required	Incoming half-echo suppressor required	Col. (b) — See Recommendation Q.115 and Notes 1 and 3 below Col. (c) — In response to signal A-14 (see Note 8 to Table 4)
I-15	Signal is not used	End of pulsing (Code 15)	Col. (c) — Q.107 and Note 4

Note 1. — It may be decided by bilateral agreement that signal I-11, when sent as the first forward signal on the international circuit, shall serve as country code indicator instead of signal I-14 to show that the first international transit exchange must insert an outgoing half-echo suppressor. If the international connection passes through two or more transit exchanges signal I-11 shall not then be sent beyond the first transit exchange.

Signal I-12 is used solely when no echo suppressor has to be inserted on the international connection.

Signal I-14 sent as the first digit on the international circuit, serves as country code indicator and shows that the connection requires echo suppressors and that the outgoing half-echo suppressor has already been inserted. In response to a signal A-14, the only meaning of the signal is that an incoming half-echo suppressor is necessary.

See the detailed specifications.

Note 2. — 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.368).

Note 3. — The sending of signals I-12 and I-14 may be repeated, as often as necessary, on request by a signal A-11.

Note 4. — Code 15 is also used to indicate (in response to signal A-13) that transmission of the code identifying the location of the outgoing international R2 register is terminated (see Recommendation Q.368).

TABLE 3

GROUP II FORWARD SIGNALS
(calling party's category)

Abbreviation designation of the signal (a)	Meaning of the signal (calling party's category) (b)	Remarks (c)
II-1 II-2 II-3 II-4 II-5 II-6	Signals assigned for national use	For the meaning of these signals, see the detailed specifications See also Note below
II-7	Subscriber (or operator without forward transfer facility)	
II-8	Data transmission call	
II-9	Subscriber with priority	
II-10	Operator with forward transfer facility	See Recommendation Q.350, section 1.5
II-11 II-12 II-13 II-14 II-15	Spare signals for national use	See Note below

Note. — The outgoing international R2 register which receives one of these signals converts it into a signal II-7, II-8, II-9 or II-10.

TABLE 4

GROUP A BACKWARD SIGNALS

Abbreviated designation of the signal (a)	Meaning of the signal (b)	Remarks (c)
A-1	Send next digit $(n+1)$	See Notes 1 and 2
A-2	Send last but one digit $(n-1)$	See Notes 1 and 2
A-3	Address-complete, changeover to reception of B signals	See Notes 3, 4 and 9
A-4	Congestion on the national network	See Note 4
A-5	Send calling party's category	See Note 5
A-6	Address-complete, charge, set up speech conditions	See Notes 4 and 9
A-7	Send last but two digits $(n-2)$	See Notes 1 and 2
A-8	Send last but three digits $(n-3)$	See Notes 1 and 2
A-9, A-10	Spare signals for the national use	See Note 6
A-11	Send country code indicator	See Recommendation Q.362 paragraph 4.2.7 and Recommendation Q.368
A-12	Send language or discriminating digit	See Notes 2 and 7
A-13	Send location of outgoing international R2 register	See Note 2 and Recommendation Q.368
A-14	Request for information on use of echo suppressor (is an incoming half-echo suppressor required?)	See Note 8 and the detailed specifications
A-15	Congestion in an international exchange or at its output	See Note 4

Note 1. — This meaning concerns the last address digit sent; this digit is part of the signal sequence mentioned in Recommendation Q.107 and is assumed to have the rank (n).

Note 2. — Reply expected in the form of a group I forward signal.

Note 3. — Reply expected in the form of a group II forward signal.

Note 4. — This signal may be sent:

— either as acknowledgement of any forward signal;

— or automatically in pulse form when there is no forward signal (Recommendation Q.362 paragraph 4.2.3).

Note 5. — This signal, used to acknowledge a group I forward signal, requests transmission of a group II signal. It may be followed by any other A signal, but the latter will be linked to the sequence of group I forward signals already received and will automatically cause the forward frequency combinations to revert to their primary meanings (group I).

Note 6. — Reply by signal I-12 (request not accepted). See Note 2 to Table 2.

Note 7. — The outgoing international R2 register is informed by the first signal A-12 that an international circuit connecting to an incoming international exchange has been added.

Note 8. — This signal is used at an incoming international exchange, where it is possible to insert an incoming half-echo suppressor. It is sent to acknowledge the discrimination digit or the language digit and the reply is received:

a) in the form of signal I-14, when an incoming half-echo suppressor is required;

b) in the form of the next digit of the address information when no incoming half-echo suppressor is required.

Note 9. — When the incoming exchange is unable to send detailed information on the condition of the called subscriber's line, transmission of signal A-3 followed by a B signal is not necessary and transmission of the signal A-6 may be used.

TABLE 5

GROUP B BACKWARD SIGNALS

(signals indicating the condition of the called subscriber's line)

Abbreviated designation of the signal (a)	Meaning of the signal (b)	Remarks (see also Note 1 below and Note 9 to Table 4) (c)
B-1	Spare signal for national use	See Note 2
B-2	Subscriber transferred	See Note 3
B-3	Subscriber line busy	See Note 4
B-4	Congestion (encountered after changeover from A signals to B signals)	See Note 5
B-5	Vacant national number	See Note 6
B-6	Subscriber line free, charge	See Notes 4 and 7
B-7	Subscriber line free, no charge	See Note 7
B-8	Subscriber line out of order	See Note 3
B-9 B-10	Spare signals for national use	See Note 8
B-11 B-12 B-13 B-14 B-15	Spare signals for international use	

Note 1. — Any group B backward signal acknowledges a group II forward signal and is always preceded by an A-3 signal which indicates that the incoming register has received all the group I forward signals it requires from the outgoing international R2 register.

Note 2. — Signal B-1 is always interpreted by the outgoing international R2 register as signal B-6.

Note 3. — After recognizing signal B-2 or B-8, the outgoing international R2 register clears forward and causes the transmission of a recorded announcement, a special information tone or, preferably, the two alternately.

If the destination national network cannot recognize a transferred subscriber or a subscriber line out of order, signal A-3 may be followed by signal B-5 instead of by signal B-2 or B-8, to ensure that the the special information tone is sent to the caller.

Note 4. — If the destination national incoming network equipments can only distinguish whether the called line is free or busy, signal A-3 shall be followed by signal B-3 when the line is occupied and by signal B-6 when it is free (or signal A-6 only shall be sent without being followed by a B signal so that the caller may hear the tones or a recorded announcement sent by the incoming equipments).

Note 5. — When the congestion condition is encountered following the changeover from A signals to B signals, signal B-4 shall be sent in the conditions specified for signal A-4.

Note 6. — After recognizing signal B-5, the outgoing international R2 register clears the forward connection and causes transmission of the special information tone.

Note 7. — After recognizing signal B-6 or B-7 the outgoing international R2 register sets up speech conditions so that a caller may hear the ringing tone.

Note 8. — Signals B-9 and B-10 are always interpreted by the outgoing international R2 register as signal B-5.

4.1.3 *Meanings of the multifrequency signals*

4.1.3.1 *Multiple meaning*

The primary meaning of both the forward and backward frequency combinations can change in response to certain backward signals. The changed meaning, or secondary meaning, is specific to the signal which caused the change. In certain cases of forward signalling a change back from the secondary to the primary meaning is possible.

4.1.3.2 *Meanings of the forward frequency combinations*

The meanings of the forward frequency combinations are indicated in Tables 2 and 3.

Group I (Table 2) represents the primary meanings of the forward frequency combinations, group II (Table 3) the secondary meanings. The change from primary to secondary meanings is commanded by a backward signal A-3 or A-5.

Secondary meanings can change back to primary only when the original change from primary to secondary was in response to signal A-5.

Apart from the primary and secondary meanings, the first forward signal transmitted on an international circuit is used for additional routing information. It enables a distinction to be made between terminal and transit calls. In this case, where terminal calls are involved, it carries the language or discriminating digit whereas, in transit calls, it serves the dual purpose of indicating that it is a transit call with a country code in the address and whether an echo suppressor is required or not (column b, Table 2).

4.1.3.3 *Meanings of the backward frequency combinations*

The meanings of the backward frequency combinations are indicated in Tables 4 and 5. Group A (Table 4) represents the primary meanings of backward frequency combinations, group B (Table 5) the secondary meanings. The change from primary to secondary meanings is indicated by the backward signal A-3. There is no change back to primary meanings once change to the secondary meanings of the backward frequency combinations has been indicated.

Recommendation Q.362

4.2 END OF THE EXCHANGE OF MULTIFREQUENCY SIGNALS

4.2.1 *Determination of the suitable moment for terminating R2 multifrequency signalling once a connection has been completely set up*

When a connection has been completely set up by means of R2 multifrequency signalling, the incoming register terminates multifrequency signalling immediately on receipt of the entire number.

The following criteria are used to determine whether the number received by the incoming register is complete:

a) analysis of the number received (normal case, i.e. the connection extends to the exchange at which the called subscriber's line terminates);

b) electrical criteria given by the switching equipment succeeding the multifrequency 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 4.2.8.2 a).

When a is applied:

— if the incoming register is equipped to send B signals to characterize the subscriber's line condition, signal A-3 is sent immediately on receipt of the last digit. As soon as it is known whether or not the connection with the subscriber's line can be established, only the B signal need be sent; hence, even if the subscriber replies immediately there will normally be no need to delay sending the answer signal in order to obtain the minimum desirable interval between the end of the last backward multi-frequency signal and the beginning of recognition of the answer-signal;

— if the incoming register is not equipped to receive information about the subscriber's line condition or if it is not sure that the incoming register is able to collect this information before the elapse of its time-out delay (see section 4.2.3) signal A-6 is transmitted immediately after reception of the last digit (no B signal will follow).

When b' is applied, it is recommended that, to avoid delay in sending the answer signal, no B signal should be sent when the subscriber's line is free, and that the setting up of speech conditions be ensured by means of signal A-6 immediately the electrical criteria are recognized. The time between the end of signal A-6 and the start of transmission of the subsequent answer signal must be not less than 75 ms.

Criterion c can be applied only of the incoming register is equipped to receive the relevant frequencies. On international calls, the signal I-15 is used in accordance with Recommendation Q.107. In general, signal I-15 will be sent immediately after the last digit.

When d is applied the A-6 signal must be sent as a pulse 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 case b, not less than 75 ms.

It may happen, however, that the called subscriber replies before the specified time has elapsed. In such exceptional circumstances the A-6 pulse must be sent immediately the subscriber's reply 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.

Note. — The above-mentioned 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 register are set for too short a delay (see also Recommendation Q.120, section 1.5.5.2 b, iii).

4.2.2 *Termination of multifrequency signalling when a connection cannot be completed*

A register should terminate multifrequency signalling immediately any conditions preventing complete setting up of a call have been recognized (A-4, A-15 or the appropriate B signal is sent).

4.2.3 *Pulse transmission of signals A-3, A-4, A-6 or A-15*

Under certain conditions it may prove desirable or even necessary 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 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 A-6 signal must be sent as specified in 4.2.1 b and d, the last forward signal having been acknowledged. It may be desirable to deliberately interrupt compelled signalling to avoid prolonging the transmission time of certain multi-frequency 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 called line's condition.

The average duration of such periods during the busy hour must be limited to 3 seconds in view of the load of the carrier systems.

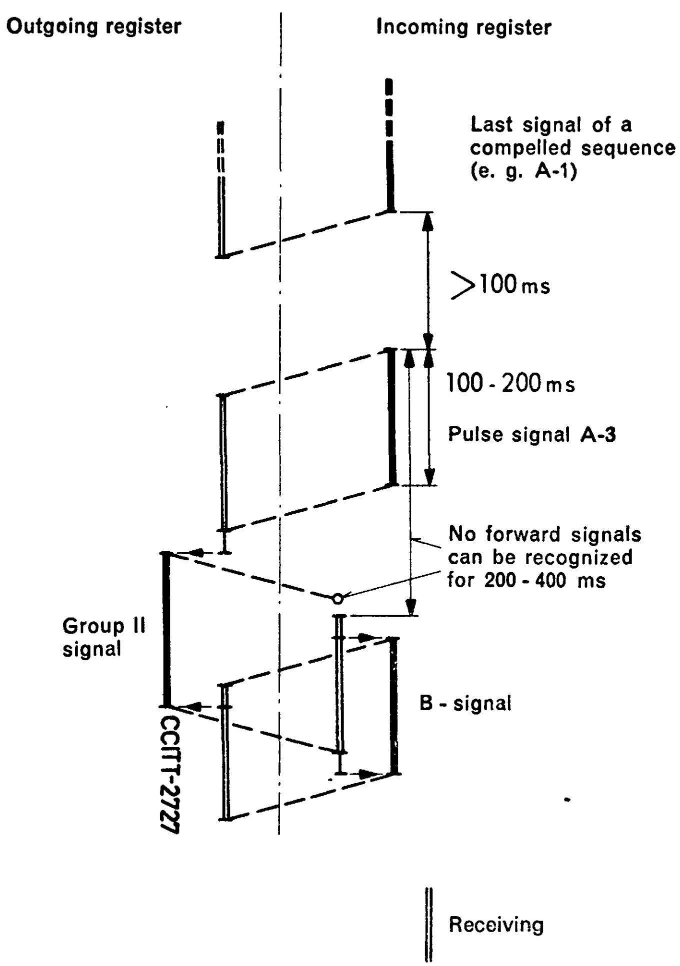


FIGURE 10/Q.362. — **Pulse transmission of signal A-3.**

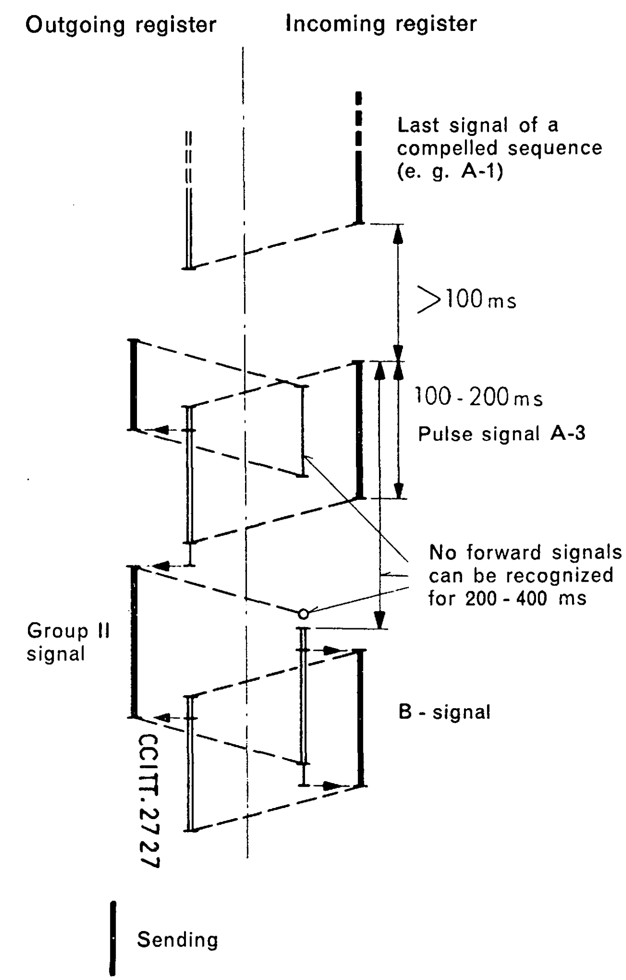


FIGURE 11/Q.362. — **Pulse transmission of signal A-3 when delayed forward signal appears.**

The following conditions should be observed in transmitting short-pulse multifrequency signals (see Figure 10/Q.362):

— 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 ± 40 ms.

On recognizing an A-4, A-6 or A-15 signal no forward signal is sent by the outgoing register. The end of these backward signals must cause the dismissal of the outgoing and incoming registers (in accordance with 4.2.3).

When the end of an A-3 signal sent in pulse form has been recognized in the outgoing register, a group II signal must be sent forward. The incoming register must acknowledge this signal by the normal compelled method (sending of a B signal).

Reception of a pulse signal must cause interruption of any forward signal in course of transmission at the outgoing register. It is sometimes impossible, however, to prevent a forward signal from being sent by the outgoing 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 register must be so designed that no forward multifrequency signal 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 signal A-3 in pulse form (see Figure 11/Q.362).

4.2.4 *Use of forward signal I-15 in semi-automatic operation*

Incoming registers equipped for the reception of six forward frequencies can acknowledge receipt of the end-of-pulsing signal I-15 by sending one of the signals A-1, A-3, A-4, A-6 or A-15 in a compelled sequence.

In semi-automatic operation, calls set up to operators' positions are always terminated by transmission of signal I-15. In this case, this signal must be received and interpreted.

In the case of international calls to subscriber stations, no provision can be made for recognition of the forward signal I-15 when an incoming register is equipped for reception of only 5 forward frequencies. Such a register is therefore unable to interpret signal I-15 and will then act as though signal I-15 had not been sent.

If analysis of the received number is performed the multifrequency signalling is terminated without request for the signal I-15 (see 4.2.1 a).

If the electrical criteria, given by the switching equipment succeeding the incoming register, are used to derive signals A-3, A-4, A-6 or A-15, those signals are sent, in pulse form if necessary, and then recognized by the international outgoing R2 register as acknowledging the signal I-15 and multifrequency signalling is terminated in the normal way (see 4.2.1 b and 4.2.3). Time-out devices may also be used (see 4.2.1 d).

4.2.5 *Setting up of speech conditions in the outgoing and incoming equipment*

The last recognized multifrequency signal preceding setting up of speech conditions will normally be a backward signal: namely, an A-6 or B signal.

The multifrequency signal 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. To this end, the following conditions regarding the duration of the various phases should be observed (see Figure 12/Q.362):

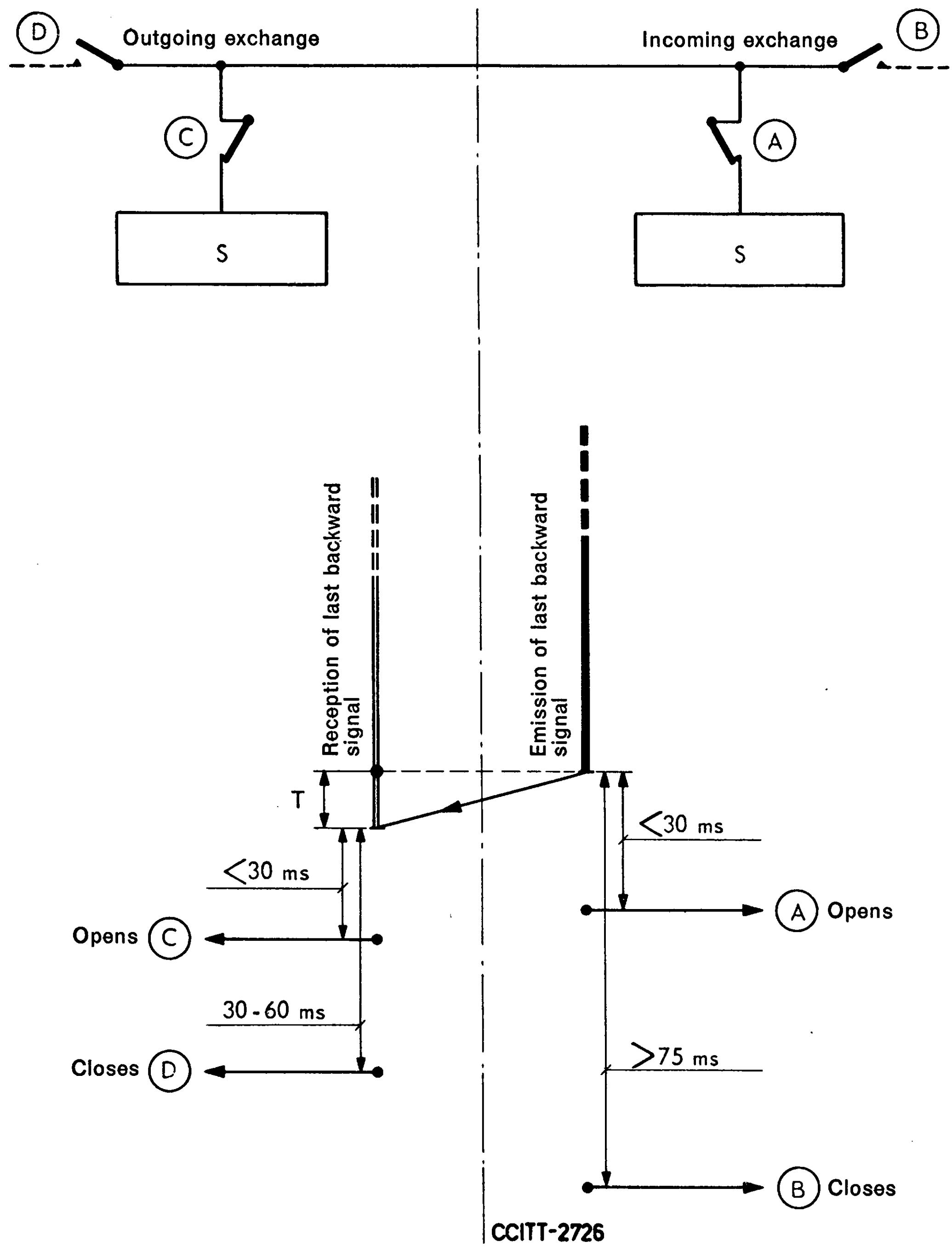


FIGURE 12/Q.362. — **Disconnection of multifrequency signalling equipment and switching to the speech position.**

Legend: T = Transmission delay +recognition time for the disappearance of the last backward multifrequency signal
S = Multifrequency signalling equipment (see 3.2.1).

a) the multifrequency signal receivers of the outgoing register must be disconnected within 30 ms after recognition of the end of the last backward signal;

b) 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;

c) the multifrequency signal receivers of the incoming register must be disconnected within 30 ms after the end of transmission of the last backward signal;

d) at the outgoing exchange, in general, speech conditions must be set up within 30 to 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 the speech conditions depends on the signalling system used on the preceding link.

4.2.6 *Normal release of outgoing and incoming R2 registers*

a) An outgoing international R2 register must be released once it has received an appropriate backward interregister signal terminating the exchange of multifrequency signals, or on receipt of a clear from the preceding link.

b) An incoming multifrequency register must be released once it has accomplished the necessary switching control and the exchange of multifrequency signals required, or on receipt of a clear from the preceding link.

4.2.7 *Termination of multifrequency signal exchange and setting-up of speech conditions at transit exchanges*

The setting-up of speech conditions following exchange of multifrequency signals entails the following three operations:

— termination of multifrequency signal exchange;

— dismissal of registers;

— through-connection of speech path.

In the normal case these operations are effected in one of the following ways:

a) the last signal received by the register at the transit exchange is not acknowledged by that register: after seizure of a circuit to the next exchange, dismissal of the register and setting up of speech conditions, the same signal is still on the line and this is the first signal received by the succeeding register;

b) the last forward signal received by the register at the transit exchange acknowledged by a backward signal inviting transmission of a clearly specified digit; this digit is the first forward signal sent to the next incoming register.

For international transit exchanges method b and the following backward signals must be used:

— A-11 if the outgoing circuit seized connects with a transit exchange and if international transit of the call at that exchange is necessary. A-11 causes signal I-12 or I-14 to be sent by the outgoing international R2 register and that signal will be the first forward signal sent to the next incoming register;

— A-12 if the outgoing circuit seized connects with an international terminal exchange. A-12 causes the language digit or discriminating digit to be sent by the outgoing international R2 register and that signal will be the first forward signal sent to the next incoming register.

If it is impossible to set up the desired connection in the transit exchange (e.g. when there is congestion) the register at the transit exchange terminates multifrequency signalling procedures by sending an appropriate backward signal according to the specifications in 4.2.5 and 4.2.3.

4.2.8 *Abnormal release of outgoing and incoming R2 registers*

To limit the holding time of multifrequency registers, when exchange of multifrequency signals is interrupted either by a fault or by any other cause, all multifrequency registers must be equipped with devices for continuous supervision of the time taken by the various phases of multifrequency signal exchange. The time-out delay of these devices must be as short as possible, but long enough not to interrupt normal operation.

4.2.8.1 *Time-out of outgoing international R2 register*

In an international outgoing R2 register, the intervals during which a forward multifrequency signal is transmitted and the intervals during which no such signal is transmitted are supervised separately.

a) *Supervision during sending of forward multifrequency signals*

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 signal and be reset at the end of the transmission of the same signal. It will start again at the beginning of the transmission of the next forward multifrequency signal.

b) *Supervision during intervals when no forward multifrequency signal is being sent*

The lower limit of the time-out delay is a function of:

— the maximum permissible time interval between dialling of two successive digits by the subscriber;

— the time-out delay specified for incoming multifrequency registers (see 4.2.8.2).

On this basis, the time-out delay is specified to be not less than 24 seconds. A longer delay and an upper limit may be specified by each Administration.

If this specification is observed an incoming multifrequency register, which has acknowledged the last received digit with the signal A-1, is bound to be released before the supervision device of the international outgoing R2 register reverts to the alarm.

c) *Procedure to be followed if time-out occurs*

If time-out occurs, the time supervision device mentioned in a and b will bring about operations producing:

— busy tone or equivalent to inform the calling party; and

— release of the outgoing multifrequency register and of the connection as far as the latter is not necessary for the above-mentioned operation.

Note. — Furthermore, fault recording equipment may start functioning or a delayed alarm may alert the technical staff.

4.2.8.2 *Time-out of incoming multifrequency register*

a) *Time-out delay*

The lower limit of the time-out delay is a function of:

— the maximum permissible time interval between the recognition of two successive forward signals; this time interval may in certain cases be influenced by the maximum permissible time interval between dialling of two successive digits by the subscriber;

— the maximum time required for setting up the connection under conditions which slow down the multifrequency procedure.

In view of the desirability in the case described in 4.2.8.1 b, that the incoming multifrequency register be released before expiry of the time-out delay specified for the international outgoing 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 to 24 seconds. A minimum delay of 15 seconds corresponding to the time-out delays in other C.C.I.T.T. standardized systems is to be preferred.

The time-out device shall supervise the interval elapsing between seizure of the register and recognition of the first forward multifrequency signal as well as the interval elapsing between the recognition of two successive multifrequency signals in the forward direction.

Note. — For incoming multifrequency registers using the criterion indicated in 4.2.1 d to determine the 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.

b) *Procedure to be followed if time-out occurs*

If time-out occurs, the time supervision device will bring about operations producing:

— the multifrequency signal for congestion in pulse form;

— release of the incoming multifrequency 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 paragraph 2.2.3.5, abnormal conditions).

Note. — Furthermore, fault recording equipment may start functioning or a delayed alarm may alert the technical staff.

Recommendation Q.363

4.3 MULTIFREQUENCY SIGNALLING EQUIPMENT

Since system R2 can provide, in international traffic, end-to-end signalling from the outgoing international R2 register to an incoming register at the called subscriber's local exchange (see Recommendation Q.361, section 4.1.1), 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 four-wire and two-wire circuits.

However, it is assumed in the following specifications for multifrequency signalling equipment for outgoing and incoming international R2 registers that the registers are directly connected by four wires to the virtual switching points of the circuits in CT3s or international exchanges of higher category. 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 four-wire circuit respectively (see Figure 13/Q.363).

When the outgoing R2 register is situated in a national exchange preceding the outgoing international exchange, which then serves as an international transit exchange for signalling between R2 registers, or when the incoming R2 register is in a national exchange following the incoming international exchange, reference should be made to the detailed specifications (see Recommendation Q.367, section 4.6.4).

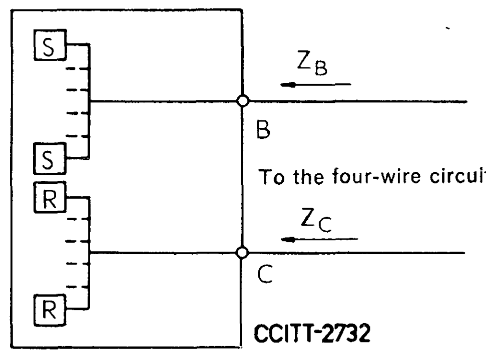


FIGURE 13/Q.363. — **Multifrequency signalling equipment.**

S = transmitting part
R = receiving part, including the " 2-out-of-*n* " and " 0-out of-*n* " checks

Recommendation Q.364

4.4 SENDING PART OF THE MULTIFREQUENCY SIGNALLING EQUIPMENT

4.4.1 *Signalling frequencies*

The composition of the multifrequency signals is specified in Recommendation Q.361 (see Table 1).

The frequencies in the forward direction are: $f_0 = 1380$, $f_1 = 1500$, $f_2 = 1620$, $f_3 = 1740$, $f_4 = 1860, f_5 = 1980$ Hz.

The frequencies in the backward direction are: $f_0 = 1140, f_1 = 1020, f_2 = 900, f_3 = 780, f_4 = 660$ $f_5 = 540$ Hz.

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

4.4.2 *Level of the transmitted signal*

For multifrequency signalling equipment in international outgoing and incoming registers assumed to be directly connected to the virtual switching point in a CT3 or in an international transit exchange of higher category the following applies:

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

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

Note. — The tolerances specified apply to the sending point itself, i.e. terminals B in Figure 13/Q.363.

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

— at least 50 dB below the nominal level of one signalling frequency when no multifrequency signal is being sent;

— at least 30 dB below the level of either of the signalling frequencies when a multifrequency signal 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 signal is being sent.

For multifrequency signalling equipment in incoming registers in national exchanges, see the detailed specifications.

4.4.3 *Harmonic distortion and intermodulation*

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

4.4.4 *Impedances*

The impedance Z_B measured at the terminal B of a four-wire multifrequency equipment (see Figure 13/Q.363) will have a nominal value equal to the nominal terminating impedance Z_r at the exchange under consideration and will be balanced to earth. In most cases the value Z_r will be 600 ohms, non-reactive. The impedance Z_B must then satisfy the following conditions:

$$20 \log \left| \frac{600 + Z_B}{600 - Z_B} \right| \geqslant 10 \text{ dB}$$

in the 300-3400 Hz band, and

$$20 \log \left| \frac{600 + Z_B}{600 - Z_B} \right| \geqslant 16 \text{ dB}$$

in the 520-1160 Hz or 1360-2000 Hz frequency band, according to the set of frequencies generated by the equipment.

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

4.4.5 *Signal time tolerance*

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

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

Recommendation Q.365

4.5 RECEIVING PART OF THE MULTIFREQUENCY SIGNALLING EQUIPMENT

4.5.1 *Sensitivity range*

The power levels given below relate to the nominal impedance of the receiving part of the multifrequency signalling equipment (see 4.5.5).

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

4.5.2 *Time requirements*

4.5.2.1 *The test signals*

Time requirements have been specified for two types of multifrequency test signals, 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.

The two types of multifrequency test signals are:

Type A

— the multifrequency test signal consists of any 2-out-of-n combinations of the n signalling frequencies;

— each frequency differs from the nominal frequency by not more than $\pm$ 5 Hz;

— the absolute power level of each of the two frequencies of the multifrequency signal lies between —5 dBm and —20 dBm;

— the difference in level between the two frequencies is not greater than 3 dB.

Type B

— the multifrequency test signal is of the same composition as the one specified for type A;

— the frequency differs from the nominal frequency by not more than $\pm$ 10 Hz;

— the absolute power level of each of the two frequencies of the multifrequency signal 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.

4.5.2.2 *The disturbing signals*

The disturbing signals 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 signal is being sent;

when a multifrequency signal is sent, one or more of the n-2 remaining frequencies with a total power level 20 dB below the highest test-signal frequency level during transmission of a multifrequency signal;

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

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

4.5.2.3 *Operating time and release time requirements*

When test and disturbing signals as specified above are applied to the terminals C in Figure 13/Q.363 the following operating time T_{O} and release time T_{R} requirements must be met when both frequencies are applied simultaneously and cut off simultaneously:

$$T_{\mathrm{O}} + T_{\mathrm{R}} \leqslant 70 \text{ ms for type A test signals}$$
$$T_{\mathrm{O}} + T_{\mathrm{R}} \leqslant 80 \text{ ms for type B test signals}$$

Note. — The recognition of faulty signals due to short-lived transient conditions can largely be avoided if a multifrequency signal 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 signals 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_O and T_R.

If one of the frequencies is applied later than the other, or if one is cut off earlier than the other, or if both of these conditions are present, the sum of the operating time measured from the appearance of the second frequency and of the release time measured from the disappearance of the second frequency, must not be more than 5 ms in excess of what would be the sum of the operating and release times if both frequencies were applied and cut off simultaneously.

When a multifrequency signal 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.

Note 1. — A method of improving the system reliability in case of interrupted signals is described in the detailed specifications.

Note 2. — With certain types of switching equipment it may prove advisable to embody devices to counteract lowfrequency disturbances in the multifrequency-signalling equipment.

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 being applied to the terminal C (Figure 13/Q.363):

— any single pure sine wave;

— 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 receivers used in the backward direction; and within the 330-1150 Hz and 2130-3400 Hz bands for the set of receivers used in the forward direction.

Furthermore, when signalling tones have activated the receivers, these 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 signal, consisting of two signalling frequencies out of the set of frequencies normally used in the direction considered, having a level of −5 dBm and a duration of less than 7 ms.

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

4.5.4 *Impedance*

The impedance Z_C measured at the terminals C in Figure 13/Q.363 must meet the requirements specified for impedance Z_B in 4.4.4.

Recommendation Q.366

4.5.5. ERROR RATE FOR COMPELLED WORKING

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

It must be ensured that all possible combinations of the forward and backward multifrequency signals 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 signals sent by the corresponding sending parts 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 signals of type A (see Recommendation Q.365) in the presence of noise at a power level of −40 dBm and a uniform power distribution in the 300-3400 Hz band (band limited white noise) and, on the other, by using type B test signals 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 under these conditions will be:

— for type A signals and noise at −40 dBm: $\leqslant 10^{-5}$;
— for type B signals and noise at −45 dBm: $\leqslant 10^{-4}$.

Recommendation Q.367

4.6 RANGE OF MULTIFREQUENCY SIGNALLING

General

Since in system R2 provisions are made for the end-to-end signalling technique, the corresponding advantages of signalling speed and reduction in register holding times can be realized if the conditions which are outlined in this Recommendation are fulfilled.

4.6.1 *Requirements to be met by the outgoing international R2 register*

The outgoing international R2 register will always be provided with four-wire multifrequency signalling equipment and the four-wire loop will be open during multifrequency signalling (see section " Echoes " in the detailed specifications).

4.6.2 *Number of international circuits*

The number of international circuits switched in tandem for establishing an international connection must not exceed four.

4.6.3 *Transmission loss in four-wire international circuits*

a) Nominal transmission loss at 800 Hz: 0.5 dB (Recommendation G.141, A);

b) Standard deviation of transmission loss variations with time must not exceed 1 dB (Recommendation G.151, C, a);

c) The difference between the mean value and the nominal is assumed to be 0 (as in Recommendation G.122, A, b, and G.131, A).

4.6.4 *National extension circuit*

When the outgoing international R2 register is situated in a national exchange preceding the outgoing international exchange, which then serves as an international transit exchange for signalling between R2 registers, or when the incoming R2 register is in a national exchange following the incoming international exchange, reference should be made to the detailed specifications. If the transmission requirements for the destination national extention circuits cannot be fulfilled a regenerating register must be used in the incoming international exchange or in a national exchange beyond.

In principle:

a) The outgoing international R2 register must be placed in an exchange where the incoming international exchange (CT3) in the country of destination is reached by a connection of *m* four-wire circuits switched in tandem, the maximum permissible value of *m* being four.

b) The maximum number *k* of national four-wire extension circuits in the country of destination is four.

c) The standard deviation of transmission loss variations with time in the national four-wire circuits in the country of origin and in the national four-wire extension circuits in the country of destination must not exceed 1 dB.

d) When the national circuits used in the country of origin do not have the same nominal transmission loss as the international circuits (0.5 dB), appropriate compensation of the multifrequency signal levels must be made in both directions of transmission.

e) The nominal transmission loss at 800 Hz in the forward direction, between the virtual switching point in the incoming international exchange and any incoming multifrequency register in the country of destination must not exceed:

11.4 dB for a country using three national four-wire extension circuits at the most;

11.0 dB for a country using four national four-wire extension circuits at the most;

and must never be less than:

$$-2.5 - (m \times 0.5) + (2.3 \times \sqrt{(m+k) + (m+k+1)\ (0.2)^2})\ \text{dB};$$

where *m* and *k* have the meanings specified in a and b above.

4.6.5 *Total attenuation distortion*

It is 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 multifrequency register will not exceed ± 3 dB.

Nevertheless, as type B test signals (see 4.5.2 in Recommendation Q.365) 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 circuit chain 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.

4.6.6 *Intermodulation*

A multifrequency signalling system in conformity with the R2 specifications will allow satisfactory working over a connection 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.

Recommendation Q.368

4.7 ANALYSIS OF INTERREGISTER ROUTING SIGNALS

4.7.1 System R2 equipment for transit exchanges must be designed for the transfer of all information necessary for setting up the connections, including information relating to access to operators' positions.

Recommendation Q.126 on signalling system No. 4 contains all necessary information regarding the number of digits that will have to be analyzed for routing purposes, and these provisions apply equally to system R2. For connections which must be set up via international transit exchanges, one of the country code indicator signals, I-12, I-14 or I-11, must precede the country code. Signals I-12 or I-14 can be requested as often as required by using the interrogation signal A-11 (see Recommendation Q.361, Table 2, Note 1).

4.7.2 *Procedure for identifying the outgoing international R2 exchange*

A multifrequency register in an international transit exchange or in a country of destination can determine the location of an outgoing international R2 register as soon as at least one forward signal has been received from that register. This is done in the following way:

— The register at the incoming end requests identification by transmitting the interrogation signal A-13. The outgoing international R2 register replies with the first digit of its country code. Each further digit of the country code is sent in reply to each subsequent repetition of signal A-13; further demands expressed through A-13 will elicit successive digits of the trunk code of the exchange where the outgoing international R2 register is situated.

When all the digits required to indicate the location have been sent, the next A-13 signal must be acknowledged by the end-of-pulsing signal I-15.

The incoming register may interrupt the identification sequence by sending a backward signal other than A-13. The outgoing register must recognize this signal and acknowledge it in accordance with its meaning.

If the outgoing international R2 register, after having sent signal I-15 terminating the identification procedure, again receives signal A-13, that signal must be interpreted as a new request and identification procedure must be recommenced.

If the identification procedure is started after the digit completing the called subscriber's number has been sent, and if the called subscriber answers the call before the identification is complete, all multifrequency procedures must be immediately terminated and speech conditions must be set up as specified in 4.2.5 of Recommendation Q.362.

Note. — The identification procedure may be of some value for regional routing, accounting or other purposes. However, it is impossible to state what the ultimate use of this procedure will be and the subject requires further study.

There is thus no necessity for an outgoing international R2 register to operate as specified above. An outgoing international R2 register which does not have the identification facilities described must reply to a backward signal A-13 with a forward signal I-12 (request not accepted).

The incoming register will then ask for the following digit of the address information, e.g. by sending signal A-1.

PART XVII

INTERWORKING OF SYSTEM R2 WITH SYSTEMS No. 4, No. 5, No. 5 *bis* AND No. 6

CONTENTS

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INTERWORKING OF SYSTEM R2 WITH SYSTEMS No. 4, No. 5, No. 5 *bis* AND No. 6

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.350) 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.

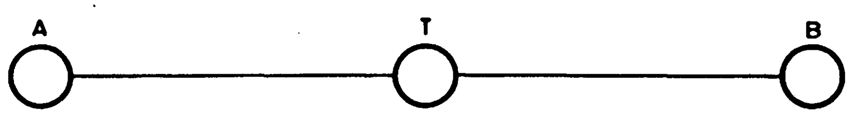
Use of universal registers at the interworking point (" T " in the following sections) considerably facilitates interworking.

Recommendation Q.381

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, where upon 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) and transmission of this signal must be accomplished before, under control of R2 backward signalling, 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 1.5 or Recommendation Q.350) in the forward direction, which is acknowledged by a 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 4.2.3 of Recommendation Q.362).

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. 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 R2 interregister signal (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 1.5 of Recommendation Q.350 is applied.

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.

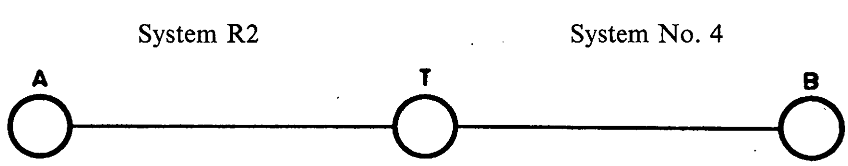
3.1.2.2 At A, the outgoing No. 4 register is released after receipt of signal P.

3.1.2.3 At T, the register is released after transmission of the number-received signal and completion of the exchange of R2 inter-register signals.

3.1.2.4 Points 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 point 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 1.4.3 of Recommendation Q.350. 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-15 or A-4.

3.2.1.8 At T, the register is released after the sending of code 15 and completion of the exchange of 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.

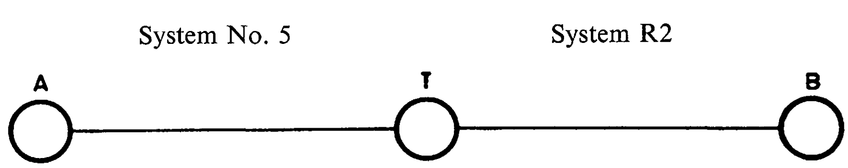
3.2.2.2 Points 3.2.1.1 and 3.2.1.3 to 3.2.1.9 are also applicable to automatic calls.

Recommendation Q.382

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 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 of Recommendation Q.381.

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 of Recommendation Q.381.

4.1.1.5 At A, the outgoing No. 5 register is released after signal ST has been sent.

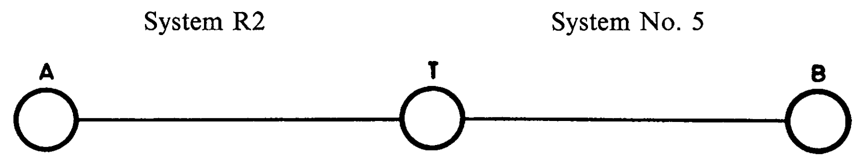
4.1.1.6 At T, the register is released after receipt of the last R2 interregister signal sent in the backward direction (B-signal, A-4, A-15, A-6).

4.1.1.7 At B, the register is released in accordance with 3.1.1.8 of Recommendation Q.381.

4.1.1.8 A forward-transfer signal arriving in T cannot be passed on to B unless the method indicated in 1.5 of Recommendation Q.350 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 1.3.4 of Recommendation Q.350. 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.

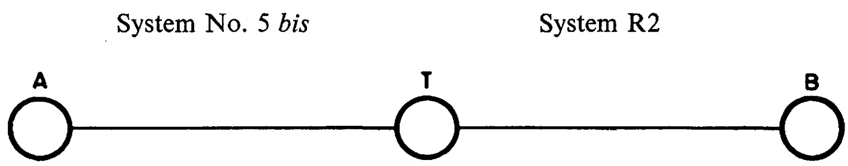
4.2.2.2 Points 4.2.1.3 to 4.2.1.8 are also applicable to automatic calls.

Recommendation Q.383

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 content 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 1.4.2 of Recommendation Q.350). The Z-signals are translated as indicated below.

No. 5 *bis* → Z	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 1.5 of Recommendation Q.350) 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 registers and must be followed by A-3, A-4, A-15 or A-6 as pulse signals (see Recommendation Q.362, section 4.2.3).

5.1.1.4 The translation of the R2 backward signals and the action required at T are listed below (see Table 4 in Recommendation Q.211):

← No. 5 *bis* signal	← 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 of Recommendation Q.381.

5.1.1.9 A forward-transfer signal arriving in T cannot be passed on to B unless the method indicated in 1.5 of Recommendation Q.350 is applied on link TB.

5.1.2 *Automatic calls*

5.1.2.1 In automatic operation the Z signals are translated as follows:

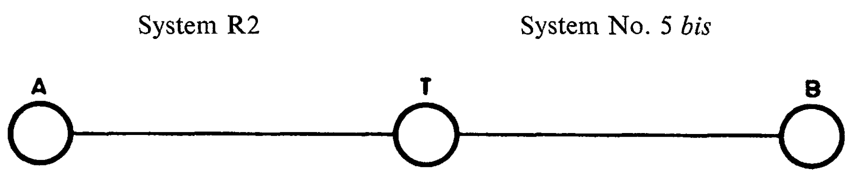
No. 5 *bis* → Z	R2 →	
	Discriminating digit	Acknowledging A-3 or A-5
0 11 12	I-10 I-10 I-10	II-7 II-9 II-8

5.1.2.2 The transit register in T awaits the receipt of one of the backward R2 interregister signals indicated under 5.1.1.4, which is then translated as described in that paragraph.

5.1.2.3 The other points under 5.1.1 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:

a) after receipt of a certain number of address signals;

b) after analysis indicating that the succeeding link uses No. 5 *bis* signalling;

c) as a result of other 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:

a) 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;

b) the country code;

c) the Z digit;

d) address signals.

Any address signal which follows the initial address block is forwarded as received.

The R2 forward signals are translated as indicated below:

R2 →	No. 5 *bis* →
I-11 Country code indicator insert, outgoing echo suppressor	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, incoming echo suppressor required	X = 2 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:

← R2	← No. 5 *bis*	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 1.3.4 of Recommendation Q.350. This causes the release of the connection. If a busy-flash signal 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.

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 register is released after receipt of A, A-6, A-15, A-4 or a B signal.

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.

Recommendation Q.384

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 inter-working point T.

Recommendation Q.385

7. INTERWORKING WITH NATIONAL SIGNALLING SYSTEMS DERIVED FROM SYSTEM R2

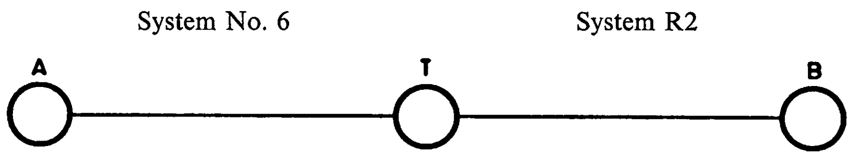
The R2 system is designed for operation on international routes with 15 frequency combinations for interregister signalling in each direction. It can, however, be adopted for interworking with a national multifrequency system derived from system R2 of an outgoing country operating with only 10 or 6 frequency combinations for backward signalling and as many forward frequency combinations as may be desired or with a national system of an incoming country operating with 10 frequency combinations for forward signalling and as many backward frequency combinations as may be desired.

For fuller information, see the detailed specifications of signalling system R2.

Recommendation Q.388

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 T-B 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 Recommendations Q.361 and Q.362. If required the calling-party's category signal (see Table 1) will be sent to B.

TABLE 1

CONVERSION OF CALLING PARTY'S CATEGORY

No. 6	R2	
Calling party's category indicator	Language or discriminating digit	Calling party's category signal
Operator, language French	L = 1	
Operator, language English	L = 2	
Operator, language German	L = 3	II-7 [a]
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 bilateral agreement, see Recommendation Q.350.

8.1.3 On receipt of any R2 backward signal except those listed in Table 2 below, no signal will be sent on link A-T. The appropriate R2 forward signal is sent to B in accordance with Recommendation Q.361.

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 R2 backward signals listed in Table 2, the register and link T-B is released and the corresponding system No. 6 signal (see Table 2) is sent to A.

TABLE 2

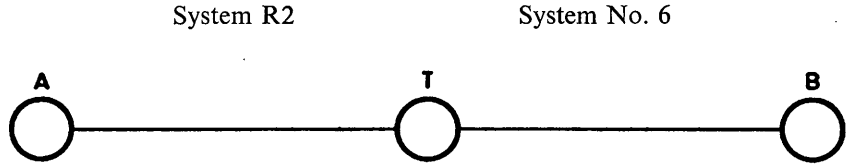
CONVERSION OF BACKWARD R2 SIGNALS

R2 signal	Meaning of 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	National-network-congestion
B-10	National-network-congestion

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 decided upon bilateral agreements (see Recommendation Q.350).

8.2 *Calls from system R2 to system No. 6*



8.2.1 A seizes link A-T and starts address signalling to T. T cannot seize link T-B 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 paragraph 8.2.2). This request will be made upon any criteria considered suitable atT (e.g. after analysis indicating that link T-B uses signalling system No. 6). Signal A-5 may only be sent as an acknowledgement to a forward signal received after 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

R2	No. 6
	Echo-suppressor indicator
	Outgoing half-echo suppressor
I-11	Included = 1
I-12	Not included = 0
I-14	Included = 1
	Calling party's category indicator
L = 1	Operator, language French
L = 2	Operator, language English
L = 3	Operator, language German
L = 4	Operator, language Russian
L = 5	Operator, language Spanish
D = 0 and II-7	Ordinary calling subscriber
D = 0 and II-9	Calling subscriber with priority
D = 0 and II-8	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 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 T-B is released and the corresponding R2 signal (see Table 4) is sent to A.

TABLE 4
CONVERSION OF BACKWARD NO. 6 SIGNALS

Meaning of No. 6 signal	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, section 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 system R2 and No. 6.

ABBREVIATIONS SPECIFIC
TO SIGNALLING SYSTEM No. 6

(Turn the flap)

ABBREVIATIONS SPECIFIC TO SIGNALLING SYSTEM No. 6

ACU	Acknowledgement signal unit
ADC	Address-complete signal, charge
ADI	Address-incomplete signal
ADN	Address-complete signal, no charge
ADX	Address-complete signal, coin-box
AFC	Address-complete signal, subscriber-free, charge
AFN	Address-complete signal, subscriber-free, no charge
AFX	Address-complete signal, subscriber-free, coin box
ANC	Answer signal, charge
ANN	Answer signal, no charge
BLA	Blocking-acknowledgement signal
BLO	Blocking signal
CB1-3	Clear-back signal No. 1-No. 3
CFL	Call-failure signal
CGC	Circuit-group-congestion signal
CLF	Clear-forward signal
COF	Confusion signal
COT	Continuity signal
CSSN	Circuit state sequence number
FOT	Forward-transfer signal
IAM	Initial address message
ISU	Initial signal unit
LOS	Line-out-of-service signal
LSU	Lone signal unit
MRF	Message-refusal signal
MUM	Multi-unit message
NMM	Network-management and maintenance signal
NNC	National-network-congestion signal
RA1-3	Reanswer signal No. 1-No. 3
RLG	Release-guard signal
SAM1-7	Subsequent address message No. 1-No. 7
SCU	System-control signal unit
SEC	Switching-equipment-congestion signal
SNM	Signalling-network-management signal
SSB	Subscriber-busy signal (electrical)
SST	Subscriber-transferred signal
SSU	Subsequent signal unit
SU	Signal unit
SYU	Synchronization signal unit
UBA	Unblocking-acknowledgement signal
UBL	Unblocking signal
VNN	Vacant-national-number signal